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Diversity of a Teleoste Fish Assembly in a Mangrove, São Luís Island, Maranhão, Brazil

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Abstract: This study addressed aspects of the fish community present in a mangrove, on the island of São Luís, Maranhão, Brazil; covering composition and diversity. Species diversity analysis was based on the Simpson Index (D), because it gives greater weight to common species and the Shannon Index (H '), because it gives greater weight to rare species. For species richness analysis, which is a measure of diversity importance, the Margalef index was chosen. Regarding uniformity, or evenness, in the distribution of individuals among species, which corresponds to the maximum possible diversity for a given number of individuals N in the total of existing species; when the N individuals are distributed as evenly as possible among the *s* species, the Simpson Equitability and Shannon Equitability indices were used. Sampling was monthly for 16 months. The fishing tackle used was a gillnet fishing. 10.824 individuals were collected, including 63 species in 27 families. Margalef's wealth index ranged from 4.48 to 9.80; Simpson diversity between 0.63 to 0.87; Shannon diversity between 1.52 to 2.45; Simpson equitability between 0.66 to 0.91 and Shannon equitability between 2.20 to 3.50. Through the application of nonparametric Mann-Whitney test there was no significant difference between these indices in the dry and rainy seasons. The diversity observed in Raposa mangroves should not only be attributed to the nutrient input that is normally higher in mangroves, because this does not mean direct influence on diversity or richness, but on biomass. Probably this fact occurred due to the foraging behavior of the ichthyofauna, both species that seek food in the bottom substrate and those that feed on organisms that are in the water column. Then the difference may be in the availability of resources of this environment, also including protection from predators.

Key words: community, richness, ichthyofauna, equitability, seasonality

1. Introduction

Mangrove is a complex tropical coastal system [1], dominated by typical plant species, where fauna and flora components adapted to a periodically flooded environment with large salinity [2].

Mangroves are well-defined marginal ecosystems in space, with boundaries marked by tidal levels, because the species of animals and plants that integrate them are all survivors of tolerance limits to extreme environmental conditions; unlike other marginal ecosystems, it is a highly dynamic ecosystem, very productive and capable of immobilizing salts and heavy metals [3]. Mangroves also provide goods and services to tropical populations around the world, and their occurrence favors high fishery productivity [4]; currently have been identified as good indicators for detecting and monitoring sea level changes [5].

Mangroves provide a natural refuge for young individuals against predators due to the protection provided by their trees. Most fish and crustaceans caught in tropical coastal areas enjoy this protection during the young phase and in the laying season, and thus closely depend on the integrity of the ecosystem. The author emphasizes that the importance of mangroves is not only as a nursery, but also as an

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exporter of organic matter and generator of primary natural resources for local populations [6].

There are few species of exclusive mangrove animals [7]. Its fauna is typically opportunistic and wide distribution. Organisms have their rhythms related to tidal variation [1]. Much of the mangrove ichthyofauna also occurs in other coastal systems such as lagoons and estuaries; are marine species that pass part of their life cycle in the mangroves [8]. Many of the food chains in shallow estuaries are not based on phytoplankton, but on mangrove, benthic algae, and epiphyte debris [9]. Ichthyofauna penetrate the estuary, mainly as juveniles, remaining until a certain period of development [10-13]. In fact, estuaries are migratory routes to catadromous and anadromous species [14].

This study aims to identify the composition and diversity of teleost fish assemblage in a mangrove of the island of São Luís, Maranhão, Brazil

2. Material and Methods

2.1 Study Area

The study area is located in the northeastern part of the island of São Luís, municipality of Raposa (02°25'22"S and 44°05'21"W), comprising a set of tidal channels, flooded during the prewater. It is characterized by low relief and a dominant mangrove flora (Fig. 1).

