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Articles

Floristic composition and structure of an urban forest along an edge-interior environmental gradient

Composição florística e estrutura de uma floresta urbana ao longo de um gradiente ambiental de borda-interior

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ABSTRACT

The interaction between the anthropic environment and vegetation can impact the forest community in various ways, depending on its surroundings. Therefore, this study aimed to assess whether there is variation in the tree assemblage composition and structure between the forest edge and the interior surrounded by the urban landscape. The study was conducted in the Mata do Passarinho Conservation Unit in Olinda, PE, Brazil, where 15 plots of 10 x 25 m were established along three environments, creating a gradient from the fragment edge to the interior, namely: A1 - edge environment; A2 - transition environment between A1 and A3; A3 - interior environment. The analysis of ecological groups indicated a predominance of early successional groups, with a dominance of pioneer and early secondary species across the established environmental gradient. The zoochory dispersal syndrome predominates in the fragment, followed by autochory and anemochory, with higher zoochoric dispersal activity observed in the A3 environment, farther from the fragment edge, which showed higher species richness. The modified Shannon diversity index ($e^{H'}$) and Pielou's Evenness index (J') values between Environment 1 ($e^{H'}$= 17 and J'=0.90), Environment 2 ($e^{H'}$= 12 and J'=0.82), and Environment 3 ($e^{H'}$= 16 and J'=0.82) showed variations along the edge-interior gradient. Therefore, variation between edge and interior environments in the urban forest fragment was observed.

Keywords: Urban ecology; Ecological groups; Dispersion syndrome; Diversity

RESUMO

A interação entre o ambiente antrópico e a vegetação pode impactar a comunidade florestal de diversas formas, a depender da sua circunvizinhança. Desse modo, este trabalho teve como objetivo avaliar se existe variação na composição e estrutura da assembleia arbórea entre a borda e o interior da floresta circundada pela paisagem urbana. O estudo foi realizado na Unidade de Conservação Mata do Passarinho em Olinda-PE, na qual foram implantadas 15 parcelas de 10 x 25 m distribuídas ao longo de três ambientes, criando assim um gradiente no sentido borda-interior do fragmento, sendo: A1 – ambiente de borda; A2 - ambiente de transição entre A1 e A3; A3 - ambiente de interior. A análise dos grupos ecológicos apontou uma predominância de grupos sucessionais iniciais, na qual ocorre a dominância das espécies pioneiras e secundárias iniciais ao longo de todo o gradiente dos ambientes estabelecidos. Em relação à síndrome de dispersão, a zoocoria predomina, seguida por autocoria e anemocoria, sendo observada uma maior atividade da dispersão zoocórica no ambiente A3, que fica mais afastado da borda do fragmento, o qual apresentou uma maior riqueza de espécies. Quanto ao índice de diversidade de Shannon modificado ($e^{H'}$) e de Equabilidade de Pielou (J'), os valores entre o Ambiente 1 ($e^{H'}$=17 e J' =0,90), Ambiente 2 ($e^{H'}$=12 e J'= 0,82) e Ambiente 3 ($e^{H'}$=16 e J'= 0,82) apresentaram variações ao longo do gradiente borda-interior. Portanto, observou-se que houve variação entre os ambientes de borda e de interior no fragmento de floresta urbana.

Palavras-chave: Ecologia urbana; Grupos ecológicos; Síndrome de dispersão; Diversidade

1 INTRODUCTION

The Atlantic Forest has been going through a long process of forest fragmentation in recent centuries, which has caused major losses in the biodiversity of this biome, in turn leading to a gradual reduction in natural forest areas (Silva *et al*., 2019). In this context, some types of matrices (predominant land use of the landscape) in which these forest fragments are inserted can be more aggressive and intense than others, so that their interior can be affected in completely different ways depending on their surroundings (Oliveira *et al*., 2015).

As a consequence of the vast fragmentation process that the Atlantic Forest is undergoing, it is currently possible to find remnants which still present difficulties in recovering even after 150 years of regeneration (Santana; Fonseca; Carvalho, 2019). In the urban context, these forest fragments are an essential component of city planning due to the ecological and social services they offer, such as aesthetic and climate improvement, generating recreational opportunities, environmental protection and biodiversity conservation, while also meeting social needs and psychological aspects of the urban population (Ignatieva; Glenn; Meurk, 2011).

However, due to disorderly growth and irregular land use and occupation, urban landscapes are increasingly suffering the consequences of the increased pressure imposed by urbanization on natural resources (Grise *et al*., 2016). With this rapid expansion, the structure of ecological systems in urban regions is affected, causing impacts which include a decrease in air and water quality, changes in microclimatic patterns and mainly the destruction of existing habitats in urban forests (Berland; Manson, 2013).

The interaction between the anthropic environment and vegetation can impact the forest community, resulting in differences in the species richness and structure located between most bordering areas and the fragment's interior areas (Oliveira *et al*., 2015). These disturbances which reach the forest edge affect its first 30 m with greater intensity, with these environments being those that suffer most from the impacts of the urban environment (Rigueira *et al*., 2012), which then result in reduced biodiversity due to physical, chemical and biological changes that the area begins to experience, making the fragment smaller and smaller (Rocha *et al*., 2020).

Thus, considering the importance of forests found in the urban context, this study aimed to characterize the structure and composition of a forest remnant along an edge-to-interior environmental gradient. We sought to answer the following question: Is there variation in the tree assemblage composition and structure between the forest edge and the interior surrounded by the urban landscape?

