SPECIES COMPOSITION AND DIVERSITY OF DECAPOD CRUSTACEANS THROUGHOUT THE LOWER SÃO FRANCISCO RIVER, NORTHEASTERN BRAZIL

Matheus Souza Ferreira de Barros[1*]
Tereza Cristina dos Santos Calado[1]
Juliana Lemos Santanna[2]
Ewerton Vieira dos Santos[1]
Alberis Santos Silva[1]

ABSTRACT: The aim of this study was to analyse the structure of the decapod crustaceans community (taxonomic composition, abundance, diversity and distribution in the lower São Francisco region, located in the northeast Brazil, which extends from Paulo Afonso, Bahia, to the mouth, between the states of Alagoas and Sergipe, and is an important ecosystem and one of the biggest lentic environments in Brazil and South America. The species were sampled, within a period of three years, in fifteen sites, manually and using drag nets. The organisms were tagged and fixed in 70% alcohol. Posteriorly, the material was sent to the research lab and identified. In order to analyse data, an analysis of variance with *a posteriori* multiple comparisons was carried out to test the null hypothesis that the diversity throughout the river is homogenous. A total of 3.103 individuals were sampled, comprising 10 families and 30 species. Was verified predominance of the family Palaemonidae in what touches abundance, specially of the genus *Macrobrachium.* The sites with the greatest taxonomic richness corresponded nearest to the estuary. Our analysis rejected the null hypothesis, allowing us to conclude that the fauna is compartmentalized.

Key words : carcinology, limnology, freshwater, invertebrates

COMPOSIÇÃO TAXONÔMICA E DIVERSIDADE DE CRUSTÁCEOS DECÁPODES AO LONGO DO BAIXO RIO SÃO FRANCISCO, NORDESTE BRASILEIRO

RESUMO: O objetivo deste estudo foi analisar a estrutura da comunidade de crustáceos decápodes (composição taxonômica, abundância, diversidade e distribuição na região do baixo São Francisco, localizada no nordeste do Brasil, que se estende de Paulo Afonso, na Bahia, até a foz, entre nos estados de Alagoas e Sergipe, e é um importante ecossistema e um dos maiores ambientes lênticos do Brasil e da América do Sul. As espécies foram amostradas, em um período de três anos, em quinze locais, manualmente e usando redes de arrasto, etiquetados e fixados em álcool a 70%. Posteriormente, o material foi enviado ao laboratório de pesquisa e identificado. Para analisar os dados, foi realizada uma análise de variância com comparações múltiplas *a posteriori* para testar a hipótese nula de que a diversidade ao longo do rio é homogênea. Foram amostrados 3.103 indivíduos, constituídos por 10 famílias e 30 espécies, sendo verificada predominância da família Palaemonidae no que toca a abundância, principalmente do gênero Macrobrachium. Os locais com maior riqueza taxonômica corresponderam aos mais próximos do estuário. Nossa análise rejeitou a hipótese nula, permitindo concluir que a fauna é compartimentalizada.

Palavras-chave: carcinologia, limnologia, água doce, invertebrados

[1] Laboratórios Integrados de Ciências do Mar e Naturais da Universidade Federal de Alagoas. Rua Aristeu Andrade, 452, Farol, CEP 57051-090, Maceió, Alagoas, Brazil. matheus.barrosteu@gmail.com; terezacalado@gmail.com; ewertonvs@gmail.com; alberissantos001@gmail.com
[2] Museu de Oceanografia Petrônio Alves Coelho, Av. da Arquitetura, 778-822 - Cidade Universitária, Recife – PE. julilemos@live.com[3]

INTRODUCTION

The evaluation of distribution patterns, ecology and taxonomic composition of aquatic environments are extremely plausible to posterior studies referring to conservation strategies, population structures, and analysis of bioindicators, considering that benthic organisms are highly sensible to variations in their habitats. The verification of abiotic factors dynamics is either important to conservationist and ecological studies, mainly to benthic communities (Branco & Necchi Jr., 1997).

Faunistic distribution patterns are results of interactions between nutrient availability, habitat morphology and organism's life story traits. Among the main abiotic factors are the stream speed, salinity and temperature. The stream speed influences the substrate particles size, while the temperature is a result of interactions between climate, vegetation, altitude and extension of marginal flora (Allan, 1995).

Aquatic environments are suffering progressive degradation, exposing the need to accelerate studies that deal with composition and biology of the aquatic communities. Changes in freshwater ecosystems due to anthropic activities can strongly affect the invertebrate's occurrence, especially those with restrict geography, bringing the risk of extinction (Almeida *et al*., 2008).

Freshwater crustaceans do not receive proper attention of the scientific community when compared with marine and estuarine crustaceans (Rocha & Bueno, 2004). However, they are primordial to environmental characterization (Raz-Guzman, 2000). They are also important in energetic flow to higher trophic levels. Therefore, this work aimed to characterize the structure of the community (taxonomic composition, abundance, species richness, diversity and distribution) of decapod crustaceans in the lower São Francisco River and its correlation with the environmental factors.

MATERIALS AND METHODS

Study area

The study area is located in the lower São Francisco region, which extends from Paulo Afonso, Bahia, to the mouth, in Piaçabuçu, Alagoas (Figure. 1) and is characterized for having slow streams, due to the localization in flat lands and suffering coastal influence (Sato & Godinho, 1999). The sampling sites were chosen based in physical river variations patterns.