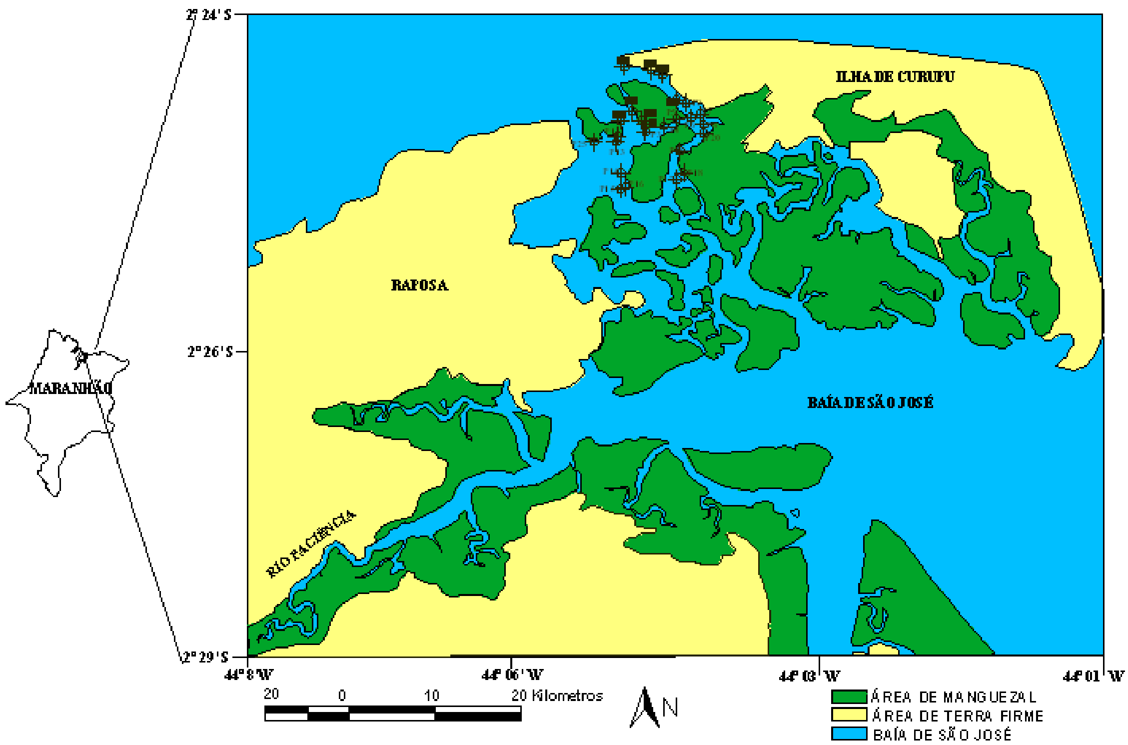

Fig. 1 Map of the State of Maranhão (Brazil) showing the municipality of Raposa.

2.2 Sampling

The sampling of the ichthyofauna for this study comprised monthly collections conducted between August 1999 and November 2000. The fishing tackle used was igarapé net, also called "capping net" or gillnet fishing.

The fish caught for this study were placed in the field in labeled plastic bags, placed in ice-cold Styrofoam boxes and transported to the laboratory, where identification was made based on the literature [15-19].

2.3 Analysis of the Composition and Diversity of Fish Assemblage

For the analysis of species diversity, the Simpson Index (D) was chosen because it gives greater weight to common species and the Shannon Index (H') because it gives greater weight to rare species [20, 21].

Simpson Index (D)

$D = 1 - \Sigma pi^2$, where:

D - Simpson diversity;

pi - proportion of the total number of individuals corresponding to species *i*;

Shannon Index (H')

$H' = -\Sigma\, pi \,\text{Ln}\, pi$, where:

ni - number of individuals of species i in the sample;

$pi = ni/N$

pi - proportion of the total number of individuals corresponding to species i;

N - total number of individuals in the sample.

For analysis of species richness that constitutes a measure of diversity importance [22].

$d = s - 1 / \log N$, where:

d - wealth;

s - number of species;

N - number of individuals

For analysis of the uniformity or equitability component in the distribution of individuals among species, which corresponds to the maximum possible diversity for a given number of individuals N in the total of existing species; when the N individuals are distributed as evenly as possible among the species, that is, when each $ni = N/s$ [23].

