Qualitative & Quantitative Analysis of Adult Arboreal Individuals from the Afforestation in the Municipality of Várzea, Paraíba, Brazil

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Authors’ contributions

This work was carried out in collaboration among all authors. Author ICAR elaborated the study, performed data collection, data analysis, bibliographic research, wrote the first draft and in the final preparation of the manuscript. Author JRM performed the data collection and final writing of the manuscript. Authors GAS and VSGF contributed to the analysis of the data. Authors JRL and EO supervised the study. Authors MPDJ, MBF, GGS and SRVA contributed to the bibliographic research and final elaboration of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Perform a qualiquantitative analysis of adult arboreal individuals in urban roads in the municipality of Várzea, Paraíba, Brazil.
Study Design: Census inventory.

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Place and Duration of Study: Várzea Municipality, Paraíba, Brazil from March to April 2018.

Methodology: The qualitative and quantitative census inventory of adult shrubs-tree individuals was carried out in the urban roads of the municipality, the level of inclusion of the individuals was circumference at breast height (CBH) of (1.30 m) was ≥ 6 cm. Common name of the species was recorded, CBH measurements, height of the first bifurcation and total and physical conditions that were classified as good, regular, bad and dead. The data were tabulated, processed and presented in tables and graphs.

Results: A total of 429 individuals were recorded on public roads distributed in 20 species. *Azadirachta indica* A. Juss and *Ficus benjamina* L. had the highest number of individuals. 85% of the species were exotic and 15% were native. 12 species offered direct nutritional benefit to man and local fauna as they were fruit trees. The physical conditions of the individuals were 55.94% good, 40.33% regular, 3.73% poor, however, 47.50% of individuals had some type of conflict. 41.72% of individuals were concentrated in the diametric class of 15-21 cm. 54.78% of individuals had height of the first bifurcation greater than 200 cm and 62% of the individuals medium size.

Conclusion: The afforestation of the municipality was satisfactory in relation to plant health. Attention needs to be paid to the diversity of native species and the injuries caused to vegetation. The height of the first fork was adequate. The trees were medium sized. It is suggested that studies of perception of afforestation be carried out in the municipality.

Keywords: Urban forestry; tree diagnosis; urban planning.

1. INTRODUCTION

Brazilian cities have grown continuously and disorderly, with this comes the neglect of the tree composition in roads and public places that generate impacts on the urban microclimate [1]. Thus, man tends to increasingly distance himself from natural resources, however, the proposal of sustainable development opens space for another look at the importance of vegetation in urban spaces for the benefits it provides for society. One of the points inherent to the theme urban space is urban afforestation, which comprises urban green areas, which must compose and be integrated to cities, inevitably, as one of the main elements in the urban planning process [2].

Urban afforestation is defined as the set of public and private lands, with predominantly arboreal vegetation (natural or cultivated) present in a city, whether in private areas, squares, parks and public roads [3,4]. Urban afforestation provides a healthy physical environment and is directly related to the presence of plant species in public spaces such as parks, streets, avenues, gardens and squares [5]. Contributed to climatic balance, decreases the speed of winds, beautifies the environment, offers shelter and food to fauna, provides shading and, consequently, thermal comfort [6,7,8].

Studies on urban afforestation are becoming more present because of the various benefits they bring to society. However, it was verified in Almeida's studies; Rondon Neto [9] Sousa; Figueirêdo; Braga [6] that there is a major flaw in the Brazilian afforestation arising from the lack of planning for tree implantation on public roads. Thus, the planning phase is essential for the success of afforestation in the urban environment. The complexity and fragility of urban planning require actions that enhance the functions of afforestation and minimize costs for both the population and public administration [10]. These authors point out that inventories and diagnosis of urban afforestation generate contributions to urban planning.

In order to obtain adequate planning it is necessary to know a qualitative and quantitative characteristics of urban afforestation, as it enables interventions with greater possibilities of success [11]. For this, sampling or census inventories are carried out [12,13]. These are defined according to the objectives they aim to achieve, which will be based on different methodologies and may present different degrees of precision [14].

For the evaluation of the problems of afforestation of public roads, the census is considered an appropriate approach, as it allows an accurate analysis of the existing damages [15]. Thus, in-depth studies of urban afforestation become increasingly necessary, as they prove the contribution of afforestation in improving the quality of life of the population [16]. In this sense, this study aimed to make a qualitative and
quantitative analysis of adult arboreal individuals from the streets of the urban area of Várzea in the state of Paraíba, Brazil through a census inventory.

2. MATERIALS AND METHODS

The study was carried out in the urban area of the municipality of Várzea (Fig. 1), located in the Metropolitan Region of Patos, in the state of Paraíba, Brazil. This municipality is located in the semi-arid region of northeastern Brazil, with an altitude of 265 meters, under the coordinates 06°6'88" S, 36°59'02" O°.