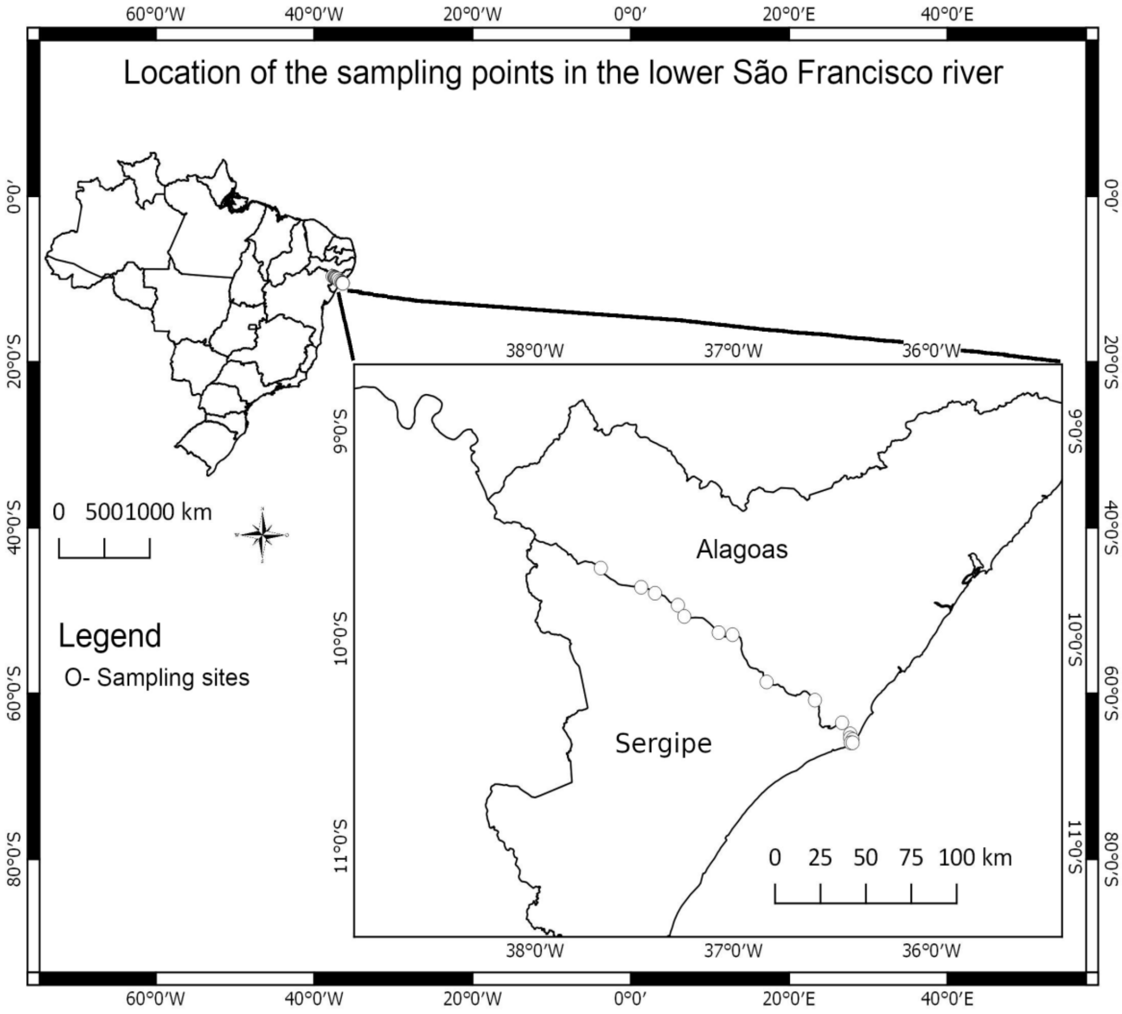

FIGURE 1. Location of the sampling sites in the lower São Francisco river

Sampling

Samplings were performed monthly between the years 2008-2010. In order to obtain the organisms, dragnets were used within a period of 20 minutes. Easy visualisation organisms were obtained manually. Posteriorly, the animals were tagged, fixed in 70% alcohol and taken to the Laboratório de Carcinologia, at LABMAR/UFAL (Laboratórios Integrados de Ciências do Mar e Naturais), where the material collected can be found. The taxons identification was done using specialized literature (Melo, 1996). In order to collect the abiotic parameters, water samples were taken by the use of a Van Dorn sampler to measure salinity and temperature. An optical refractometer and a mercury thermometer were used. To register depth (in meters), an ecobathymeter equipped with an GPS was used.

Data analysis

Univariate data such as species richness and total abundance were calculated for each collection site. For each sampling site, the Shannon diversity index was calculated, considering each collection month as replicates. We used an one-way analysis of variance (ANOVA) to compare diversity among sampling points, testing the alternative hypothesis that the faunistic composition differs throughout the river. If significant, the *a posteriori* Tukey test was used towards determining which pairs of sampling sites were different. Assumptions of normality and homoscedasticity were checked prior to any other analysis by means of the Shapiro-Wilk test and Levene test, respectively. All data was analysed in the R sofware (R Core Team, 2017) using the vegan package (Oksanen *et al.*, 2015).