Simpson equitability.

$Es = D / D_{max}$ where:

Es = Equitability.

D_{max} = maximum diversity;

$D_{max} = (s - 1 / s)\ (N / N - 1)$, where:

s = number of species;

N = number of individuals in the sample;

Shannon equitability.

H'max = maximum diversity;

H'max = log s where:

s = number of species

To verify the presence of differences between the indices computed for each sample and seasonality, the Mann-Whitney test was used [24].

3. Results and Discussion

3.1 Composition of the Fish Assemblage in Raposa Mangrove, São Luís Island

10 824 individuals were collected, including 63 species in 27 families. Table 1 shows the list of fish collected from the Raposa mangrove. Order and family names follow the order proposed by Nelson [25].

Table 1 List of teleost fish species that occur in the Raposa mangrove, São Luís island.

Ordem Clupeiformes
Família Clupeidae
Odontognathus sp.
Família Engraulidae
Anchoa sp.
Cetengraulis edentulus (Cuvier, 1928)
Pterengraulis atherinoides (Linnaeus, 1766)
Ordem Elopiformes
Família *Elopidae*
Elops saurus Linnaeus, 1766
Ordem Anguilliformes
Família Muraenidae
Gymnothorax funebris Ranzani, 1839
Família Ophichthidae
Ophichthus parilis (Richardson, 1844)
Ordem Siluriformes
Família Ariidae
Sciades herzbergii (Bloch, 1794)
Arius sp.
Cathorops spixii (Agassiz, 1829)
Cathorops sp.
Família Auchenipteridae
Pseudauchenipterus nodosus (Bloch, 1794)
Ordem Batrachoidiformes
Família Batrachoididae
Batrachoides surinamensis (Bloch & Schneider, 1801)
Thalassophryne nattereri Steindachner, 1876.
Ordem Beloniformes
Família Belonidae
Strongylura marina (Walbaum, 1792)
Ordem Atheriniformes
Família Atherinopsidae
Atherinella brasiliense (Quoy & Gaimard, 1825)
Ordem Cyprinodontiformes
Família Anablepidae
Anableps anableps (Linnaeus, 1758)
Ordem Perciformes
Família Centropomidae
Centropomus parallelus Poey, 1860
Centropomus undecimalis (Block, 1792)
Família Serranidae
Epinephelus itajara (Lichtenstein, 1822).

Rypticus randalli Courtenay, 1967
Família Carangidae
Caranx latus Agassiz, 1831
Caranx sp. "Xareuzinho"
Oligoplites palometa (Cuvier, 1832) "Tibiro"
Oligoplites saurus (Bloch & Schneider, 1801) "Tibiro"
Selene vomer (Linnaeus, 1758) "Peixe galo"
Trachinotus carolinus (Linnaeus, 1766) "Pampo
Família Lutjanidae
Lutjanus buccanella (Cuvier, 1828)
Lutjanus jocu (Bloch & Schneider, 1801) "Carapitanga"
Lutjanus synagris (Linnaeus, 1758) "Carapitinga"
Família Lobotidae
Lobotes surinamensis (Bloch, 1790)
Família Gerreidae
Diapterus auratus Ranzani, 1842
Diapterus rhombeus (Cuvier, 1829)
Eucinostomus argenteus Baird & Girard, 1855
Eugerres sp.
Família Haemulidae
Conodon nobilis (Linnaeus, 1758)
Genyatremus luteus (Bloch, 1790)
Orthopristis ruber (Cuvier, 1830)
Pomadasys corvinaeformis (Steindachner, 1868).
Família Sciaenidae
Cynoscion acoupa (Lacepède, 1801)
Cynoscion leiarchus (Cuvier, 1830)
Cynoscion sp.
Isopisthus parvipinnis (Cuvier, 1830)
Macrodon ancylodon (Bloch & Schneider, 1801)
Micropogonias furnieri (Desmarest, 1823)
Bairdiella ronchus (Cuvier, 1830)
Stellifer naso (Jordan, 1889)
Stellifer sp.
Nebris microps Cuvier 1830
Família Ephippidae
Chaetodipterus faber (Broussonet, 1782)
Família Mugilidae
Mugil curema Valenciennes, 1836
Mugil gaimardianus Desmarest, 1831
Mugil incilis Hancock, 1830
Família Polynemidae
Polydactylus oligodon (Günther, 1860)
Família Trichiuridae
Trichiurus lepturus Linnaeus, 1758
Ordem Pleuronectiformes
Família Paralichthyidae
Paralichthys sp.
Citharichthys sp.
Família Achiridae
Achirus sp.
Trinectes sp.
Famíla Cynoglossidae
Symphurus diomedeanus (Goode&Bean,1885)
Ordem Tetraodontiformes
Família Tetraodontidae
Colomesus psittacus (Bloch & Schneider, 1801).
Lagocephalus sp.
Sphoeroides testudineus (Linnaeus, 1758).

