PHYTOSOCIOLOGICAL CHARACTERISTICS AND ANTHROPOGENIC IMPACTS ON THE MANGROVE OF INTERMARES COASTAL LAGOON, NORTHEASTERN BRAZIL.

Rômulo Romeu da Nóbrega **ALVES** [1]
Roberto **SASSI** [2]

[1] Programa de Pós-Graduação em Ciências Biológicas (Zoologia), Departamento de Sistemática e Ecologia, Universidade Federal da Paraíba E-mail: romulo@dse.ufpb.br. Autor para correspondência.
[2] Universidade Federal da Paraíba, CCEN, Departamento de Sistemática e Ecologia, NEPREMAR

Características fitossociológicas e impactos antropogênicos no manguezal da laguna costeira de Intermares, nordeste do Brasil.

RESUMO

O sistema lagunar de Intermares (07º 02’ 52’’ e 07º 06’ 02’’ S e 34º 49’ 10’’ e 34º 51’ 34’’ W) foi estudado, visando caracterizar a estrutura e a composição do manguezal que o margeia e, ao mesmo tempo, caracterizar as principais interferências antrópicas na área. Os impactos antrópicos foram catalogados mediante a elaboração de uma matriz descritiva. Os estudos no manguezal foram conduzidos em 3 transecções, respectivamente localizadas próximo a desembocadura (T1, 800 m^2), na porção mediana do sistema lagunar (T2, 1000 m^2) e na porção superior (T3, 500 m^2), entre os meses de maio de 1996 e janeiro 1997. Amostras para a análise da composição florística foram obtidas tanto no manguezal como na zona de transição com a restinga. Foram identificadas 13 espécies vegetais na área estudada, 7 das quais no interior do manguezal, 3 na zona de transição e 3 comuns às duas áreas. *Rhizophora mangle* e *Laguncularia racemosa* foram as únicas espécies típicas de manguezais. A última predominou, quantitativamente. *Conocarpus erecta* também esteve presente na área, porém em baixas densidades. *Annona glabra*, *Dalbergia ecastophyllum*, *Sophora tomentosa* e *Acrostichum aureum* também foram encontradas no manguezal. As transecções T1 e T2 apresentaram os menores valores estruturais, em decorrência, principalmente, do elevado número de cortes (até 1576,2 cortes/0,1 ha e até 75 cortes/árvore em T1). A terceira transecção mostrou-se mais preservada, com menor número de cortes e valores estruturais mais expressivos. O DAP médio variou de 3,6 a 7,2 cm, a altura média de 2,9 a 7,3 m e a área basal de 5,7 a 14,08 m^2/ha. De modo geral, os valores para os parâmetros estruturais analisados foram baixos, possivelmente em decorrência dos vários impactos que atuam no ambiente. Entre eles, foram catalogados: cortes das árvores de mangue, acúmulo de lixo, ocupação humana em área de mangue, expansão urbana nas adjacências, além da presença de esgotos domésticos e alterações no regime hidrológico.

Palavras chave: Impactos antrópicos; Laguna Costeira; Manguezal; Nordeste do Brasil; Fitossociologia; Composição de Espécies.

ABSTRACT

Phytosociological characteristics and anthropogenic impacts on the mangrove of Intermares coastal lagoon, northeastern Brazil.

This study objective aimed to evaluate the structure of the mangrove forest and to provide a checklist of the main anthropogenic impacts at the Intermares lagunar system (lat 07º 02’ 52’’ and 07º 06’ 02’’ S, and long 34º 49’ 10’’E and 34º 51’ 34’’ W), Northeastern Brazil. Samplings were carried out from May 1996 to January 1997 in three transects perpendicular to the estuarine channel. The first measuring 10 x 80 m (T1, near the river mouth), the second measuring 10 x 100 m (T2, in the median part of the mangrove), and the third measuring 10 x 50 m (T3, in the upper part of the mangrove), with a total area of 0.23 ha. A total of 13 species of plants were recorded both in the mangrove area and in the transitional zone. *Rhizophora mangle* and *Laguncularia racemosa* were typical species of mangrove areas; the latter was dominant. Five associated species (*Annona glabra, Dalbergia ecastophyllum, Conocarpus erecta, Sophora tomentosa*, and *Acrostichum aureum*) were also present; *C. erecta* was found in low densities. Smallest values in mangrove structure were found in T1 and T2, a possibility due to the high number of tree cuts (up to 1576.2 cuts/0.1 ha and 75 cuts/tree in T1). T3 had the smallest number of cuts and the highest values for structural data, being the most preserved zone. Transection mean ranges were: Diameter at Breast Height (DBH) 3.6 to 7.2 cm; height, 2.9 to 7.3 m; and basal area, 5.7 to 14.08 $m^2.ha^{-1}$. These values are low and seem associated with the anthropogenic impacts identified, e.g. tree cuts, litter disposal, mangrove and supra-tidal zone invasions, waste and domestic sewage effluents, and reductions in the water input to the lagunar system.