RESULTS

Abiotic factors

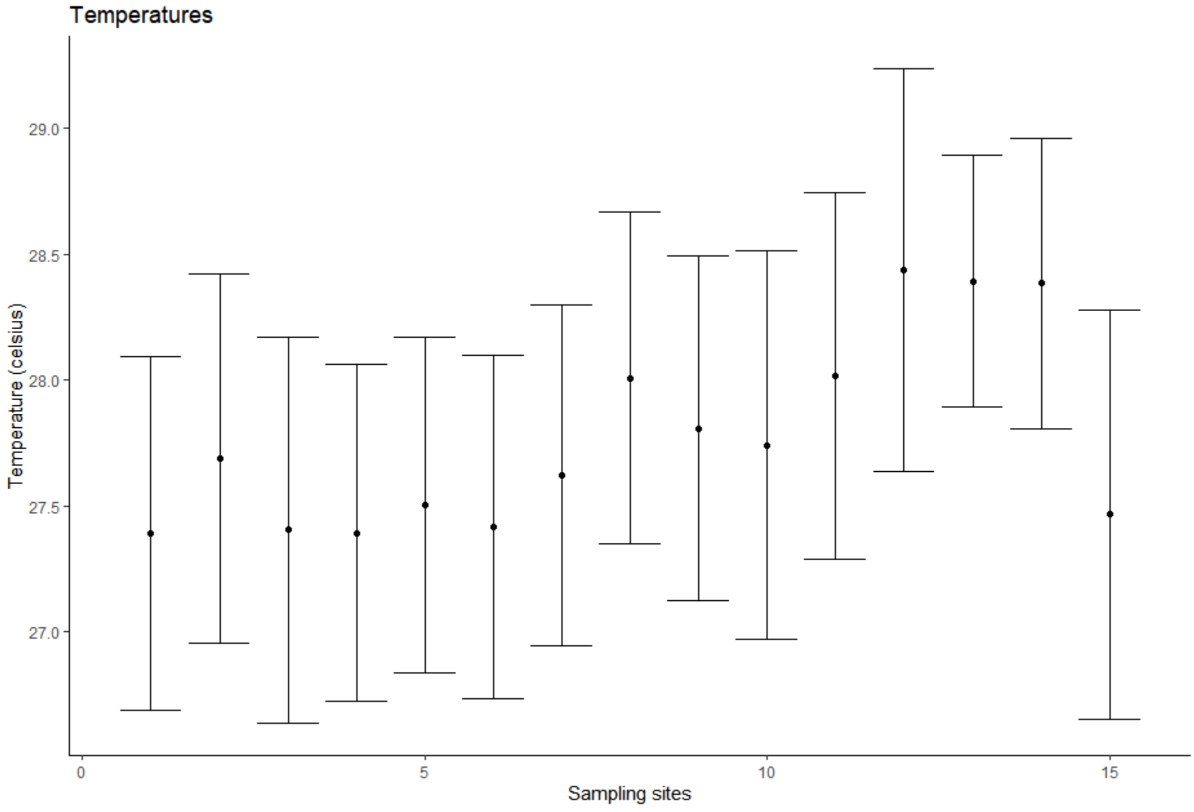

FIGURE 2. Means and standard deviations of the temperatures for each sampling site