Other studies performed on the island of São Luís have obtained the following results: 132 species belonging to 56 families in five different locations of estuarine areas of São Luís Island during almost 50 months of sampling [26]; 34 species belonging to 22 families in four locations along the Tibiri River estuary, south of São Luís Island, during 12 months of sampling corresponding to 40 samples [27]; 75 species belonging to 33 families during 12 months of sampling corresponding to 33 samples [28]; 43 species belonging to 23 families bimonthly catch from march 2002 to may 2002 [29].

3.2 Diversity of the Fish Assemblage in Raposa Mangrove, São Luís Island

Table 2 shows the monthly values of Margalef richness indices, Simpson diversity (D), Shannon diversity (H'), Simpson equitability (Es) and Shannon equitability (Es').

By applying the non-parametric Mann-Whitney test, there was no significant difference between the levels of richness Margalef, Simpson diversity, diversity Shannon, Simpson equitability and Shannon equitability when comparing the wet and dry seasons.

Fig. 2 shows the pattern of coincidence between Simpson's diversity and uniformity during all months of collection, and Fig. 3 shows the pattern of coincidence between Shannon's diversity and uniformity indices.

In estuaries on the island of São Luís, using the Simpson diversity index, comments that the highest values were observed in January and February, showing a sharp decline in april and june [28], while other authors observed that diversity values showed little variability between sites, which would indicate, according to these authors, a homogeneous distribution in the Anil River estuary and that the most expressive indices were in the months of may and january [29]. And in the Tibiri River estuary, they found that Shannon Wiever's specific diversity index was 1.33 in the rainy season and 1.74 in the dry season [27].

Table 2 Monthly values of Margalef's wealth indices (d), Simpson's diversity (D), Shannon's diversity (H'), Simpson's equitability (Es) and Shannon's equitability (Es').

Meses	d	D	H'	Es	Es'
Ago/99	5,14	0,64	1,61	0,69	2,77
Sep/99	7,58	0,83	2,15	0,88	2,30
Oct/99	4,48	0,69	1,52	0,78	2,20
Nov/99	8,35	0,84	2,34	0,89	3,04
Dec/99	7,26	0,87	2,07	0,83	3,04
Jan/00	9,80	0,73	2,45	0,90	3,50
Feb/00	6,32	0,69	1,64	0,72	2,94
Mar/00	8,97	0,87	2,43	0,91	3,04
Abr/00	6,43	0,65	1,68	0,70	2,70
May/00	7,74	0,63	1,76	0,67	3,04
June/00	8,21	0,67	1,89	0,71	3,14
July/00	7,76	0,70	1,90	0,74	3,14
Ago/00	8,65	0,75	1,85	0,77	3,33
Sep/00	7,52	0,82	2,19	0,86	3,09
Oct/00	6,30	0,83	2,04	0,87	3,00
Nov/00	7,64	0,70	1,67	0,73	3,22