Key words: Anthropogenic impacts, Coastal lagoon, Mangrove, Northeast Brazil, Phytosociology, Species composition.

INTRODUCTION

Despite the 1,010.000 ha of mangroves found along Brazil’s 6806 km coastal line (Herz 1991), studies dealing with the structural characteristics of these ecosystems remain scarce. Most studies related to this theme were conducted in a few specific mangroves of the Brazilian coast – particularly those associated with large estuaries – due to economical or social interest involved. Some examples are the studies carried out by Damásio (1980), in the State of Maranhão; Silveira (1993) and SEMACE (1994), in Ceará; Silva (1990) and Souza (1996), in Pernambuco; ADEMA (1984), in Sergipe; Soares (1999), in Rio de Janeiro; CETESB (1983, 1988) and Peria et al. (1990), in São Paulo; and Couto (1996), in Paraná.

Unfortunately, studies about mangroves associated with micro-estuaries have been neglected in Brazil either because of their low economic value or their atypical forests, commonly subjected to a degradation process due to coastal urban expansion. In general, these ephemeral estuaries have an obstructed characteristic impeding an efficient mangrove forest drainage. Consequently, the mangrove soil is more consistent and frequently covered by a dense layer of organic material. In addition, the presence of some arboreal and/or shrub-like species is common, unlike typical mangroves.

In Brazil micro-estuaries can be found in several Northeastern states exhibiting, eventually a well-structured mangrove forest. However, the use of their lagunar systems for recreational purposes and human invasions, frequently occurring along their drainage basins, cause environmental problems and interfer in their structural characteristics.

This study was designed to assess the mangrove forest characteristics at Intermares lagunar system in both floristic and structural terms, and to catalog the main human interferences in this ecosystem. The Intermares lagoon receives water from the Jaguaribe river's former bed, which constitutes the main drainage channel of the local coastal plain. It is frequently obstructed by a sand bank which is occasionally ruptured, during extreme tides. It is located in the transitional coastal zone south of the city of João Pessoa, capital of Paraíba State, in Northeastern Brazil. The region is located between lat 07º 02' 52''N and 07º 06' 02''S, and long 34º 49' 10''E and 34º 51' 34'' W, in an area undergoing a rapid urbanization process.

MATERIALS AND METHODS

Three transects, on wide and variable lengths were established for this study (Figure 1). The transects were located near the river mouth (Transect 1: 800 m^2), in the median portion of the mangrove (Transect 2: 1000 m^2), and in the extreme upper portion of the mangrove (Transect 3: 500 m^2). Overall, 23 parcels of 10 x 10 m were analyzed according to Cintrón and Schaeffer-Novelli (1986).

In each parcel, the trees were counted (including the re-growths), the diameters at breast height (DBH) were measured with a 50 cm wooden caliper, and the heights of the trees were measured using previously calibrated articulate aluminum tubes. Special attention was given to the quantification of trees cutted (base of trunk) and their diameters. A checklist of the main anthropogenic impacts was applied to the area. Mangrove tree and vegetation of the transitional zone samples and identified were collected, pressed and dried in a sterilizer at a temperature of 50ºC. Exsiccates were prepared and deposited in the Professor Lauro Pires Xavier Herbarium (JPB/DSE/CCEN/UFPB, João Pessoa, Paraíba, Brazil).