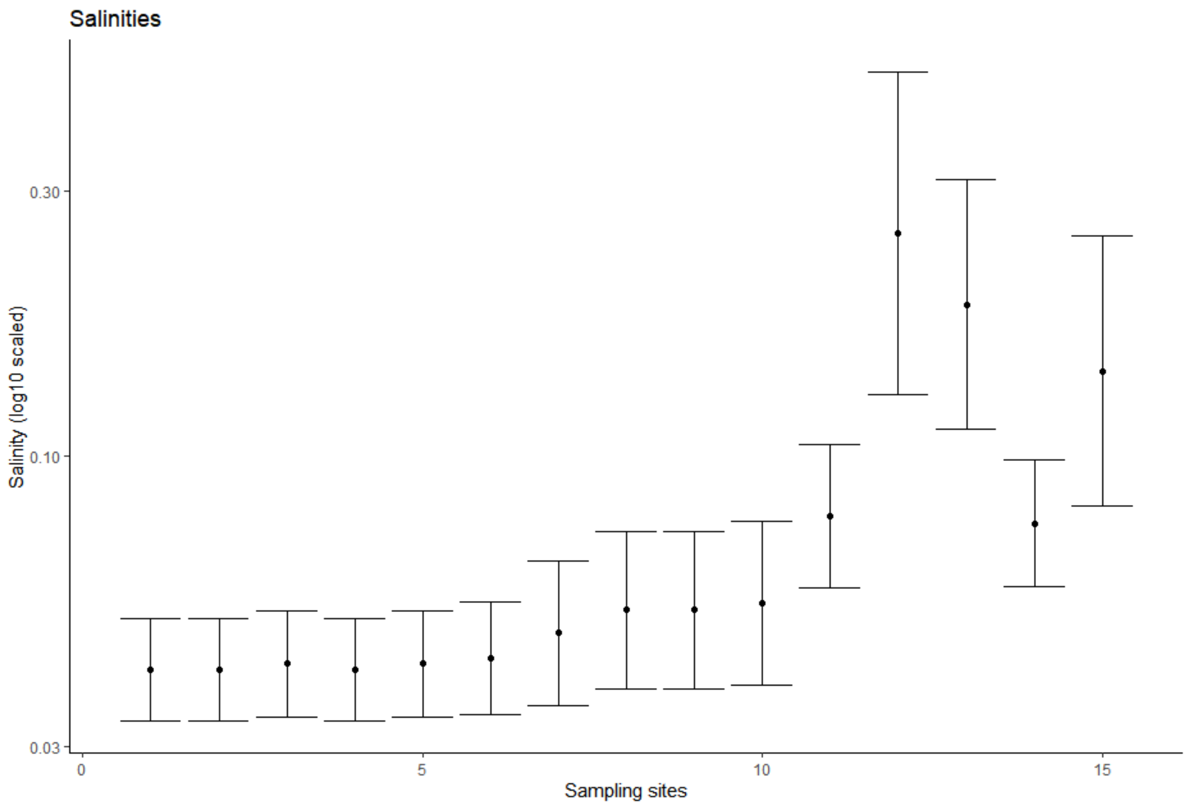

FIGURE 3. Means and standard deviations of the salinities for each sampling site

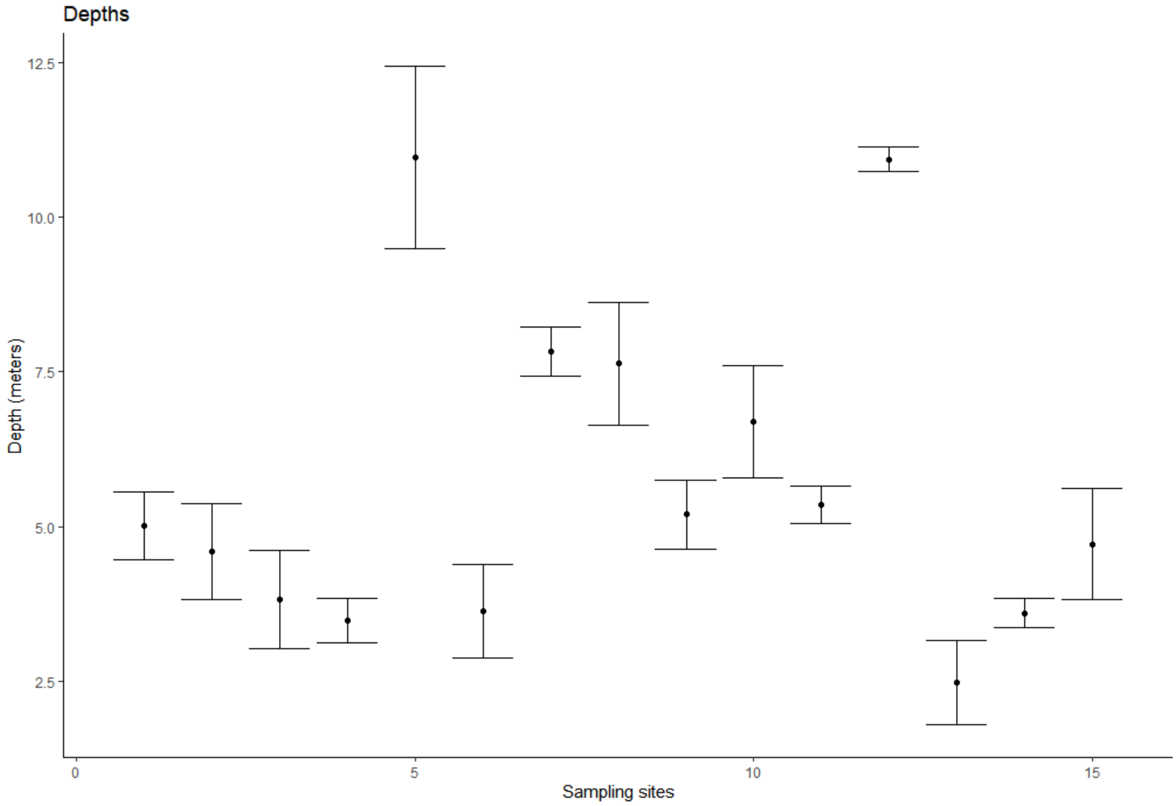

FIGURE 4. Means and standard deviations of depth for each sampling site

Species composition

We collected a total of 30, distributed among 17 genus and 10 families (Table 1). The Table 2 shows the species distribution among the sampling sites.

Table 1. Taxonomic composition of the crustaceans in the lower São Francisco river.

Alpheidae Rafinesque 1815
Alpheus estuariensis Christoffersen, 1984.
Gecarcinidae MacLeay, 1838
Cardisoma guanhumi Latreille in Latreille, Le Peletier, Serville & Guérin, 1828
Grapsidae Macleay 1838
Goniopsis cruentata Latreille 1802
Palaemonidae Rafinesque 1815
Macrobrachium acanthurus Linnaeus 1758
Macrobrachium amazonicum
Macrobrachium carcinus Wiegmann 1836
Macrobrachium denticulatum Ostrovski, Da Fonseca & Da Silva-Ferreira, 1996
Macrobrachium jelskii Miers 1778
Macrobrachium olfersii Wiegmann 1836
Palaemon northropi Rankin 1898
Palaemon pandaliformis Stimpson 1871
Potimirim potimirim Müller, 1881
Ocypodidae Rafinesque 1815
Leptuca cumulanta Crane 1943
Leptuca leptodactyla Rathbun 1898
Leptuca thayeri Rathbun 1900
Minuca burgersi Holthuis, 1967
Minuca mordax Smith 1870
Minuca rapax Smith 1870
Minuca vocator Herbst 1804
Ucides cordatus Linnaeus 1763
Panopeidae Ortmann 1893
Panopeus lacustris Desbonne in Desbonne & Schramm, 1867
Penaeidae Rafinesque 1815
Penaeus subtilis Pérez Farfante, 1967
***Portunidae* Rafinesque 1815**
Callinectes sapidus Rathbun 1896
Callinectes danae Smith 1869
Sergestidae Dana 1852
Acetes paraguayensis Hansen, 1919
Sesarmidae Dana 1851
Aratus pisonii H. Milne-Edwards, 1837
Armases angustipes Dana 1852
Armases benedicti Rathbun 1897
Armases rubripes Rathbun 1897
Pachygrapsus gracilis Saussure, 1857
Pachygrapsus transversus Gibbes 1850
Sesarma crassipes Cano 1889

Table 2. Taxonomic composition of each sampling site and geographic coordinates.

Site	Taxons	Geographic coordinates
01	*M. carcinus, M. olfersii*	9°39'29.35"S 37°40'4.94"W
02	*P. potimirim, M. olfersii*	9°45'1.89"S 37°27'50.56"W
03	*No crustaceans occurred*	9°46'45.41"S 37°23'39.17"W
04	*M. amazonicum, M. denticulatum, M. olfersii, M. jelskii, P. potimirim*	9°50'13.65"S 37°16'43.40"W
05	*M. amazonicum, M. denticulatum, M. olfersii, M. jelski, P. potimirim*	9°53'28.00"S 37°14'47.43"W
06	*M. acanthurus, M. olfersii, M. carcinus, M. jelskii*	9°58'9.08"S 37° 4'22.86"W
07	*M. amazonicum, M. acanthurus, M. carcinus, M. olfersii, M. jelskii, P. potimirim*	9°58'44.53"S 37° 0'11.16"W
08	*M. amazonicum, M. olfersii, M. carcinus, M. denticulatum, M. jelskii, P. potimirim, P. glabra*	10°12'25.18"S 36°49'51.71"W
09	*M. acanthurus, M. carcinus, M. denticulatum, M. olfersii, M. jelskii, P. potimirim*	10°17'41.37"S 36°35'13.98"W
10	*A. benedicti, A. rubripes, C. danae, C. sapidus, M. acanthurus, M. olfersii, P. pandaliformis. P. potimirim, S. crassipes*	10°24'13.45"S 36°27'10.66"W
11	*Alpheus estuariensis, A. angustipes, A. benedicti, A. rubripes, C. danae. C. sapidus, M. acanthurus, M. rapax, P. lacustris, P. transversus, P. northropi, P. pandaliformis, P. subtilis, L. thayeri*	10°27'26.39"S 36°24'32.85"W
12	*A. paraguayensis, A. pisonii, A. rubripes, C. danae, L. cumulanta, L. leptodactyla, M. acanthurus, M. burgersi, P. pandaliformis, P. transversus, S. crassipes, A. benedicti, M. vocator*	10°28'36.02"S 36°24'33.38"W