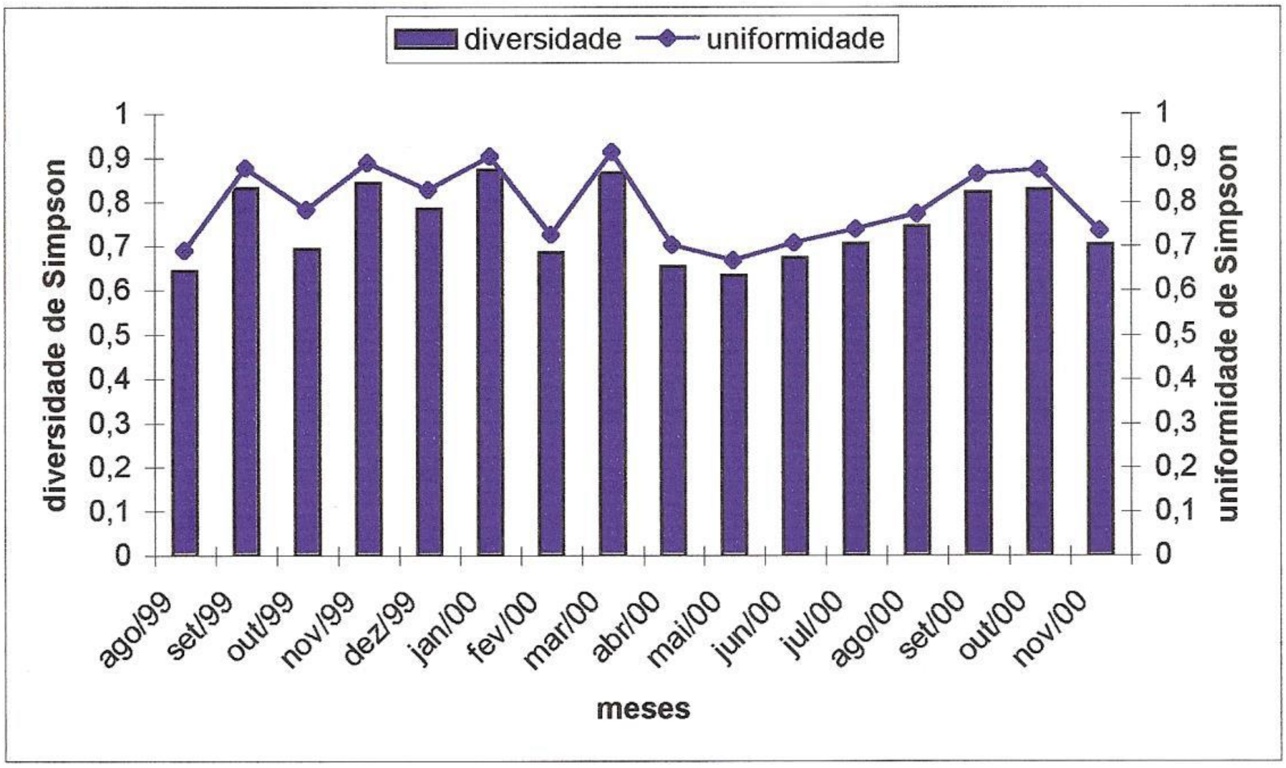

Fig. 2 Monthly values of Simpson diversity and uniformity during the collection period in the Raposa Mangrove.

In the present study, the amount of Margalef richness index ranged from 4.48 to 9.80; Simpson diversity between 0.63 to 0.87; Shannon diversity between 1.52 to 2.45; Simpson equitability between 0.66 to 0.91 and Shannon equitability between 2, 20 to 3.50.