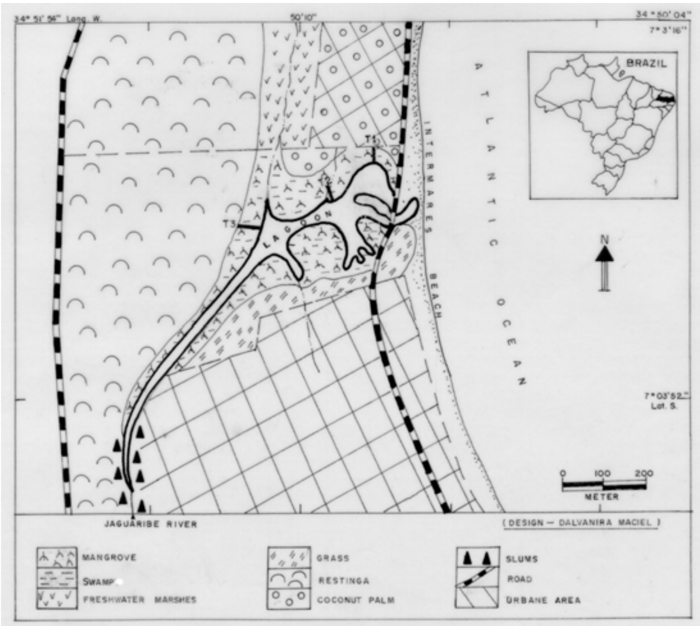

Figure 1 – Map of the study area.

RESULTS

Floristic composition

A total of 13 plant species were found in the studied area: 7 species were exclusive of the inner mangrove area, 3 occurred in the area between the mangrove forest and the transitional zone, and 3 species occurred in both areas (Table 1). The species *Dalbergia ecastophyllum* Taub., *Sophora tomentosa* L., and *Schinus terebentifolius* Raddi. were common to both areas, while *Calotropis procera* Dryand., *Chamaecrista desrauxii* (Collad.) Killip., and *Tocoyena Formosa* K. Schum. occurred exclusively in the area between the mangrove forest and the transitional zone. The other species were found exclusively in the inner part of the mangrove. Only three of the listed species are typical of mangrove areas: *Rhizophora mangle* L., *Laguncularia racemosa* Gaertn. f., and *Conocarpus erecta* L.

Table 1: Plant species found inside the mangrove and in its border zone.

SPECIES	PLACE OF OCURRENCE	
	INNER PORTION OF THE MANGROVE	AREA BETWEEN MANGROVE AND TRANSITION ZONE
Rhizophora mangle L.	**X**	-
Laguncularia racemosa Gaertn. f.	**X**	-
Conocarpus erecta L.	**X**	-
Annona glabra L.	**X**	-
Dalbergia ecastophyllum Taub.	**X**	**X**
Sophora tomentosa L.	**X**	**X**
Calotropis procera Dryand.	-	**X**
Blecnum serrulatum L. C. Rich	**X**	-
Schinus terenbentifolius Raddi.	**X**	**X**
Chamaecrista desrauxii (Collad.) Killip.	-	**X**
Tocoyena formosa k. Schum	-	**X**
Acrostichum aureum L.	**X**	-
Cocos nucifera L.	**X**	-
Total number of species	**10**	**6**

Structural characteristics

The three studied transects had a total area of 2300 m^2. In this area it was registered the predominance of *L. racemosa,* followed by *R. mangle*. The species *D. ecastophyllum* and *C. erecta* occurred occasionally in transects T1 and T2, *Annona glabra* was observed in T1, and *S. tomentosa* was observed in T2, where its density was greater than that of *R. mangle.* Higher densities of *L. racemosa* was observed in T1 and T2; while in the third transect its density was similar to that of *R. mangle*. The absolute density was of 9200, 4860, and 3400 ind. ha^{-1}, respectively, in T1, T2, and T3 (Table 2**).** These high numbers are due to the great quantity of re-growths from cut trees, which were also considered in the density calculations.

Table 2 – Density of species per diameter class in the three transections studied.