According to the Köppen classification the climate is BSh type, hot and dry, with average annual rainfall of 600 to 800 mm with irregular distribution [17]. The vegetation is of the Caatinga-Seridó type and the average annual temperature is 28°C [18]. The soils of the region are characterized by the association of soils of the types Neossolos Litolicos, Luvisolos and Rocky Outcrops [19]. According to IBGE data [20], the municipality has a population of 2,504 people, has a territorial area of approximately 190,526 km², a demographic density of 13.15 hab/km² and 96.8% of its wooded public roads.

The study of urban afforestation was carried out from March to April 2018, in which a qualitative and quantitative survey of adult arboreal individuals present in all streets of the municipality of Várzea-PB was carried out. All individuals with circumference at breast height (CBH = 1.30 m from the ground) greater than or equal to six centimeters were included. The data were recorded in spreadsheets, including the common name of the species, CBH (circumference at breast height) measurements, height of the first bifurcation, total height and physical conditions.

The specimens were identified in loco, and in case of doubt, the material was collected in exsiccates for further identification through consultation of the literature [21,22,23]. The Species List of Flora Brasil 2020 was consulted for the spelling of the scientific names and for the classification of native and exotic species from Brazil. The families of specimens were classified according to the APG IV [24].

Fig. 1. Location of the municipality of Várzea in the state of Paraíba, Brazil
The measurements of CBH and height of the first bifurcation were made with the aid of a graduated measuring tape of approximation of 0.5 cm, total heights were estimated with the aid of a graduated stick with intervals of 0.5 m. Subsequently, the CBH data were transformed into diameter at breast height and for individuals who presented more than one bifurcation at breast height (1.30 m), the equivalent diameter at breast height of the tree was performed. The individuals were classified according to the physical-sanitary aspect and the size.

Physical conditions were classified according to Sousa; Figueirêdo; Braga [6] as good (without any kind of pest or signs of vandalism or drastic pruning), regular (with mild presence of pests), bad (severe attack of pests or drastic pruning) and dead (difed). Regarding size, the individuals were classified according to the height in small (up to 4 meters), medium (4 - 7 meters) and large (greater than 7 meters), according to the methodology used by Salvi et al. [25].

The data were annotated in field worksheets and then tabulated in Microsoft Office Excel 2010 software, where they were processed and presented in tables and graphs.

3. RESULTS AND DISCUSSION

A total of 429 arboreal individuals were recorded on public roads, distributed in 14 botanical families and 20 species (Table 1). The *Azadirachta indica* A. Juss and *Ficus benjamina* L. were responsible for the greatest predominance in the afforestation of the municipality, because together they presented 79.73% of the individuals.

*Azadirachta indica* was the most found species in this study. These individuals are characterized by being attractive trees, with a large amount of leaves that are always green, with leaflets in odd numbers, alternating, with leaflets of intense light green coloration, which fall only in cases of extreme drought, the roots penetrate deeply into the soil, when the site allows, and when they suffer some kind of damage, produce shoots, the root system of the plant is composed of a pivoting root, responsible mainly for the support, and for allowing the removal of water and nutrients at great depths and with auxiliary lateral roots [26]. Still according to the authors, this species has strong potentiality as an insecticide. The sprinkling of seed and leaf powder is applied to crops for pest control such as caterpillar, the spraying of aqueous extracts or emulsifiable oil solutions for insect and other leaf pest control.

The ideal for urban afforestation planning is that each species should not exceed 15% of the total individuals of the tree population [27,28,29]. Thus, it is notable that the afforestation of the studied municipality was not satisfactory in this respect, because there is a discrepancy in the distribution of individuals by species, which was confirmed by the frequency of individuals in *Azadirachta indica* that it represented 68.07% of the total number of individuals.

A similar result was verified in the municipality of Santa Helena-PB, in which 69.2% of the inventoried individuals were of the species *Azadirachta indica* [30]. As in a study conducted in the city of Baixoï-CE, who observed a strong predominance of *Azadirachta indica*, corresponding to 68% of the total individuals [31].

The *Ficus benjamina* also presented frequency of individuals (11.66%) compared to other species. These results corroborate the study conducted in the center of Juazeiro-BA, where a large amount of *Ficus benjamina* was found [32]. In the research conducted in the municipality of Pombal-PB, a higher concentration of individuals was also observed in a few species [33]. This shows a lack of landscape planning, and the need for more scientific work in this area to improve the understanding and planning of urban forests. High frequencies of the same species causes very serious damage and can compromise the entire forest cover of the municipality in case of attack of diseases or pests [30].