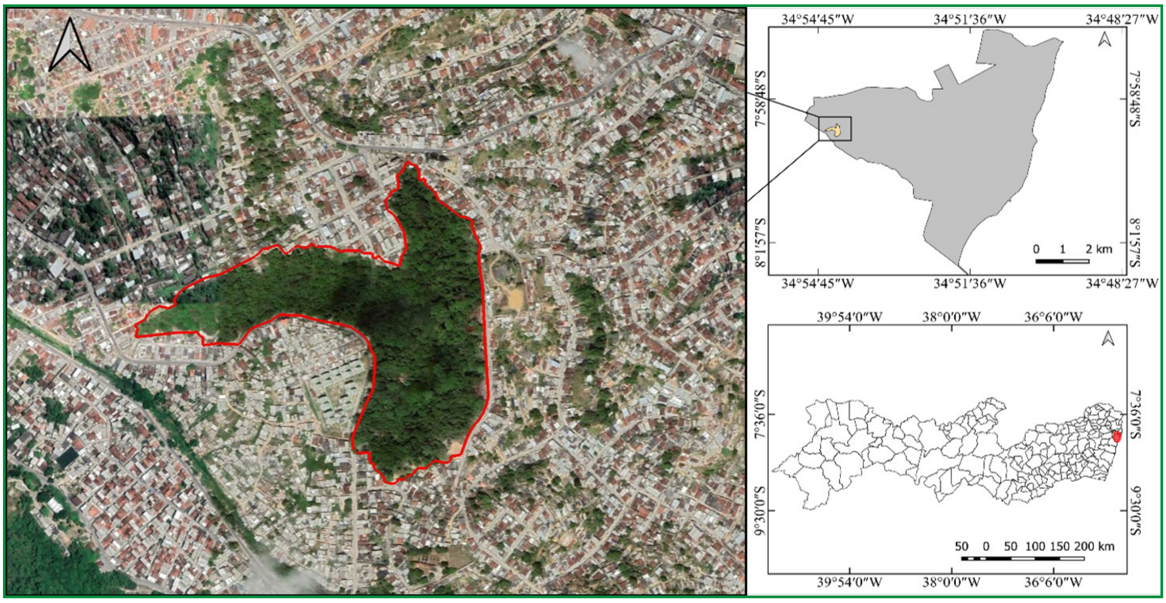
2 MATERIALS AND METHODS

2.1 Characterization of the study area

The study was conducted in a Conservation Unit (CU) called the Mata do Passarinho Urban Forest Reserve (*Reserva de Floresta Urbana - FURB*) in Olinda, in the

State of Pernambuco, (07°59'29.69"S and 34°54'21.43"W) (Figure 1). The municipality has a territorial area of 41.30 km² and has an estimated population of 393,734 people (IBGE, 2021). It is located in the Beberibe River basin, characterized by a tropical monsoon climate, with average annual temperatures of 25.8ºC (Alvares *et al*., 2013).

Figure 1 – Location of the study area: Mata do Passarinho *FURB*, Olinda, PE, Brazil



Source: Authors (2024)

The Urban Forest Reserves of Pernambuco, located in the Metropolitan Region of Recife, were initially categorized as Ecological Reserves until they underwent changes and were recategorized with State Law No. 14,324/2011, in order to be made compatible with the categories created by the State System of Conservation Units (SEUC: State Law no. 13,787/09). According to this last law, an Urban Forest Reserve (*Reserva de Floresta Urbana* - *FURB*) is a remaining area of ecosystems with a predominance of native species located in the urban perimeter. They consist of public or private domain areas, which still have significant environmental attributes despite the pressures existing in their surroundings. *FURB*s are part of the Sustainable Use group, and therefore their basic objective is to make nature conservation compatible with the sustainable use of a portion of its natural resources.

The Mata do Passarinho *FURB* has an area of 13.36 hectares and has an altitude varying between 0 m and 50 m, making this the largest forest fragment in the municipality of Olinda, covering 0.31% of its total area. Of this area, 11.60 hectares were acquired by Olinda City Hall, leaving 1.76 hectares in private land. Despite being transformed into a Conservation Unit in 1987, this forest remnant underwent a vast deforestation process that began in the 1980s and lasted until 1997, with the purpose of building houses and extracting natural resources (Pernambuco, 2013).