SPECIES	DBH (cm)	T1 (800m^2)	T2 (1000m^2)	T3 (500m^2)	TOTAL
Rhizophora mangle	< 2.5	35	04	4	43
	≥ 2.5	60	29	79	168
	> 10	01	-	02	03
Laguncularia racemosa	< 2.5	291	142	1	434
	≥ 2.5	319	176	73	568
	> 10	13	12	11	36
Conocarpus ereta	< 2.5	-	6	-	6
	≥ 2.5	6	6	-	12
	> 10	-	-	-	-
Annona glaba	< 2.5	7	-	-	7
	≥ 2.5	3	-	-	3
	> 10	-	-	-	-
Dalbergia ecastophyllum	<2.5	1	14	-	15
	≥ 2.5	-	12	-	12
	>10	-	-	-	-
Sophora tomentosa	<2.5	-	76	-	76
	≥ 2.5	-	09	-	09
	>10	-	-	-	-
Total Density (ind/ha) (indivíduos/ha)		9200	4870	3400	-

The maximum heights observed were for *L. racemosa* and *R. mangle,* which reached up to 11 m in the third transect. The mean heights found for most individuals, however, did not surpass 5 m, except in T3 where the average was over 7 m (Table 3).

In the first transect the mean height was 3 m; the height class of 2 to 4 m had the greatest concentration of individuals (40%), followed by the class of 4 to 6 m (35%). Most individuals were regrowths. The remaining species catalogued did not reach 3 m heights, except *C. erecta*, which measured up to 5 m. In the second transect the mean height was 2.9 m, with a greater concentration of individuals from the height classes of 2 to 4m and of 0 to 2 m, (37.6% and 30.9%, respectively). In T3 the mean height was 7.3 m. The height classes of 6 to 8 m and of 8 to 10m presented the highest individual concentrations: 38.9% and 42.3%, respectively (Figure 2).

All the three transects had higher individuals concentration between the >2.5 and <10 quota (Table 2). Higher contribution to the total basal area was from *L. racemosa*, the most abundant species. The remaining species contributed less, due to their low DBH and density values.
In T1 the greatest concentration of individuals was from the 0 to 2 cm class (44.7%), followed by the 2 to 4 cm class (31%). The distribution, however, measured up to 16 cm, but in small proportions, starting at quotas higher than 10 cm (Figure 2). In this transect the mean DBH was 3.6 cm and the total basal area was 9.43 m^2. ha^{-1}, from which 1.04 m^2. ha^{-1} was for the <2.5 cm quota, 6.51 m^2. ha^{-1} for the quota between 2.5 and 10 cm, and 1.87 m^2. ha^{-1} for the >10 cm quota.

Table 3 – Height of mangrove species in the transects studied

SPECIES	HEIGHT	T1	T2	T3
	Maximum	8.30	9.00	11.00
Rhizophora mangle	Minimum	0.90	0.80	1.80
	Mean	3.64	4.10	7.20
	Maximum	10.00	9.00	11.00
Laguncularia racemosa	Minimum	0.80	0.60	4.00
	Mean	3.48	3.80	7.50
	Maximum	5.00	5.50	-
Conocarpus erecta	Minimum	5.00	0.60	-
	Mean	5.00	3.30	-
	Maximum	2.80	-	-
Annona glaba	Minimum	0.40	-	-
	Mean	1.40	-	-
	Maximum	1.50	5.00	-
Dalbergia ecastophyllum	Minimum	1.50	0.50	-
	Mean	1.50	2.00	-
	Maximum	-	3.00	-
Sophora tomentosa	Minimum	-	0.50	-
	Mean	-	1.40	-

In T2 the greatest concentration of individuals per diameter class was from the 0 to 2 cm class (49.6%), while the mean DBH was 3.8 cm. Overall basal area data for the different quotas of DBH showed values of 0.47 m^2. ha^{-1} for the <2.5 DBH, 3.2 m^2. ha^{-1} for the DBH between >2.5 and <10, and 2.0 m^2. ha^{-1} for the >10 cm DBH, totaling 5.7 m^2. ha^{-1} (Table 4).

Table 4 – Total basal area of the species (m^2/ ha) according to diameter class in the transects studied.