The family Palaemoniade seemed to dominate the assemblage. The genus *Macrobrachium* was the most dominant, being represented by *M. carcinus, M. olfersii, M. acanthurus, M. amazonicum* and *M. denticulatum.* Species such as *Armases benedicti, Armases* *rubripes*, *Armases angustipes* and the genus *Minuca and Leptuca* predominated in the sampling points that suffer higher sea influence (Table 2 and Figure 5).

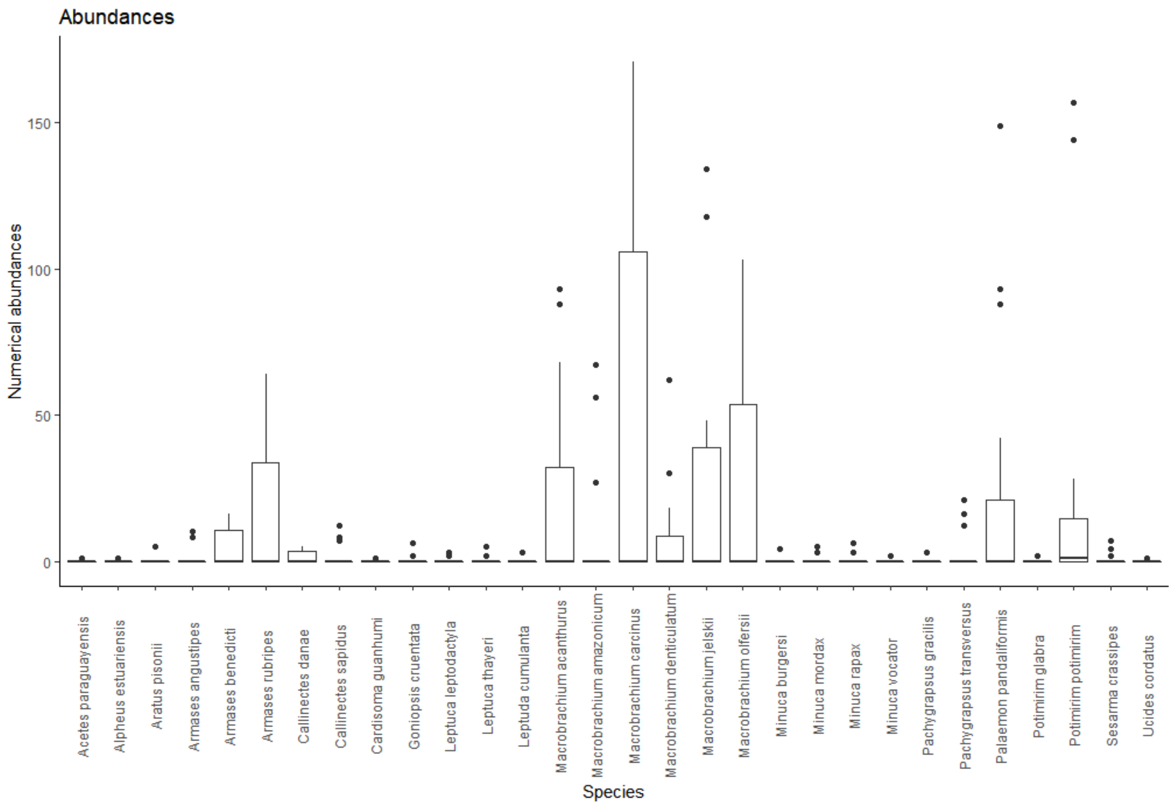

FIGURE 5. Numerical abundances for each collected specie in the Lower São Francisco river.

The ANOVA test rejected the null hypothesis, confirming that the species composition is significantly different throughout the river (F = 222.6, $p < 0.0001$) (Figure 5) and the Tukey HSD test determined which pairs of sampling sites are different. The table 3 shows results of multiple comparisons.

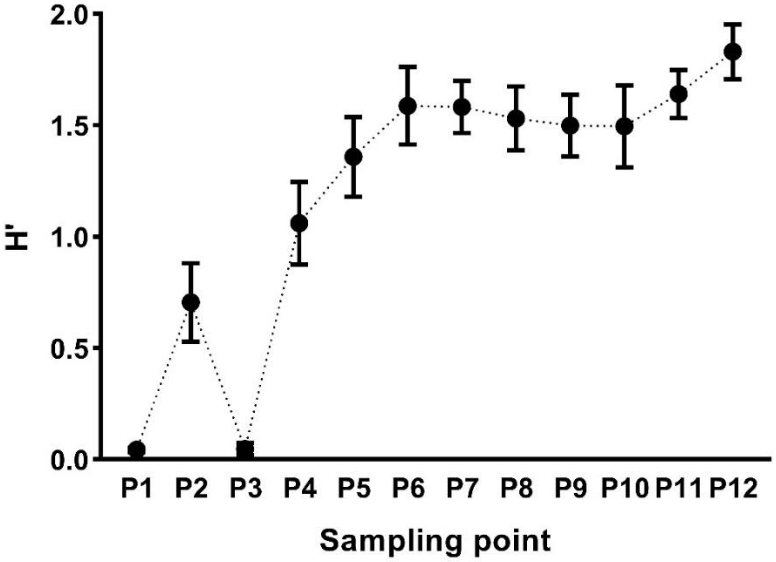

FIGURE 6. Shannon diversity index for each sampling site

Table 3. Results of Tukey HSD test for multiple comparisons of diversity between each sampling points