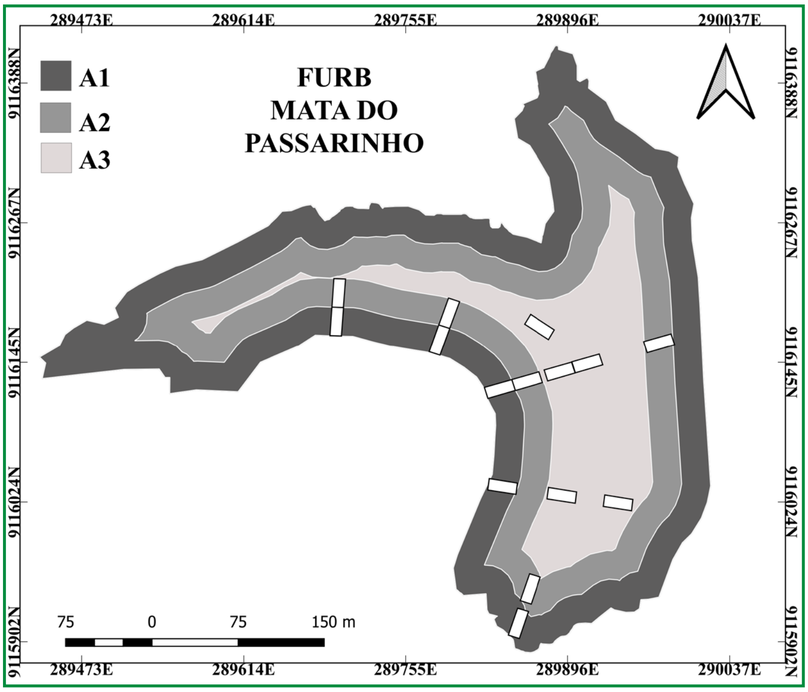
The fragment presents a forest formation with vegetation reminiscent of the Atlantic Forest Domain, with phytophysiognomy of the Lowland Dense Ombrophilous Forest type characterized by the presence of phanerophyte, liana and epiphyte species (IBGE, 2012). This forest type generally occupies coastal plains occurring from the Amazon and extending throughout the Northeast region to the state of Rio de Janeiro.

2.2 Data collection

First, 15 rectangular plots measuring 10 x 25m (250 m²) were systematically installed along an environmental gradient going from the fragment edge to the interior to enable comparison between the different environments. However, some of these plots were relocated due to security concerns. The method used was based on adaptations of the methodologies of Oliveira et al. (2015) and Lima et al. (2020), dividing the forest fragment into three distinct areas: A1 - edge environment (0 - 25m); A2 - transition environment between A1 and A3 (25m - 50m); A3 - interior environment (>50m), as illustrated in Figure 2. Each environment received five plots to ensure a representative and systematic distribution along the gradient.

The plots were assembled and properly georeferenced using a Garmin GPS (Global Positioning System, model 76map CSx). Circumference at breast height (CBH) greater than or equal to 15 cm was adopted as a criterion for including arboreal individuals, measured with a measuring tape. All sampled individuals were identified and recorded in a field notebook, in which the scientific or popular/vernacular name and height were collected, which was obtained through visual estimation with a 3-meter mark.

Figure 2 – Different environments and plots demarcated in white in the study area



Source: Authors (2024)

In addition, other dendrological information necessary for species identification was recorded, such as: presence of exudates, the color of leaves and flowers, and hairiness (trichomes). Botanical samples of all species were collected to make exsiccates, analyzed and deposited in the Sérgio Tavares Herbarium (HST). The nomenclature used followed the classification proposed in APG IV.

2.3 Data analyses

Data analyses were processed using the RStudio software program (2022) and the Microsoft Office Excel 2016 package. First, density, frequency, and dominance in their absolute and relative values, and the importance value index were calculated to characterize the plant community structure. These parameters have been applied in recent studies involving forest remnants of the Atlantic Forest in the context of urban areas (Brun *et al*., 2017; Silva *et al*., 2017; Guilherme *et al*., 2021).

The successional classification of the species was performed in accordance with the work of Lima et al. (2020), covering the following ecological groups: pioneers (PI), early secondary (ES) and late secondary (LS). The dispersal syndrome was classified according to the proposal adapted from Van der Pijl (1982), using the categories: autochory (Aut), anemochory (Ane) and zoochory (Zoo), which were defined for each species through bibliography research and field observations.

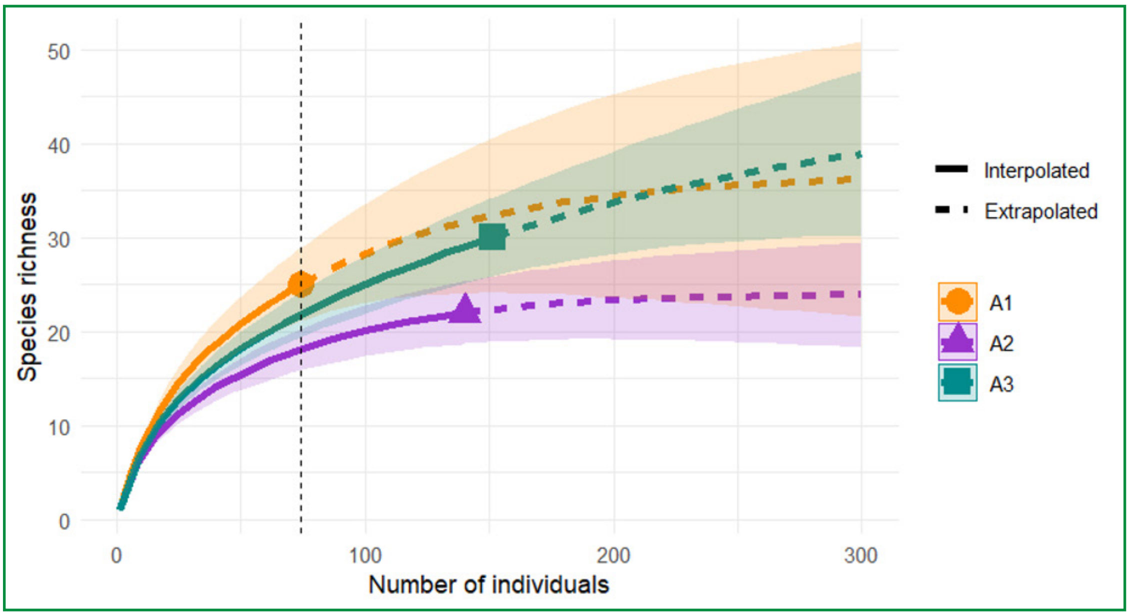
Each environment was then evaluated considering the established environmental gradient. Given that the number of samples is uniform in all environments, the diversity between them was analyzed using the rarefaction method. This method represents the diversity of species in relation to the number of individuals. The Shannon diversity indices were used in exponential form to compare the floristic data between the three areas, thus obtaining the modified Shannon index ($e^{H'}$), in addition to the Pielou evenness (J'), in each of them (Shannon; Weaver, 1949; Pielou, 1975). Next, the species richness in common between the environments was assessed based on these indices using the Venn diagram (Zar, 1999). The comparison between the three environments was also performed using the Jaccard Similarity Index (J), which expresses the similarity between environments based on the number of common species (Magurran, 2004).