In addition, it was also found that 85% of the species found were of exotic origins and only 15% were native. Studies in the municipality of Recife-PE found that at least 60% of the species raised in Jaqueira Park were exotic, this fact may be derived from the lack of knowledge of native species present in Brazil or by the easy adaptation of exotic species to environmental conditions and, therefore, many exotic so still remain used in urban afforestation instead of native Brazilian species [34].

Sousa, Figueirêdo and Braga [6] highlight the importance and richness of the Native Brazilian flora because it has species of great landscape value. They also emphasize that these species, besides being adapted to local climatic conditions, ensure the presence of regional landscape references.
Table 1. List of species recorded in the afforestation of the municipality of Várzea, Paraíba, Brazil with their respective scientific names, popular name, family, origin, frequency and relative frequency

<table>
<thead>
<tr>
<th>Species</th>
<th>Common name</th>
<th>Family</th>
<th>Origin</th>
<th>FR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azadirachta indica A. Juss</td>
<td>Nim</td>
<td>Meliaceae</td>
<td>Exotic</td>
<td>68.07</td>
</tr>
<tr>
<td>Ficus benjamina L.</td>
<td>Ficus</td>
<td>Moraceae</td>
<td>Exotic</td>
<td>11.66</td>
</tr>
<tr>
<td>Citrus limon (L.) Burm. F.</td>
<td>Limoeiro</td>
<td>Rutaceae</td>
<td>Exotic</td>
<td>3.73</td>
</tr>
<tr>
<td>Prosopis juliflora (SW. DC)</td>
<td>Algaroba</td>
<td>Fabaceae</td>
<td>Exotic</td>
<td>3.26</td>
</tr>
<tr>
<td>Bauhinia forficata Link</td>
<td>Pata de vaca</td>
<td>Fabaceae</td>
<td>Native</td>
<td>2.56</td>
</tr>
<tr>
<td>Mangifera indica L.</td>
<td>Manguinha</td>
<td>Anacardiaceae</td>
<td>Exotic</td>
<td>2.56</td>
</tr>
<tr>
<td>Terminalia catappa Linn.</td>
<td>Castanhola</td>
<td>Combretaceae</td>
<td>Exotic</td>
<td>1.86</td>
</tr>
<tr>
<td>Senna siamea (Lam.) Irwin &amp; Barneby</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carica papaya L.</td>
<td>Mameiro</td>
<td>Caricaceae</td>
<td>Exotic</td>
<td>0.70</td>
</tr>
<tr>
<td>Tabebuia aurea (Silva Manso)</td>
<td>Craíbeira</td>
<td>Bignoniaceae</td>
<td>Exotic</td>
<td>0.70</td>
</tr>
<tr>
<td>Benth. &amp; Hook. f ex S. Moore</td>
<td></td>
<td></td>
<td>Native</td>
<td></td>
</tr>
<tr>
<td>Annona squamosa L.</td>
<td>Pinheira</td>
<td>Annonaceae</td>
<td>Exotic</td>
<td>0.47</td>
</tr>
<tr>
<td>Psidium guajava L.</td>
<td>Goiabeira</td>
<td>Myrtaceae</td>
<td>Exotic</td>
<td>0.47</td>
</tr>
<tr>
<td>Sapindus saponaria L.</td>
<td>Saboeiro</td>
<td>Sapindaceae</td>
<td>Native</td>
<td>0.47</td>
</tr>
<tr>
<td>Spondias purpurea L.</td>
<td>Siriguela</td>
<td>Anacardiaceae</td>
<td>Exotic</td>
<td>0.47</td>
</tr>
<tr>
<td>Anacardium occidentale L.</td>
<td>Cajuete</td>
<td>Anacardiaceae</td>
<td>Native</td>
<td>0.23</td>
</tr>
<tr>
<td>Annona muricata L.</td>
<td>Graviola</td>
<td>Annonaceae</td>
<td>Exotic</td>
<td>0.23</td>
</tr>
<tr>
<td>Citrus sinensis L.</td>
<td>Laranjeira</td>
<td>Rutaceae</td>
<td>Exotic</td>
<td>0.23</td>
</tr>
<tr>
<td>Cocos nucifera L.</td>
<td>Coqueiro</td>
<td>Areaceae</td>
<td>Exotic</td>
<td>0.23</td>
</tr>
<tr>
<td>Gibasis pellucida</td>
<td>Véu de noiva</td>
<td>Commelinaceae</td>
<td>Exotic</td>
<td>0.23</td>
</tr>
<tr>
<td>(M. Martens &amp; Galeotti) D.R. Hunt</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Morinda citrifolia L.</td>
<td>Noni</td>
<td>Rubiaceae</td>
<td>Exotic</td>
<td>0.23</td>
</tr>
</tbody>
</table>

*FR - Frequência relative


The problem of fruit trees in urban afforestation is the risk of incidents, among which can be cited the fall of fruits in people and cars. Thus, the fruit trees used in urban afforestation must have small to medium-sized fruits, as described in the work of Lacerda et al. [35] on the indication of species used in urban afforestation of the Semi-arid Paraíba.