DBH	TRANSECT 1	TRANSECT 2	TRANSECT 3
<2.5 cm	1.04	0.47	0.03
≥ 2.5 cm	6.51	3.20	10.34
>10 cm	1.87	2.00	3.71
TOTAL	9.43	5.70	14.08

In T3 the greatest concentration of individuals had their DBH in the quota between >2.5 and <10 cm. The individuals distribution per diameter class presented higher proportions in the 4 to 6 cm class (27%) and in the 6 to 8 cm class (22.3%). The distribution attained measurements of up to 18 cm (Figure 2). The mean diameter was 7.2 cm. In relation to the basal area *L. racemosa* was the most expressive species (10.12 m^2. ha^{-1} in comparison to the 3.96 m^2. ha^{-1} of *R. mangle*). The total basal area calculated for this transect was 14.08 m^2/ha, from which 0.04 m^2/ha was for the <2.5

DBH quota, 10.34 m^2. ha^{-1} for the DBH between >2.5 and <10, and 3.7 m^2. ha^{-1} for the >10cm DBH (Table 4).

Anthropogenic impacts

The main human interferences observed in the Intermares lagunar system included the cutting of mangrove trees, litter disposal, human invasion, and the canalization of the lagoon for the construction of the Intermares coastal highway. This last interference suppressed the mangrove view that could be seen from the beach, modifying the natural scenario. The main problems affecting the drainage area of the lagunar system hydrographic basin are: water contamination by domestic sewage and water reductions influx to the lagoon. The latter was caused by change in the Jaguaribe river course (the main contributor to the lagunar system) of the Paraíba River estuary. This was made from north to west in the 1940's with the purpose of draining the waterlogged area in order to combat malaria (Table 5).

Table 5 – Main anthropogenic impacts found in the studied mangrove forest and surroundings

IMPACTS	ARBITRARY LEVEL
Cuts	High
Sewage	High
Litter disposal	High
Alterations in the hydrologic regime	High
Fires	Low
Roads/paths	High
Urban expansion and mangrove invasions	High
Erosion	Moderate
Filling in with land	Moderate
Traditional fishing	Low
Degradation of surrounding vegetation	Low
Recreation	Low

The first two transects showed the highest degree of destruction, seen by the cut tree regrowths. The second transect had the lowest structural values and significant presence of species atypical to mangroves such as *D. ecastaphyllum* and *S. tomentosa* (this last one had the second highest density level in the second transect, even higher than *R. mangle,* a typical mangrove species). In this transect, besides forest destruction, paths formed by cattle herds, which use the area for pasture and drinking, were observed. These herds tread and compact the soil, possibly altering the soil, making easier the establishment of invasive species substitution of typical mangrove species, as already observed.

The third transect was the best preserved. There were fewer cuts and, consequently, the structural values obtained were more expressive. This suggests that the cut-down of trees is an important factor in the destruction of this environment.

Among all the impacts observed those that deserve most attention are forest cut-down and human occupation in the surroundings areas, as these have immediate effects on the mangrove. In relation to the cuts, high numbers were observed in the studied area: up to 1576.2 cuts/0.1 ha in the first transect, where there were up to 14.3 cuts on average and some sites with up to 75 cuts. The two last transects also had high numbers of cuts: 748 and 698 cuts/0.1 ha in T2 and T3, respectively (Table 6)

Table 6 – Wood cuts data found in the studied mangrove forest

TRANSECT	Trees cut/0.1ha	Cuts/tree (maximum number)	Cuts/tree (Average)	Cuts/tree (Minimum number)	Total cuts/0.1ha
1	110	75	14.3	1	1576.2
2	57	50	13.1	1	748.0
3	76	21	9.1	1	698.0

Along with forest cut-down, urban expansion has worsening the process of vegetation degradation. Human occupation is most intense in the upper portion of the mangrove, invaded by low-income populations, where the construction of walls for land plots along the mangrove limits was observed.

DISCUSSION

The presence of *L. racemosa* as the most expressive element in the Intermares mangrove both in density and in size is a fact that disagrees with the opinion of Fernandes (1975), who cites *R. mangle* as the dominant species among estuary spermatophytes of Northeastern Brazil. In other lagunar systems at the south of Paraíba state (Jacarapé and Camurupim lagoons), dominance of *R. mangle* has been observed (Sassi, 1997, Coutinho 1999), in accordance to Fernandes (*op. cit.*). It must be noted, however, that the mangrove adjacent to the Intermares lagunar system has been submitted to intense anthropogenic interference, which causes the alteration of species dominance.