Analysis of variance (ANOVA) was performed between the three environments in order to verify the occurrence of differences between them. To this end, the absolute density, absolute dominance, mean diameter and mean height of the individuals present in A1, A2 and A3 were evaluated, followed by the Tukey's test (α = 5%). Finally, the Shapiro-Wilk test was used to verify the normality of data distribution between groups.

3 RESULTS AND DISCUSSIONS

A total of 41 species and 32 genera belonging to 25 botanical families were catalogued across the 15 sampling units, accounting for a total of 365 individuals, of which 73 occurred in A1, 140 in A2, and 152 in A3. Observing the 95% confidence interval, it becomes evident that there is variation in the diversity of rarefied species only between environments A2 and A3 when extrapolated to predict the number of species in case of an increase in collection effort (Figure 3), as according to Chao *et al*. (2014), the curves only show discrepancies when the confidence intervals do not intersect.

Figure 3 – Rarefaction curves based on individuals from the studied environments



Source: Authors (2024)

A total of 24 from the total species sampled occurred in A1, 21 of which were identified at the species level, two at the genus level and one unidentified. The botanical families with the highest specific richness were Fabaceae (4 species), followed by Anacardiaceae (3) and Melastomataceae (2), corresponding to 37.5% of the total species. The remaining families sampled are represented by just one species (15 families – 65.5% of the species). When considering the number of individuals, *Tapirira guianensis* Aubl. (10 individuals), *Muntingia calabura* L. (8), *Miconia minutiflora* (Bonpl.) DC. (7), *Cecropia* sp. (6), and *Ocotea glomerata* (Nees) Mez (6) were the species which stood out the most, together accounting for 50.7% of the total number of individuals.

In relation to the phytosociological structure of A1, the Importance Value Index (IVI) was concentrated in the first eight species, which are: *Tapirira guianensis* Aubl., *Cecropia* sp., *Artocarpus heterophyllus* Lam., *Inga edulis* Mart., *Ocotea glomerata* (Nees)

Mez, *Muntingia calabura* L., Protium sp. and Miconia *minutiflora (Bonpl*.) DC. These composed 69.1% of the total IVI, revealing that the tree community studied has a strong dominance of a few species. The highest values of the three phytosociological parameters (density, frequency and dominance) were what determined the positions of the first five species. However, the appearance of a single individual of the *A. heterophyllus* species stands out due to its reduced density and low frequency, presenting the third highest IVI due to its high dominance value.

Next, 17 of the species sampled in A2 were identified at the species level, three at the genus level and 2 were not identified. Fabaceae, Anacardiaceae and Melastomataceae were the families that presented the greatest richness, with 4, 3 and 2 species, respectively. Together, they correspond to 40.9% of the total species, while the other families had only one species (13 families – 59.1% of the species). The most abundant species in A2 were: *Cecropia* sp. (30 indivíduos), *Muntingia calabura* L. (22), *Protium* sp. (19), *Tapirira guianensis* Aubl. (11), *Miconia affinis* DC. (9), *Miconia minutiflora* (Bonpl.) DC. (9), and *Ocotea glomerata* (Nees) Mez (8) together represent 77.1% of the total number of individuals. The Importance Value Index (IVI) of A2 was concentrated in species: *Tapirira guianensis* Aubl., *Cecropia* sp., *Protium* sp., Indeterminada 2, *Muntingia calabura* L. and *Simarouba amara* Aubl. These six species composed 59.3% of the total IVI.

Then, 23 of 31 species sampled in A3 were identified at species level, three at genus level and five unidentified. Fabaceae (6 species), Anacardiaceae (4), Annonaceae (2), Melastomataceae (2) and Moraceae (2) were the five botanical families with the greatest specific richness, corresponding to 51.6% of the total cataloged species. The remaining families sampled (12 – 48.45% of species) have only one species. The species with the greatest abundance regarding the number of individuals were: *Thyrsodium spruceanum* Benth. (27 individuals), *Protium* sp. (24), *Cecropia* sp. (14), *Tapirira guianensis* Aubl. (13), *Simarouba amara* Aubl. (10) and *Parkia pendula* (Willd.) Benth. ex Walp. (8). Together they total 57.9% of the total number of individuals. The Importance Value index was predominantly represented by six species, which totaled 53.7% of the IVI, consisting of: *Tapirira guianensis* Aubl.; *Simarouba amara* Aubl.; *Thyrsodium spruceanum* Benth.; *Protium* sp.; *Eschweilera ovata* (Cambess.) Mart. ex Miers and *Cecropia* sp.