Regarding plant health, it was observed that more than half of the individuals presented adequate survival conditions and there were no individuals killed in urban public roads (Fig. 2). In the studies of Sousa, Figueirêdo and Braga [6] conducted in the municipality of Sobral-CE results similar to that of this study were found, in which 73.54% of the individuals studied were in good condition, only 3.82% found poor condition and only 0.64% of the individuals were dead.

It was verified that 47.5% of individuals present some type of problem, such as: conflicts with home, wiring, sidewalks, flower beds (58.3%), injuries (26.5%) or drastic pruning (15.2%). It was observed that some individuals who make up the afforestation of the municipality suffered from attitudes such as perforations of nail, screw, cords and hoses perforations strongly tied to the trunk, lathes and other human actions that cause damage to the plants (Fig. 3 (A) and (B)).

The results of the phytosanitary were positive for the survey conducted in the municipality, mainly due to the lack of dead individuals on public roads. However, it is important to highlight the damage that arboreal individuals have been suffering from human injuries as previously shown, so it is important that environmental awareness policies are adopted in order for citizens to become aware of the environmental
damage they cause with small attitudes such as a nail perforation in a tree.

Regarding diameters, it was found that the largest number of individuals is in the central diameter class (Fig. 4), and 41.72% between 15-21 cm and 33.10% in the class of 8-14 cm, indicating that the individuals who make up the afforestation of the municipality of Várzea - PB could be considered young. In a study developed by Melo; Lira Filho and Rodolfo Junior [36], in the Bivar Olinto neighborhood, in the municipality of Patos-PB, the highest concentration of individuals (60%), had the DAP of less than 10 cm.

Regarding the distribution of individuals at the time of the first bifurcation (Fig. 5), the afforestation of the municipality was within the standards, since majority of individuals (54.78%) presented height of the first bifurcation greater than 200 cm (2.0 m). In the Sampaio studies [38] it is indicated that the height of the first bifurcation is greater than 180 cm (1.8 m), so as not to hinder the transfer between urban roads. Thus, this result emphasizes that the trees passed through the appropriate forestry tracts. Melo; Lira Filho and Rodolfo Junior [36] in Bivar Olinto, municipality of Patos-PB, found a higher proportion of individuals with bifurcation height of less than 100 cm (1.0 m).

Afforestation individuals were classified in majority (62%) in medium height (4-7 meters) (Fig. 6). Usually Azadirachta indica is characterized by being 15 to 20 meters tall [26]. By relating the results of the heights found in this study with the average height of this species it is possible to observe that there are few individuals with height greater than seven meters, this can be justified by the fact that it is a young population, by the very conditions to which they are subject or even by the forestry tracts that trees have in urban afforestation, such as pruning.
Fig. 4. Distribution in diameter classes of individuals from the afforestation of the municipality of Várzea, Paraíba, Brazil

Fig. 5. Distribution of individuals in the height classes of the first bifurcation in the municipality of Várzea, Paraíba, Brazil

Fig. 6. Classification of the total heights of individuals surveyed in the municipality of Várzea, Paraíba, Brazil
In a way, it is of paramount importance to note that there is a small percentage of large trees and these can cause conflicts with wiring. Trees in the urban area with a height of more than five meters tend to reach the network of electrical services and are subject to inappropriate pruning that deforms vegetables and, in many situations, compromises their integrity and development [25]. These same authors say that the contributions made by vegetation in urban environments, such as ecosystem services, should constitute sufficient elements to boost the search for alternatives to situations that represent conflicts between the various infrastructure services.

4. CONCLUSION

The afforestation of the municipality of Várzea, Paraíba, Brazil proved to be satisfactory from a phytosanitary point of view, however, there are conflicts with the vegetation, among them are the injuries caused by the population itself. Although the diversity of species in the afforestation of the municipality is positive, the largest number of individuals was present in four exotic species: Azadirachta indica A. Juss, Ficus benjamina L., Citrus limon (L.) Burm. F. and Prosopis juliflora (SW. DC), being necessary to pay attention in this aspect because the ideal is to prioritize the use of native trees mainly from the region. The height of the first bifurcation of the trees is adequate, avoiding conflicts with pedestrians or cars on public roads. Most individuals presented size of 4 to 7 meters in height and diameter at breast height between 15 and 21 centimeters and may indicate that it is a young vegetation. It is suggested that studies of urban afforestation perception be carried out with the population to subsidize environmental education activities, aiming to sensitize the population to the functions of afforestation and its influence on the quality of life of society.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES


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