Tukey's HSD test	Mean Diff.	95.00% CI of diff.	Summary	Adjusted P Value
P1 vs. P2	-0.6613	-0.8545 to -0.4680	****	<0.0001
P1 vs. P3	-0.002917	-0.1962 to 0.1904	ns	>0.9999
P1 vs. P4	-1.017	-1.210 to -0.8238	****	<0.0001
P1 vs. P5	-1.315	-1.508 to -1.121	****	<0.0001
P1 vs. P6	-1.545	-1.738 to -1.351	****	<0.0001
P1 vs. P7	-1.539	-1.732 to -1.345	****	<0.0001
P1 vs. P8	-1.487	-1.680 to -1.294	****	<0.0001
P1 vs. P9	-1.455	-1.649 to -1.262	****	<0.0001
P1 vs. P10	-1.451	-1.645 to -1.258	****	<0.0001
P1 vs. P11	-1.597	-1.790 to -1.404	****	<0.0001
P1 vs. P12	-1.786	-1.980 to -1.593	****	<0.0001
P2 vs. P3	0.6583	0.4651 to 0.8516	****	<0.0001
P2 vs. P4	-0.3558	-0.5491 to -0.1626	****	<0.0001
P2 vs. P5	-0.6533	-0.8466 to -0.4601	****	<0.0001
P2 vs. P6	-0.8833	-1.077 to -0.6901	****	<0.0001
P2 vs. P7	-0.8775	-1.071 to -0.6842	****	<0.0001
P2 vs. P8	-0.8258	-1.019 to -0.6326	****	<0.0001
P2 vs. P9	-0.7942	-0.9874 to -0.6009	****	<0.0001
P2 vs. P10	-0.7900	-0.9833 to -0.5967	****	<0.0001

P2 vs. P11	-0.9358	-1.129 to -0.7426	****	<0.0001
P2 vs. P12	-1.125	-1.318 to -0.9317	****	<0.0001
P3 vs. P4	-1.014	-1.207 to -0.8209	****	<0.0001
P3 vs. P5	-1.312	-1.505 to -1.118	****	<0.0001
P3 vs. P6	-1.542	-1.735 to -1.348	****	<0.0001
P3 vs. P7	-1.536	-1.729 to -1.343	****	<0.0001
P3 vs. P8	-1.484	-1.677 to -1.291	****	<0.0001
P3 vs. P9	-1.453	-1.646 to -1.259	****	<0.0001
P3 vs. P10	-1.448	-1.642 to -1.255	****	<0.0001
P3 vs. P11	-1.594	-1.787 to -1.401	****	<0.0001
P3 vs. P12	-1.783	-1.977 to -1.590	****	<0.0001
P4 vs. P5	-0.2975	-0.4908 to -0.1042	****	<0.0001
P4 vs. P6	-0.5275	-0.7208 to -0.3342	****	<0.0001
P4 vs. P7	-0.5217	-0.7149 to -0.3284	****	<0.0001
P4 vs. P8	-0.4700	-0.6633 to -0.2767	****	<0.0001
P4 vs. P9	-0.4383	-0.6316 to -0.2451	****	<0.0001
P4 vs. P10	-0.4342	-0.6274 to -0.2409	****	<0.0001
P4 vs. P11	-0.5800	-0.7733 to -0.3867	****	<0.0001
P4 vs. P12	-0.7692	-0.9624 to -0.5759	****	<0.0001
P5 vs. P6	-0.2300	-0.4233 to -0.03673	**	0.0066
P5 vs. P7	-0.2242	-0.4174 to -0.03089	**	0.0093
P5 vs. P8	-0.1725	-0.3658 to 0.02077	ns	0.1296
P5 vs. P9	-0.1408	-0.3341 to 0.05244	ns	0.3972
P5 vs. P10	-0.1367	-0.3299 to 0.05661	ns	0.4453
P5 vs. P11	-0.2825	-0.4758 to -0.08923	***	0.0002
P5 vs. P12	-0.4717	-0.6649 to -0.2784	****	<0.0001
P6 vs. P7	0.005833	-0.1874 to 0.1991	ns	>0.9999
P6 vs. P8	0.05750	-0.1358 to 0.2508	ns	0.9977
P6 vs. P9	0.08917	-0.1041 to 0.2824	ns	0.9279
P6 vs. P10	0.09333	-0.09994 to 0.2866	ns	0.9036
P6 vs. P11	-0.05250	-0.2458 to 0.1408	ns	0.9990
P6 vs. P12	-0.2417	-0.4349 to -0.04839	**	0.0032
P7 vs. P8	0.05167	-0.1416 to 0.2449	ns	0.9991
P7 vs. P9	0.08333	-0.1099 to 0.2766	ns	0.9544
P7 vs. P10	0.08750	-0.1058 to 0.2808	ns	0.9363

P7 vs. P11	-0.05833	-0.2516 to 0.1349	ns	0.9974
P7 vs. P12	-0.2475	-0.4408 to -0.05423	**	0.0022
P8 vs. P9	0.03167	-0.1616 to 0.2249	ns	>0.9999
P8 vs. P10	0.03583	-0.1574 to 0.2291	ns	>0.9999
P8 vs. P11	-0.1100	-0.3033 to 0.08327	ns	0.7609
P8 vs. P12	-0.2992	-0.4924 to -0.1059	****	<0.0001
P9 vs. P10	0.004167	-0.1891 to 0.1974	ns	>0.9999
P9 vs. P11	-0.1417	-0.3349 to 0.05161	ns	0.3879
P9 vs. P12	-0.3308	-0.5241 to -0.1376	****	<0.0001
P10 vs. P11	-0.1458	-0.3391 to 0.04744	ns	0.3427
P10 vs. P12	-0.3350	-0.5283 to -0.1417	****	<0.0001
P11 vs. P12	-0.1892	-0.3824 to 0.004107	ns	0.0611