The analysis of ecological groups showed that there is a predominance of initial successional groups in the Mata do Passarinho *FURB*, with pioneer species covering a greater number of individuals and species in A1 and A2. The early secondary species present an increasing number of individuals as one advances towards the fragment interior (Environment A3). These initial ecological groups correspond to the highest importance value of the entire fragment (Table 1). Such results may be related to the negative effects arising from wood removal which previously occurred at the Mata do Passarinho *FURB*, today resulting in the predominance of species from initial ecological groups throughout all of the A1, A2 and A3 environments.

Table 1 – Distribution of ecological groups by Importance Value Index (IVI) found in the Environments (A1, A2, and A3) of the Mata do Passarinho *FURB,* Olinda, PE, Brazil

Environment	Ecological group	Species	NI	RD	RF	RDo	IVI%
A1	PI	10	41	56.3	50.1	63.5	56.4
	ES	9	25	34.2	36.4	33.5	34.6
	LS	3	4	5.5	8.4	3.0	5.6
	NC	2	3	4.1	5.6	0.2	3.3
A2	PI	10	92	65.6	46.2	44.6	52.2
	ES	6	40	28.6	36.6	20.6	28.5
	LS	4	6	4.2	12.1	11.7	9.4
	NC	2	2	1.4	4.8	23.2	9.9
A3	PI	13	58	38.3	42.8	45.5	42.2
	ES	9	84	55.4	39.7	45.9	46.9
	LS	3	3	2.1	5.1	7.8	5.0
	NC	6	**7**	4.8	11.9	0.8	5.8

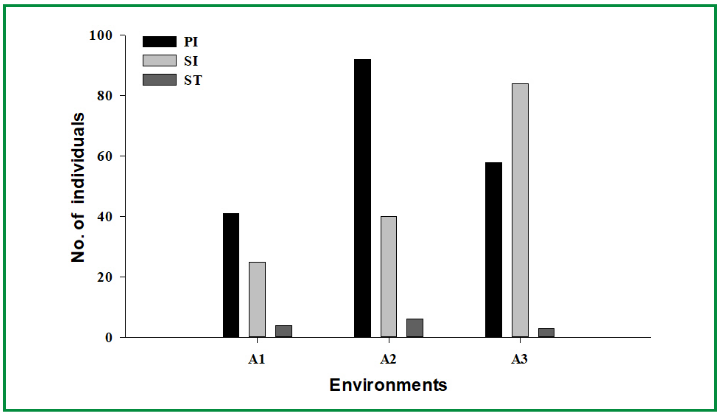
Source: Authors (2024)

In where: NI = number of individuals, RD = relative density (%), RF = relative frequency (%), RDo = relative dominance (%), IVI = importance value, PI = pioneer; ES = early secondary; LS = late secondary, NC = not cataloged.

The greater presence of species in early succession stages was also found in other studies carried out in urban environments (Paiva; Ribeiro; Carvalho, 2015; Silva *et* *al*., 2017; Santana; Fonseca; Carvalho, 2019). Late secondary species appear in smaller quantities, showing little variation in both the number of individuals and the number of species across the three environments. This dominance pattern of pioneer and initial secondary species can be observed along the established gradient (Figure 4).

According to Vale *et al*. (2009), many forest species suffer from the negative effects of illegal exploitation due to gaps opening in the canopy, as there is an increase in light in the understory which in turn favors species that require light to grow, such as pioneers. Due to their plasticity to overcome adverse environmental conditions typical of the initial succession stages, these species become important for the functioning of the forest ecosystem due to their ability to quickly colonize disturbed areas and initiate the process of ecological succession, which is fundamental for recovering biodiversity and functionality of these ecosystems (Paiva; Ribeiro; Carvalho, 2015; Missio *et al*., 2020; Guilherme *et al*., 2021). Therefore, the ability to establish themselves in adverse conditions significantly contributes to the ecological resilience of the fragment.

Figure 4 – Ecological group of species among the different environments of the Mata do Passarinho *FURB*



Source: Authors (2024)

For Fonseca and Carvalho (2012), this greater representation of species from the initial groups may indicate that the forest fragment is not capable of progressing to more advanced successional phases, or that progress is occurring very slowly.

Some indications regarding vegetation can be provided since these species from initial ecological groups are mainly responsible for the initial colonization of disturbed forests. The first is that the succession process is being led to its intermediate phase due to the arrival of species from more advanced ecological groups; the second is that the forest fragment has been recovering from its history of disturbances, as the arrival of these more demanding species provide an increase in diversity in the area (Silva *et al*., 2017; Santana; Fonseca; Carvalho, 2019).

In relation to the dispersal syndrome, it is clear that zoochory predominates in all environments, presenting a greater number of both individuals and species. It also proportionally has the highest importance value, which justifies its predominance throughout the area. This pattern is followed by autochoria and anemochory, as detailed in Table 2.