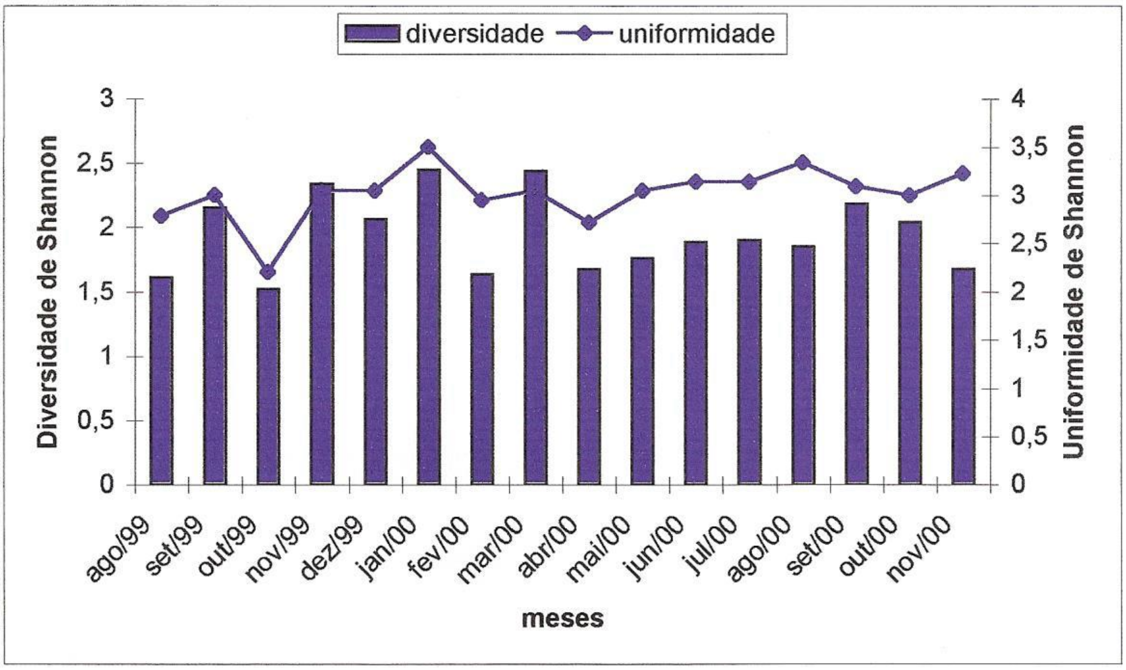

Fig. 3 Monthly values of Shannon diversity and uniformity during the collection period in the Raposa mangrove.

In a mangrove area on the west coast of Costa Rica, the Shanon index ranged from 2.39 to 3.18 [30]. These results are relevant because, besides the similarity of this system, the authors also used the same fishing net used in the Raposa mangrove. Moreover, as in the present study, they did not find any seasonal relationship between the diversity indices.

Another study carried out in the Caribbean involving mangrove habitats [31] also did not observe the existence of a seasonal relationship regarding diversity indexes. As for the richness indices, these were higher in the mangrove. The unifomity index showed a lack of dominance in the community. This fact also occurred in the Raposa mangrove, when it was observed that the uniformity indices were always high and coincided with the diversity indices.

The seasonality pattern in relation to the number of individuals was observed in Baguaçu gamboa [32]; on the Sucuriu gamboa [33] and on a tidal plain also in Paraná [34].

The monthly variation of the richness, diversity and uniformity indices showed no seasonal trend in relation to the dry and rainy seasons in the Mangrove Raposa fish fauna. In a shallow infralittoral of a beach, they also observed no seasonal trend in the richness, diversity and evenness índices [35].

4. Conclusion

Studies show that in Mangue da Raposa there was no relationship between species presence and seasonality. And the fact that certain species only occur in the dry or rainy season is related to their reproductive dynamics, as well as the different role that this environment offers, as a refuge, feeding site, both seasonally and in the daily cycle due to tidal rhythms.

In general, the subequatorial ichthyofauna present in the estuaries of São Luís Island has a high species richness and diversity, which can be attributed to its latitudinais location.

By comparing the results obtained in Mangue da Raposa and those obtained in other estuarine areas of Golfão Maranhense, one can attribute greater richness and diversity to Mangue da Raposa, considering that 63 species belonging to 27 families were obtained in a smaller area. than 4 Km^2 during 16 months of collection, corresponding to 16 samples. This fact should not be attributed only to the nutrient input that is usually higher in mangroves, but this does not mean direct influence on diversity or richness, but on biomass. Probably this fact occurred due to the foraging behavior of the ichthyofauna, both species that seek food in the bottom substrate and those that feed on organisms that are in the water column. Then the difference may be in the availability of resources of this environment, also including protection from predators.