DISCUSSION

Temperature and salinity are key factors in influencing decapod crustacean's metabolism, survival/mortality rate and migration patterns, being important to emphasize that specific species have their own response to each parameter (Staples & Heales, 1991; Kir & Kumlu, 2008). Abiotic factors like salinity and depth of the sampled areas seem to interact with the fauna and affect the distribution of the macrocrustaceans. Barros *et al.* (2004) concluded that depth was crucial in determining average density, diversity and spatial distribution of galatheid crabs in the Beagle Channel, Shouthern Argentina and Normam & Jones (1992) that this same abiotic factor is a key in determining the diet in a swimming crab of the genus *Callinectes*. That environmental parameters either seem to influence distribution and many ecological aspects in other groups of animals, like molluscs, zooplankton and ectoparasites (Johnson, & Smee, 2014; Groner *et* al., 2016; Picapedra *et al.*, 2019), allowing the authors to use it to explain the conpartmentalization in the ecosystem.

Macrobrachium carcinus was highly present in sites not influenced by the ocean and juvenile shrimps were found in higher salinities, probably due to the larvae release in estuaries. Lima *et al.* (2014) studied its feeding habits and concluded that this prawn is omnivore, but also presents a great carnivore component. It can be suggested that this specie highly influences the trophic structure of the community. The species *Macrobrachium amazonicum, Macrobrachium jelskii, Macrobrachium carcinus, Macrobrachium acanthurus, Macrobrachium denticulatum* and *Macrobrachium olfersii* demonstrated to be sympatric.

The palemonid *Palaemon pandaliformis* was encountered in higher abundance at sampling sites located closer to the estuary. Is known that many species that belong to the genus *Palaemon* can explore a wide range of environments, like freshwater, brackish and marine conditions (De Grave *et al.,* 2008), because of the support for a wide salinity range (Paschoal *et al.*, 2016). The species *Potimirim potimirim* and *Potimirim glabra* was sampled by Lima & Oshiro (2002) in the Sahy river, municipality of Mangaratiba, Rio de Janeiro, who verified occurence of environmental partition. In this study, *P. potimirim* showed a bigger distribution area when compared to *P. glabra.* Was also stated that these organisms prefer slow streams.

Callinectes danae and *Callinectes sapidus* were sampled at the sites 10, 11 and 12. The *Callinectes* genus is and important fishery resource for the communities that live alongside the coasts, supporting locals that rely exclusively on commercialization of these crabs (Barreto *et al.*, 2006). The specie *C. sapidus* has its occurrence in the Estuário de Cananéia, Iguape and Ilha Comprida, São Paulo, where a study about fishery management was released by Mendonça *et al.* (2010).

The Sesarmidae family is constantly present in estuaries. The specie *Armases rubripes* was also sampled at the estuarine region of the Río de la Plata, Uruguai, by Luppi (2003). *Pachygrapsus transversus* is a common specie in the intertidal zones and marine rocky environments (Flores & Fransozo, 1999).

The Ocypodidae family, represented by the species *Leptuca leptodactyla*, *Minuca burgergi*, *Minuca mordax* and *Minuca rapax*, was registered near the estuary. This family is common in coastal zones with estuarine characteristics (Crane, 1975).

Goniopsis cruentata, either found next to the estuary, is a resource for low scale commerce and subsistence. Maciel & Alves (2009), discussed about its specie importance as nutrients and money source to the population living near the river in Barra de Sirinhaém, in the Pernambuco state, a pattern that can be also observed in the lower São Francisco.

The less representative families were Panopeidae, Alpheidae and Sergestidae, whose were composed in this study by only one specie each. Crustaceans comprised by the Panopeidae family, represented in this study by *Panopeus lacustris*, are common in intertidal environments, non-consolidated substrata and estuaries (Schubart *et al.*, 2000). The Alpheidae family, having the shrimp *Alpheus estuariensis* as representant has occurrence registered in shallow waters in marine coast areas (Anker *et al.*, 2006). It is possible to explain its low abundance in the estuarine region by the low familiarity of this organisms with the habitat cited. The Sergestidae family registered only the taxon *Acetes paraguayensis* in the present study. The *Acetes* genus usually habits estuarine and coastal environments at the tropical, subtropical and temperate regions (Xiao & Greenwood, 1993), corroborating with the occurrence near the river mouth.

This work contributed to the knowledge of the crustacean taxonomic composition of the lower São Francisco River. It may help to subside studies regarding on species distribution and life story traits of the present taxa. It was clear that the fauna is compartmentalized throughout the river. This might be a result of interspecific competition, differences in habitat use and response to abiotic factors.

REFERENCES

ALMEIDA, A.O., COELHO, P.A., LUZ, J.R., ALMEIDA. J.T.; NEYVA, R.F. Decapod crustaceans in fresh waters of shouteastern Bahia, Brazil. **Revista de Biologia Tropical (online)**, 2008, 56 (3)1225-1254

ANKER, A., AHYONG, S.T.; NOËL, P.Y.; PALMER, A.R. Morphological phylogeny of alpheid shrimps: parallel preadaptation and the origin of a key morphological innovation, the snapping claw. **Evolution**, 2006, 60: 2507-2528.

BARRETO, A.V., BATISTA-LEITE, L.M.A.; AGUIAR, M.C.A. Maturidade sexual das fêmeas de Callinectes danae (Crustacea, Decapoda, Portunidae) nos estuários dos rios Botafogo e Carrapicho, Itamaracá, PE, Brasil. **Iheringia. Série Zoologia**, 2006.

BARROS, P.P., TAPELLA, F., ROMERO, M. C., CALAGNO, J.A.; LOVRICH, G.A. Benthic decapod crustaceans associated with captures of Munida spp.(Decapoda: Anomura) in the Beagle Channel, Argentina. **Scientia Marina**, 2004, 68(2), 237-246.

BRANCO, L.H.Z.; NECCHI JR., O. Variação longitudinal de parâmetros físicos e químicos em três rios pertencentes a diferentes bacias de drenagem na região noroeste do Estado de São Paulo. **Acta Limnologica Brasiliensia**, 1997, 9, 165-177.