Table 2 – Classification of dispersion syndromes by Importance Value Index (IVI) in the Environments (A1, A2, and A3) of the Mata do Passarinho *FURB*

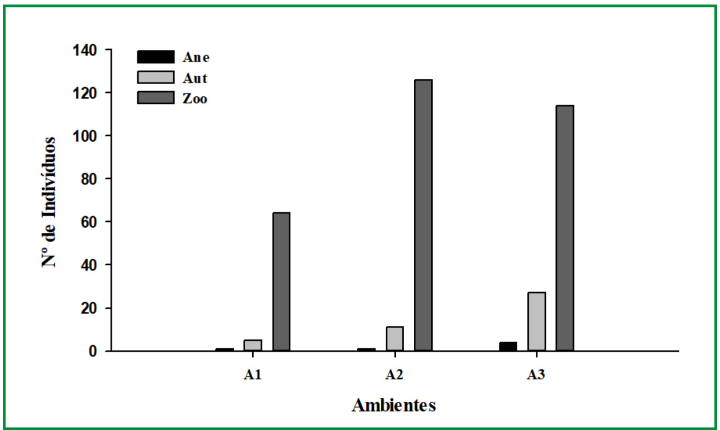
Environment	Dispersion syndrome	Species	NI	RD	RF	RDo	IVI%
A1	Zoo	18	64	87.7	80.9	98.1	88.6
	Aut	3	5	6.9	11.2	1.6	6.5
	Ane	1	1	1.4	2.8	0.3	1.5
	NC	2	3	4.1	5.6	0.2	3.3
A2	Zoo	15	126	89.8	75.5	58.4	74.6
	Aut	4	11	7.9	17	11.8	12.2
	Ane	1	1	0.7	2.4	6.7	3.3
	NC	2	2	1.4	4.8	23.2	29.6
A3	Zoo	17	114	75.2	61.8	55	64
	Aut	5	27	17.9	19	32.9	23.2
	Ane	3	4	2.7	6.8	11.3	6.9
	NC	6	7	4.8	11.9	0.8	5.77

Source: Authors (2024).

In where: NI = number of individuals, RD = relative density (%), RF = relative frequency (%), RDo = relative dominance (%), Zoo = zoochory, Aut = autochory; Ane = anemochory; NC = not cataloged.

A large representation of zoochoric species in the environment (Figure 5) may indicate that a strong interaction between flora and fauna has been occurring due to their coexistence mechanisms (Missio *et al*., 2020), which makes them of great importance for natural ecosystems. This dispersion type becomes fundamental for the current context of the Mata do Passarinho *FURB*, which is isolated in the urban matrix, as it enriches the complexity of the environment due to this relationship between plants and animals (Guilherme *et al*., 2021).

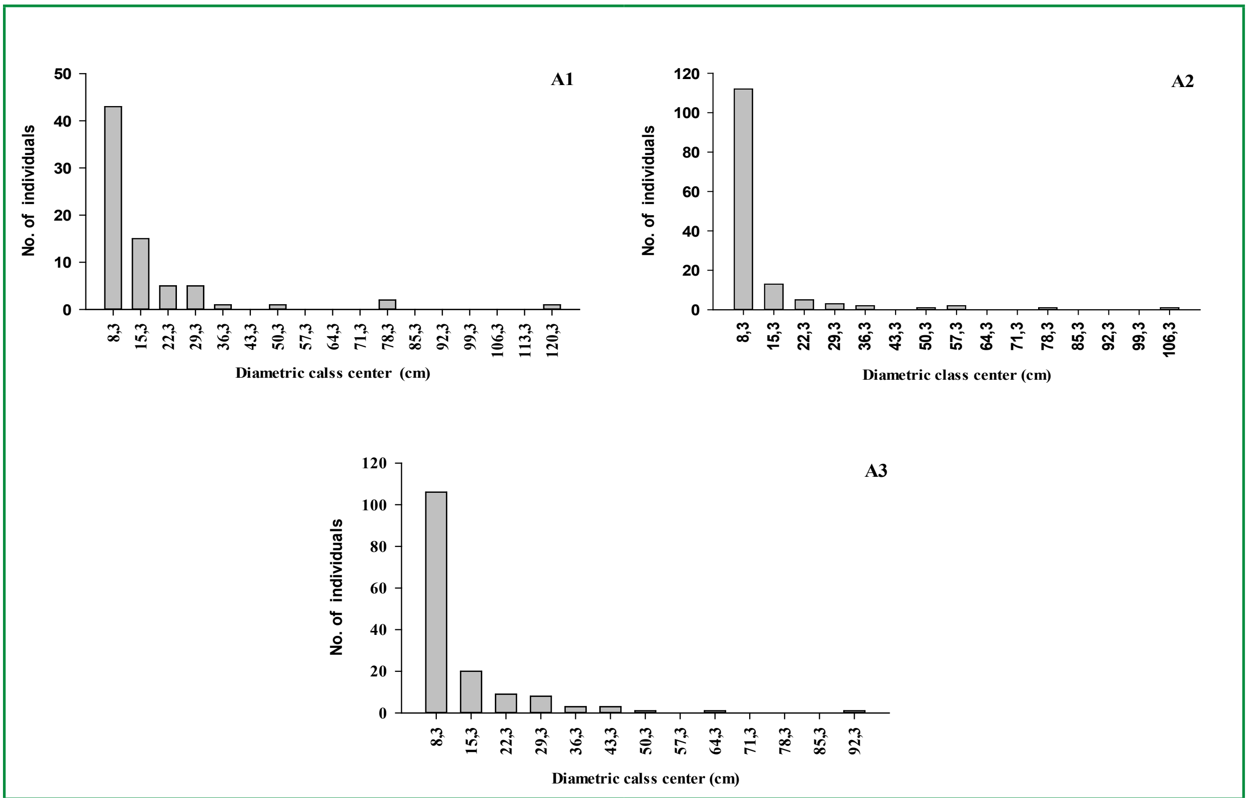
Figure 5 – Dispersion syndrome between the different environments of the Mata do Passarinho *FURB*