References

[1] Y. Schaeffer-Novelli and G. Cintrón, *Guia para estudo de áreas de manguezal: Estrutura, Função e Flora*, São Paulo. Caribbean ecologica! Research, 1986, p. 150.

[2] S. Watanabe, *Glossário de ecologia*, São Paulo, Academia de Ciências do Estado de São Paulo, 1987, p. 271.

[3] M. Vannucci, What is só special about rnangroves? *Brazilian Journal of Biology* 61 (2001) (4) 99-603.

[4] M. Vannucci, The mangrove ecosystem: an overview of present knowledge, *Revista Brasileira de Biologia* 58 (1998) (1) 1-15.

[5] Y. Schaeffer-Novelli, G. Cintrón-Molero and M. L. G. Soares, Mangroves as indicators of sea levei change in the muddy coasts of the world, in: T. Healy, Y. Wing, J. A. Healy, *Muddy Coasts of the World: Processes, Deposits and Function*, Amsterdan, Elsevier Science, 2002, pp. 245-261.

[6] L. D. Lacerda, Manguezais florestas de beira-mar, *Ciência Hoje* 3 (1984) (13) 64-70.

[7] H. Luederwaldt, Os manguesaes de Santos, *Revista do Museu Paulista* 11 (1919) 309-408.

[8] L. D. Lacerda and Y. Schaeffer-Novelli, Mangroves of Latin America: The need for conservation and sustainable utilization, in: A. Yánez-Arancibia & A. L. Lara-Domingueez (Eds.), *Ecosistemas de manglar en América Tropical, Instituto de Ecologia*, A. C. México, UICN/NMFS Silver Spring MD USA, 1999, pp. 5-8.

[9] W. E. Odum and E. Helad, Trophic analices of an estuarino mangrove community, *Bulletin of Marine Science* 22 (1972) (3) 671-738.

[10] A. Yanez-Arancibia, F. Amezcua- Linares and J. W. Day, Fish community structure and function in Términos Lagoon, a tropical estuary in the Souther Gulf of México, in: Kennedy V. S. (Ed.), *Estuarine Perspectives*, New York, Publ. Academic Press, 1980, pp. 465-482.

[11] J. H. Day, S. J. M Blaber and J. H. Wallace, Estuarine fishes, in: Day J. H. (Ed.), *Estuarine Ecology with Particular Reference to Southern Africa*, Rotterdam, Balkena, 1981, pp. 197-221.

[12] L. N. Chao, L. E. Pereira, J. P. Vieira, M. A. Benvemuti and L. P. R. Cunha, Relação preliminar dos peixes estuarinos e marinhos da Lagoa dos Patos e região costeira adjacente, Rio Grande do Sul, Brasil, *Atlântica* 5 (1982) (1) 67-75.

[13] L. N. Chao, L. E. Pereira and J. P. Vieira, Estuarine fish community of the Patos Lagoon, Brazil: A baselirie study, in: A. Yanez-Aranciba (Ed.), *Fish Community Ecology in Estuaries And Coastal Lagoons: Towards An Ecosystem Integration*, México, UNAM Press, 1985, pp. 429-450.

[14] P. N. Claridge, I. C. Potter and M. W. Hardisty, Seasonal changes in movements, abundance, size composition and diversity of the fish fauna of the Severn Estuary, *Journal of Marine Biology and Association U.K.* 66 (1986) 229-258.

[15] J. L. Figueiredo and N. A. Menezes, Manual de peixes marinhos do sudeste do Brasil. III. Teleostei (2), São Paulo, Museu de Zoologia da Universidade de São Paulo, 1980.