CRANE, J. Fiddler crabs of the world:Ocypodidae: genus Uca. **Princeton Univ Press**, 1975, Princeton, NJ.

DE GRAVE, S., CAI, Y.; ANKER, A. Global diversity of shrimps (Crustacea: Decapoda: Caridea) in freshwater. **Hydrobiologia**, 2008, 595.1: 287-293.

DE MELO, G.A.S. **Manual de identificação dos Crustacea Decapoda de água doce do Brasil**. Edições Loyola, 2003.

FLORES, A.A.; NEGREIROS-FRANSOZO, M.L. On the population biology of the mottled shore crab Pachygrapsus transversus (Gibbes, 1850)(Brachyura, Grapsidae) in a subtropical area. **Bulletin of Marine Science**, 1999, 65(1), 59-73.

GRONER, M.L., MCEWAN, G.F., REES, E.E., GETTINBY, G.; REVIE, C.W. Quantifying the influence of salinity and temperature on the population dynamics of a marine ectoparasite. **Canadian journal of fisheries and aquatic sciences**, 2016, 73.8: 1281-1291.

JOHNSON, K.D.; MEE, D.L. Predators influence the tidal distribution of oysters (Crassostrea virginica). **Marine biology**, 2014, 161.7: 1557-1564.

KIR, M.; KUMLU, M. Effect of temperature and salinity on low thermal tolerance of Penaeus semisulcatus (Decapoda: Penaeidae). **Aquaculture Research**, 2008, 39(10), 1101-1106.

LIMA, J.F., GARCIA, J. S.; SILVA, T.C. Natural diet and feeding habits of a freshwater prawn (Macrobrachium carcinus: Crustacea, Decapoda) in the estuary of the Amazon River. **Acta Amazonica**, 2014, 44.2: 235-244.

LIMA, G.V.; OSHIRO, L.M.Y. Partição ambiental de Potimirim glabra (Kingsley) e Potimirim potimirim (Müller) (Crustacea, Decapoda, Atyidae) no rio Sahy, Mangaratiba, Rio de Janeiro, Brasil. **Rev. bras. Zool**, 2002, 19 (Supl. 2): 175-179

LUPPI, T.A., SPIVAK, E.D.; BAS, C.C. The effects of temperature and salinity on larval development of Armases rubripes Rathbun, 1897 (Brachyura, Grapsoidea, Sesarmidae), and the southern limit of its geographical distribution**. Estuarine, Coastal and Shelf Science**, 2003, 58(3), 575-585.

MACIEL, D.C.; GIUSEPPE CHAVES ALVES, Â. Conhecimentos e práticas locais relacionados ao aratu Goniopsis cruentata (Latreille, 1803) em Barra de Sirinhaém, litoral sul de Pernambuco, Brasil. **Biota Neotropica**, 2009, 9(4).

MENDONÇA, J.T., VERANI, J.R.; NORDI, N. Evaluation and management of blue crab Callinectes sapidus (Rathbun, 1896)(Decapoda-Portunidae) fishery in the Estuary of Cananéia, Iguape and Ilha Comprida, São Paulo, Brazil. **Brazilian Journal of Biology**, 2010, 70(1), 37-45.

NORMAN, C.P.; JONES, M.B. Influence of depth, season and moult stage on the diet of the velvet swimming crab Necora puber (Brachyura, Portunidae). **Estuarine, Coastal and Shelf Science**, 1992, 34.1: 71-83.

OKNANSEN J, BLANCHET, F.G, KINDT R, LEGENDRE P, MINCHIN, PR, O'HARA, RB, SIMSPSON, GL, SOLYMOS, P, STEVENS, M.H.; WAGNER, H. **Vegan: community ecology package**. 2015. R package version. 2015 Jan;2(10).

OLDEN, J.D.; POFF, N.L. Ecological processes driving biotic homogenization: testing a mechanistic model using fish faunas. **Ecology**, 2004, 85.7: 1867-1875.

PASCHOAL, L.R.P, GUIMARÃES, F.J.; COUTO, E.C.G. Growth and reproductive biology of the amphidromous shrimp Palaemon pandaliformis (Decapoda: Caridea) in a Neotropical river from northeastern Brazil. **Zoologia (Curitiba)**, 2016, 33.6.

PICAPEDRA, P.H.S, FERNANDES, C.; BAUMGARTNER, G. Structure and ecological aspects of zooplankton (Testate amoebae, Rotifera, Cladocera and Copepoda) in highland streams in southern Brazil. **Acta Limnologica Brasiliensia**, 2019, 31.

R CORE TEAM. 2017. **R: A language and environment for statistical computing. R Foundation for Statistical Computing**. Vienna, 2017, Austria.

SAMPAIO, S.R., NAGATA, J.K., LOPES, O.L.; MASUNARI, S. Camarões de águas continentais (Crustacea, Caridea) da Bacia do Atlântico oriental paranaense, com chave de identificação tabular. **Acta Biológica Paranaense**, 2009, 38.

SATO, Y.; GODINHO, H.P. Peixes da bacia do rio São Francisco. Estudos ecológicos de comunidades de peixes tropicais. **São Paulo: Edusp**, 1999, 401-413

SCHUBART, C.D., NEIGEL, J.E.; FELDER, D.L. Molecular phylogeny of mud crabs (Brachyura: Panopeidae) from the northwestern Atlantic and the role of morphological stasis and convergence. **Marine Biology**, 2000, 137(1), 11-18.

STAPLES, D.J.; HEALES, D.S. Temperature and salinity optima for growth and survival of juvenile banana prawns Penaeus merguiensis. **Journal of Experimental Marine Biology and Ecology**, 1991, 154(2), 251-274.

XIAO, Y.; GREENWOOD, J.G. The biology of Acetes (Crustacea; Sergestidae). **Oceanography and Marine Biology: An Annual Review**, 1993, 31, 259-444.