Source: Authors (2024)

Regarding diameter distribution, it was observed that there is a greater frequency of individuals in the first diameter classes in all environments, with a sharp drop in subsequent diameter classes (Figure 6). It is therefore noted that the vegetation studied followed the characteristic pattern for natural forests, which resembles an inverted "J", with the first classes covering a greater number of individuals with the smallest diameters. This indicates that the Mata do Passarinho *FURB* has a high regeneration capacity due to the high presence of young individuals, providing the forest community with the diameter standard expected for uneven forests (Cysneiros *et al*., 2017; Paschoal *et al*., 2021).

Figure 6 – Diametric distribution of the different environments of the Mata do Passarinho *FURB*



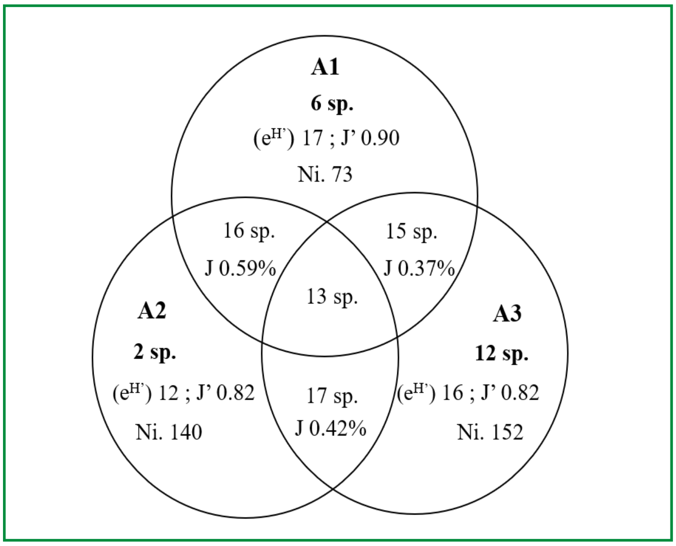
Source: Authors (2024)

The diameter distribution behavior of the studied community may be related to the fragment's general successional stage, in which species from initial ecological groups with rapid growth and high dispersal rates predominate (Cysneiros *et al*., 2017; Guilherme *et al*., 2021), characterizing it as a still young remnant.

This diametric distribution behavior may also be associated with the history of anthropogenic pressure that affects the Mata do Passarinho *FURB*, which results from the challenges faced in the period prior to its creation due to the high deforestation rates that occurred and persisted until the initial stages of its implementation. Due to human pressures, trees with slower growth may face difficulties in establishing themselves, which favors the concentration of other less sensitive species in disturbed areas (Vale *et al*., 2009), resulting in a distribution in which younger individuals with smaller diameter classes predominate.

The comparison of the flora found in the three environments obtained through the Jaccard Similarity Index revealed that between A1 and A3 (Edge/Interior – 0.37%) there was a greater floristic difference. Greater similarity was found both between A1 and A2 (Edge/Transition – 0.59%), and between A2 and A3 (Transition/Interior – 0.42%). It can be seen from the Venn diagram (Figure 7) that 13 species were common to the three environments. Moreover, 6 exclusive species were identified in A1, 2 in A2 and 12 in A3. A total of 16 species were common between A1 and A2, while there were 15 species in common between A1 and A3. The number of common species for A2 and A3 were 17.

Figure 7 – Evaluation of species richness through the Venn diagram



Source: Authors (2024).

In where: Ni = number of individuals; $e^{H'}$ = Modified Shannon's Diversity Index; J' = Pielou; J = Jaccard.

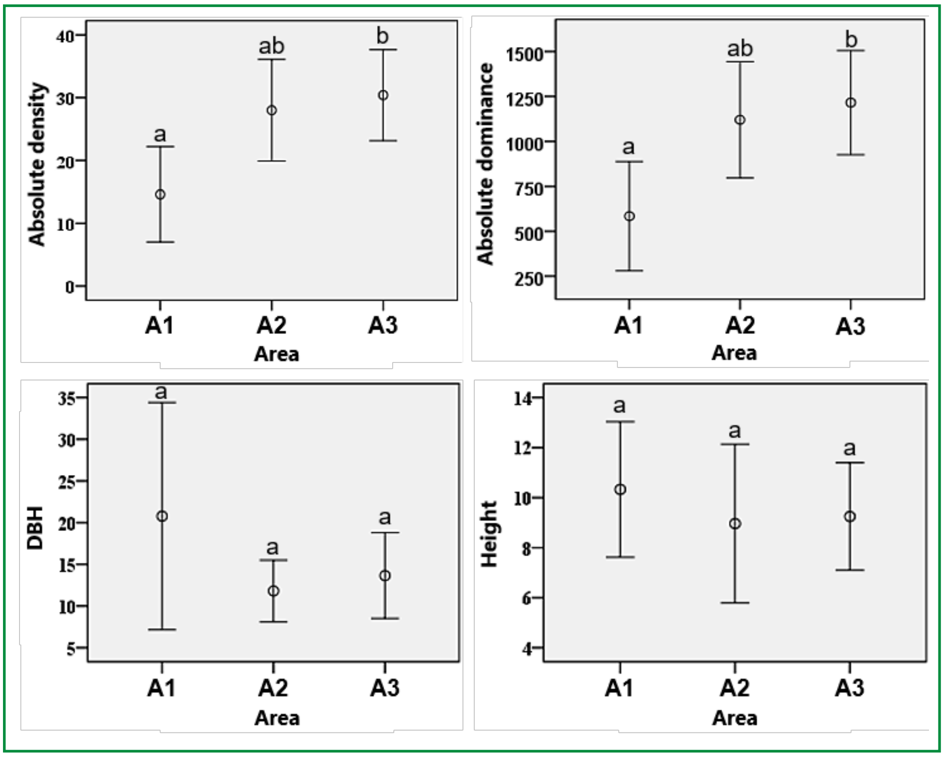
The difference between the number of species that occur exclusively in A2 compared to other environments is justified by the high floristic similarity between this intermediate environment and the others. This is different from what happens between A1 and A3, in which the fragment interior presents double the amount of exclusive species as the edge, with greater dissimilarity between them. According to Oliveira *et al*. (2015), areas further away from the edge in the Atlantic forest demonstrate greater richness compared to the area adjacent to the edge.