The excessive cutting observed in Intermares probably provoked the substitution of *R. mangle* by *L. racemosa*, which is apparently more resilient to cutting and reacts better to this kind of impact. According to Thom (1967) and Rabinowitz (1975) *L. racemosa* is more opportunist than *R. mangle*, being able to grow in any part of the mangrove. As an example, observations by Soares (1999) and Soares and Tognella (1994) in mangroves from Southeastern Brazil demonstrated that forests dominated by short-sized *L. racemosa* are characteristic of altered areas in process of recomposition.

In Intermares, species do not show a clear zoning pattern. A homogeneous forest constituted mainly by *L. racemosa* (first two transects), with *R. mangle* individuals concentrated in the areas near the tide channel were observed. Associated forest was also observed in the third transect, where *L. racemosa* and *R. mangle* were equally distributed along all parcels. Overall, *L. racemosa* density was always equal or greater than *R. mangle* in all parcels in the three transects. *R. mangle* also occurring together were also observed with specimens of *C. erecta*, a species characteristic of areas between the mangrove and the adjacent vegetation.

The structural parameters obtained in Intermares were low when compared to other mangroves of the Paraíba coast, which have trees up to 15 m tall and basal areas of up to 21.1 $m^2.ha^{-1}$ (Sassi, 1997, Coutinho 1999). Nevertheless, if only the data of the third transect is considered the values are similar to those found by these authors. The values found in Intermares are also similar to those found for the Piraquê River, Sepetiba Bay, Rio de Janeiro (Corrêa *et al*. 1997), and for the Bertioga Channel, São Paulo (Peria *et al*. 1990), but are much lower than those found for Vitória

Bay, Espírito Santo, (Carmo *et al*. 1995) (Table 7). The citations of this table refer to preserved or impacted areas (natural and/or anthropogenic), which makes it hard to compare the mangrove forests. Variation in relation to the structural development of these forests, however, can be observed, which must reflect the sum of several factors that interact in the environment. According to Cintrón and Schaeffer-Novelli (1985), the structural development that a forest reaches is the function of the periodicity levels of subsidiary energy and is influenced by the intensity of the tensors present in the area.

Table 7 - Structural data on Intermares and other Brazilian mangroves.

Locality	**Average height (m)**	**Average diameter (cm)**	**Basal area (m^2/ha)**	**Author**
Intermares, PB	2.6 to 7.3	3.6 to 7.2	5,7 to 14	This study
Rio Piraquê, Baía de Sepetiba, RJ.	2.6 to 6.9	1.6 to 7.04	10,02 to 24,22	Corrêa *et al.* (1997)
Baixada Santista, SP	4.6 to 12.9	3.7 to 10,9	3.4 to 25,2	CETESB (1983)
Baía de Vitória, ES	5.2 to 17.3	4.2 to 18,9	5.3 to 29.8	Carmo *et al.* (1995)
Canal de Bertioga, SP	3 to 7.7	2.5 to 7.5	4.5 to 16.3	Peria *et al.* (1990)
Ilha do Cardoso, SP	5.7 to 9.8	9.5 to 12	Up to 5.6	Peria *et al.* (1990)

Most trees that occur in Intermares' mangrove forest are re-growths of plants that had already been cutted. With the increasing of wood removal from the area, clearings can already be observed in the inner part of the mangrove where the soil is exposed to intense solar radiation, drying and favoring the non occurrence of plants or the growth of atypical mangrove plants. Therefore, the intense use of the mangrove's floristic resources reflects on its physiognomy, whose structure is being profoundly altered.

The presence of several atypical species found along with *L. racemosa* and *R. mangle* in the Intermares mangrove shows how the specific characteristics of the area are mainly a consequence of the inefficient water exchange between the lagoon and the sea. The water and saline stress, a result of the inefficient drainage of the area, is caused by the obstruction of the lagunar system by a barrier sand that is only ruptured in exceptionally high tides or when the volume of water of the inundated plain increases substantially during the rainy seasons.

This characteristic is also common in other lagunar systems at the south of the studied area, where sandbar ruptures are sporadic and the mangrove has similar characteristics. In the Jacarapé lagoon, for example, located approximately 17 km south, only 8 ruptures of the strip of sand were recorded during 68 weeks of continuous observations (Silva Jr. 1998), which demonstrates the magnitude of the saline stress to which these mangroves are constantly submitted.