[16] N. A. Menezes and J. L. Figueiredo, *Manual de peixes marinhos do sudeste do Brasil*, IV, Teleostei (3), São Paulo, Museu de Zoologia da Universidade de São Paulo, 1980, p. 96.

[17] N. A. Menezes and J. L. Figueiredo, *Manual de peixes marinhos do sudeste do Brasil*, V, Teleostei (4), São Paulo, Museu de Zoologia da Universidade de São Paulo, 1985, p. 105.

[18] J. L. Figueiredo and N. A. Menezes, *Manual de peixes marinhos do sudeste do Brasil*, VI, Teleostei (5), São Paulo, Museu de Zoologia da Universidade de São Paulo, 2000.

[19] W. Fischer (Ed.), *FAO Species Identification Sheets for Fishery Purposes*, Western Central Atlantic (Fishing Área 31), Rome, FAO, 1978, pp. 1-7.

[20] C. J. Krebs, *Ecological Methodology*, New York, Harper Colins Publishers, 1989.

[21] W. E. Odum, *Ecologia*, Rio de Janeiro. Ed. Guanabara, 1988, p. 434.

[22] A. E. Magurran, *Ecological Diversity and Its Measurement*, New Jersey, Princeton, 1988, p. 179.

[23] J. E. Brower, J. H Zar and C. N. Von Ende, *Field and Laboratory Methods for General Ecology* (4th ed.), WCB/McGraw-Hill, 1998.

[24] P. E. Vanzolini, *Métodos estatísticos elementares em sistemática zoológica*, São Paulo, Editora Hucitec, 1993, p. 130.

[25] J. S. Nelson, *Fishers of the World* (3rd ed.), Jonh Wiley & Sons, Inc. New York, 1994, p. 600.

[26] L. A. G. Martins-Juras, A. A. Juras and N. A. Menezes, Relação preliminar dos peixes da ilha de São Luis,

Revista Brasileira de Zoologia 4 (1987) (2) 105-113.

[27] V. S. Batista and F. N. Rego, Análise de associações de peixes, em igarapés do estuário do rio Tibiri, Maranhão, *Revista Brasileira de Biologia* 56 (1996) (1) 163-176.

[28] A. C. L. Castro, Diversidade da assembleia de peixes em igarapés do estuário do rio Paciência (MA-Brasil), Atlântica 23 (2001) 39-46.

[29] J. R Pinheiro Jr, A. C. L. Castro and L. N Gomes, Estrutura da comunidade de peixes do estuário do Rio Anil, Ilha de São Luís, Maranhão, *Arq. Cien. Mar.* 38 (2005) 29-37.

[30] J. R. Rojas, M. J. F. Pizarro and M. V. Castro, Diversidad y abundancia íctica em três áreas de manglar em el Golfo de Nicoya, *Costa Rica. Revista de Biologia Tropical*.42 (1994) (3) 663-672.

[31] G. Sedberry and J. Carter, The fish community of a Shallow Tropical Lagoon in Belize, Central America, *Estuaries* 6 (1993) (2) 98-215.

[32] A. L. Vendel, H. L. Spach, S. G. Lopes and C. Santos, Structure and dynamics of fish assemblages in a tidal creek environment, *Brazilian Archives of Biology and Technology* 45 (2002) (3) 365-373.

[33] H. L. Spach; C. Santos and R. S. Godefroid, Padrões temporais na assembléia de peixes na gamboa do Sucuriú, Baía de Paranaguá, Brasil, *Revista Brasileira de Zoologia* 20 (2003) (4) 591-600.

[34] H. L. Spach, C. Santos, R. S. Godefroid, M. Nardi and F. Cunha, A study of the fish community structure in a tidal creek, *Brazilian Journal of Biology* 64 (2004) (2) 337-351.

[35] R. S Godefroid, H. L. Spach, C. Santos, G. Maclaren and R. Schwarz Jr, Mudanças temporais na abundância e diversidade da fauna de peixes do infralitoral raso de uma praia, sul do Brasil, *Iheringia*, *Série Zoologia* 94 (2004) (1) 95-104.