The modified Shannon diversity index ($e^{H'}$) and the Pielou evenness (J’) values showed the variation between environments. The modified Shannon diversity index ($e^{H'}$) individually showed that around 17 of the 24 species which compose A1 show greater dominance. In turn, A2 has 22 species in its floristic composition, and the modified Shannon value ($e^{H'}$) was equal to 12, with this value corresponding to the most dominant species in this environment. Then, the modified Shannon value ($e^{H'}$) showed that 16 of the 31 species cataloged in A3 show greater dominance. It can be observed that A1 and A3 demonstrated the highest diversity indices, as indicated by the modified Shannon index ($e^{H'}$ A1 = 17; $e^{H'}$ A3 = 16), highlighting the large number of dominant species, as these values approached the total richness found in each environment.

Next, the value found regarding the Pielou index (Figure 7) for the total area was J’= 0.80, indicating that 80% of the maximum hypothetical diversity (H’) was reached. The evenness indices between the environments presented very similar values, however a higher value was observed in A1 than in A2 and A3, which presented the same evenness in the distribution of individuals. The individual distribution in A1 was generally similar between species, resulting in a more uniform environment (J’= 0.90). Some species in A2 and A3 had a greater number of individuals, and consequently a lower J’ value (J’= 0.82). According to Santana, Fonseca and Carvalho (2019), these values indicate a difference in the proportion of individuals that compose these populations, in which a few species have a higher density than the others.

Thus, a statistically significant difference can be seen from the analysis of variance between Absolute Density according to the type of environment ($f = 4{,}940$, $p < 0.05$) and also between Absolute Dominance and the type of environment ($f = 4{,}940$, $p < 0.05$). In this sense, the Tukey’s test revealed a significant difference in pairs between A3 and A1 for both phytosociological parameters, with an average difference in density of 15.8 individuals/ha ($p < 0.05$), with no difference between the other environments. Comparisons of DBH ($f = 1.191$, $p = 0.337$) and Height ($f = 0.283$, $p = 0.758$) between the three environments did not show significant differences (Figure 8).

Figure 8 – Bar representation of the average standard error between the variables and the different environments of the Mata do Passarinho *FURB*



Source: Authors (2024)

Another possible explanation for a greater diversity of species and increasing number of individuals recorded in the A3 environment may be related to the decrease in anthropogenic pressure within the fragment due to natural barriers, such as the slope, which becomes quite accentuated at some points in the fragment areas, in addition to the presence of security agents who work on site to prevent the misuse of natural resources. Therefore, areas closer to the edge become more vulnerable as they are more susceptible to the effects of the urban environment, thus making it difficult for more sensitive species to establish themselves in A1.

In addition to the natural pressures that have been proven to occur in edge areas, such as changes in the microclimate (Paiva; Ribeiro; Carvalho, 2015; Lima *et al*., 2020, Silva *et al*., 2021), this environment can be even more impacted in the urban context by human actions which can alter the forest fragment dynamics. When devoid of planning, human action in edge areas can put the arboreal component's self-perpetuation at risk due to losses in the characteristics of their habitats. As observed by Oliveira *et al*. (2015), this interaction between the anthropic environment and the fragment causes negative effects on the tree community, in which differences can be seen in the diversity, richness and structure of species located on the edge when compared to species established inside the fragment.

3 CONCLUSIONS

It was found that there is variation in the floristic composition (richness, diversity and dispersion type) and structural composition (density, dominance) of the studied urban forest fragment, with this variation being more evident between the edge (A1) and interior (A3) environments. There exists a scenario in which few species predominate, with these belonging to initial ecological groups. In addition, there are a greater number of individuals grouped in the first diameter classes and a greater occurrence of different dispersion types within the fragment compared to the edge area.

The results can contribute to planning and managing the Mata do Passarinho *FURB*, as they indicate that it is necessary to employ actions which aim to establish and direct recovery programs in the CU management plan for the areas which are most affected in composition and structure. Thus, conservation of this environment is ensured, seeking to prevent sudden changes in habitat caused by human pressure from advancing into the fragment interior and compromising the establishment of the most sensitive species.

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