The freshwater supply to the lagunar system of Intermares was reduced following the change of the original course of the Jaguaribe river to the Paraíba do Norte river estuary. This caused a constant water stress to the lagunar system, reducing its flooding area and favoring invading species. As reported by Schaeffer-Novelli (1995), the lack of water flow turned the sediment very acid and the freshwater flow difficult. The movement of nutrients and organic matter, as well as the exchange of material between water and sediment is interrupted, contributing to modify the typical physiognomy of the mangrove.

In addition, invasions observed in the mangrove area as well as the constant obstructions that occur along the former bed of the Jaguaribe river (that forms the lagunar system) have surely contributed to the elevation of the area’s topographic quota, modifying the native vegetation and resulting in the growth of species such as *A. glabra*, *S. tomentosa, A. aureum*, and *D. ecastophyllum,* some in expressive densities.

Carmo (1987) reported several factors, like alterations of the river course, canalization, drainage, sewage and other, that interfere in the normal water flow, modifying sedimentation or the water level and altering the forest structure or even killing the trees. Such disturbances were observed at Intermares and at portions of the mangrove affected by urbanization. The lack of supervision and of punishment by government authorities, has led to increase the mangrove degradation.

Despite this growing process of degradation, mangrove-associated fauna can still be found occasionally (small monkeys, alligators, several birds), including animals protected by law such as marine turtles, which comes to the beaches of this region to lay its eggs. The Intermares forest is also a beautiful example of Paraíba’s mangroves and, therefore, it is of urgent and fundamental importance to establish programs to maintain this ecosystem’s integrity.

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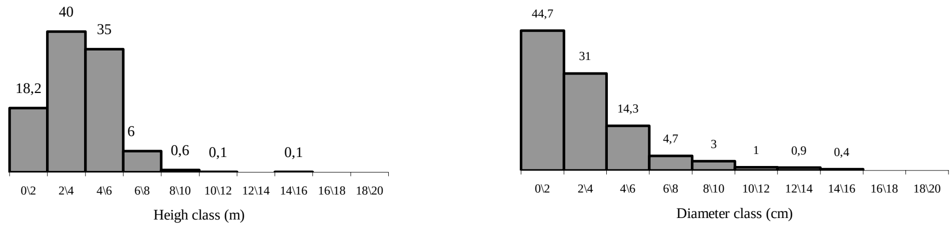
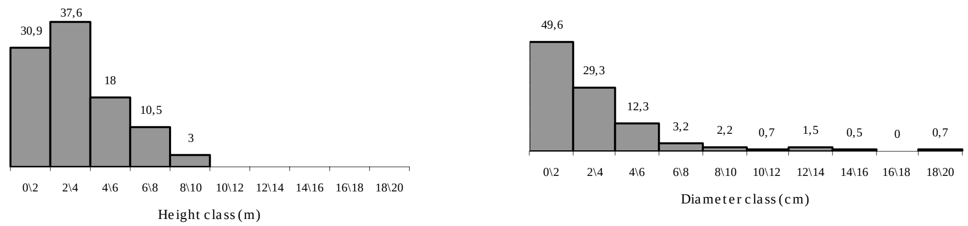
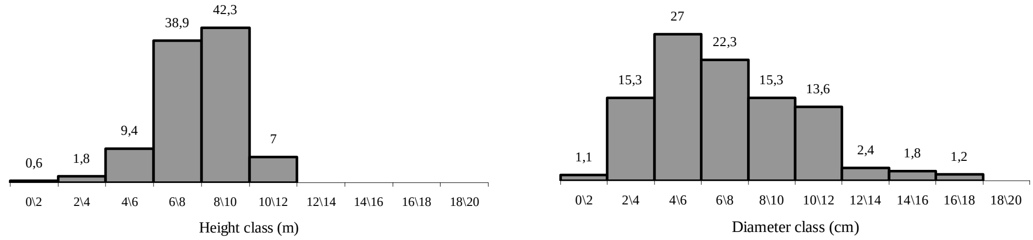


Tranect 1



Transect 2



Transect 3

Figure 2 – Distribution of the number of individuals found in the three transects, in classes of height with 2 m fixed intervals (closed to the left and open to the right) and in diameter classes with 2 cm fixed intervals (closed to the left and open to the right).