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Assessment of Tree Species Diversity and Abundance in Forest Arboretum and Adjacent Farm at Badole, Dutsin-Ma

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ABSTRACT
Background and Objective: The knowledge of tree species diversity and abundance serves as baseline information to know the status of the tree species which is basic in understanding regeneration processes, such as tree growth, tree mortality, under-story development and the spread of disturbances. It provides baseline research data to different stakeholders of the Forest Arboretum Badole, Federal University Dutsin-Ma. The objectives of the study were to evaluate the abundance of trees, identify the diversity in the tree species and enumerate tree species present in the study area. **Materials and Methods:** A field inventory of tree flora was adopted for data collection. The study area was divided into two (sites A and B). Using the footpath as a transect for sampling, all tree species were counted with their frequency of occurrence, height and diameter. **Results:** There were 1608 trees identified with 13 tree species and 8 families. Families of Fabaceae had frequencies of 5, Meliaceae 2, Anacardiaceae, Asteraceae, Chrysobalanaceae, Ebenaceae, Moringaceae and Myrtaceae have the frequency of 1 each. Margalef species richness index was 1.6385 for site A and 2.6538 for site B while Shannon-Wiener diversity index was 0.0409 and 0.2765 for sites A and B, respectively. **Conclusion:** Comparing the levels of diversity using Sørensen's similarity coefficient, both sites are only 25% similar. Anthropogenic activities are the major reasons behind the rapid decrease in the tree species in the study area.

KEYWORDS
Arboretum, tree flora, economic trees, margalef index, Shannon-Weiner index, species diversity, weather

INTRODUCTION
Arboretum plays a central role in the *ex-situ* conservation and exploration of global plant biodiversity (Mounce *et al.*[1]). One of the targets of the Global Strategy for Plant Conservation (GSPC) is to have 70% of the world's threatened plant species conserved *ex situ* (Huang *et al.*[2]). Arboretum serves as sources of plant ecology data collection such as plant growth tactics, the phenological indication of climate change, plant physiology and plant-animal interactions.

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Forest resources have the natural ability to renew themselves which offers the man a great opportunity to tap these resources for his benefit. The availability of a reliable database on the potential, extent and state of the resources, is a basic requirement for a sound forest management strategy.

An increase in anthropogenic activities like cutting of trees for firewood, charcoal production and infrastructural developments make trees undergo different levels of disturbance over the years (Omoro *et al.*[3]). This has impacted tree diversity and abundance. Patel and Patel[4] and Ajayi *et al.*[5] stated that trees constitute an integral part of human existence and that they provide raw materials, foods, shelter, clothing, medicine, oral care, fuel wood and woodcraft for humans, fodder and forage for livestock.

Diversity and abundance of tree species are fundamental to total forest biodiversity because trees provide resources and habitat for almost all wildlife species (Malik *et al.*[6] and Singh *et al.*[7]).

Data on tree species diversity and abundance will serve as baseline information to know the status of the tree species in the study area, which is basic in understanding regeneration processes, such as tree growth, mortality, under-story development and the spread of disturbances (Attua and Pabi[8] and Gonçalves *et al.*[9]). The objectives of the study were to evaluate the abundance of trees, Identify the diversity in the tree species and enumerate tree species present in the study area.

MATERIALS AND METHODS

Study area: The arboretum and adjacent farm are located at Badole. Badole is located in Dutsin-Ma local government area, in Katsina State Nigeria. Dutsin-Ma is located at 12°27'18"N and longitude 7°29'29"E. This research project was conducted from 2020-2021.

Data collection: A field inventory of tree flora was adopted for data collection. The study area was divided into two (sites A and B) for accurate recording of different tree species. Site A covered the entire forest Arboretum while B was the adjacent farm. Using the footpath as a transect, sampling was done on both sites to enable accurate enumeration of all tree species. Field surveys were conducted. Through these surveys, all the tree species encountered within the sample areas were recorded as well as their frequency of occurrence, height and diameter. During data collection, the sites were marked using wooden pegs, within the sites, all tree species present were identified and counted.

Data analysis

Basal area calculation: The basal area of all trees in the two sites was calculated using the formula[10-12]:

$$BA = \left[\frac{\pi D^2}{2}\right] \tag{1}$$

Where:

BA = Basal area (m^2)

D = Diameter at breast height (cm)

pi = 3.142

The total basal area for each of the sites was obtained by adding the BA of all trees in the site while the mean BA for the site (BAP) was obtained by dividing the total BA by the number of sites.

Basal area per hectare was obtained by multiplying the mean basal per site:

$$BA/ha = BAP \times 2 \tag{2}$$

Where:
BA/ha = Basal area per hectare

From each site, diversity indices were determined using the following:

- Margalef species richness index (d), which is used as a simple measure of species richness according to Margalef:

$$D = (S-1)/\ln N \tag{3}$$

Where:
S = Total number of species
N = Total number of individuals on the site and
In = Natural logarithm

- Shannon-Weiner index (H), which is the measure of diversity within a site according to Shannon and Wiener:

$$H = -\sum Pi \ln Pi \tag{4}$$

Where:
Pi = S/N
S = Number of individuals of one species
N = Total number of all individuals on the site and
In = Natural logarithm

- Sørensen similarity coefficient (C_S), measures similarity in species composition for two sites, A and B, according to Sørensen.

$$Cs = \left(\frac{2.C}{A+B}\right) \tag{5}$$

Where:
C = Number of species found in both sites
A = Number of species found only in site A
B = Number of species found only in site B. Expressed as a percentage of similarity or dissimilarity.

$$\text{Relative density of species (RD)} = \frac{\text{No of individuals of the species}}{\text{Total no of individuals of all species}} \times 100 \tag{6}$$

$$\text{Relative abundance of (Pi)} = \frac{\text{Total number of individual species}}{\text{Total number of species populaion}} \times 100 \tag{7}$$

RESULTS

There were 13 tree species present in the study area, they include the following, *Delonix regia*, *Piliostigma thonningii*, *Azadirachta indica*, *Albizia lebbeck*, *Khaya senegalensis*, *Eucalyptus camaldulensis*, *Moringa oleifera*, *Anacardium occidentale*, *Gliricidia sepium*, *Vernonia amygdalina*, *Diospyros mespiliformis*, *Tamarindus indica* and *Parinari macrophylla*. The botanical names, common names and families of all the tree species encountered in the study area were presented in Table 1.

Table 1: Botanical names, common names and families of all the tree species encountered in the study area

Botanical Names	Common names	Family
Eucalyptus camaldulensis	River red gum	Myrtaceae
Khaya senegalensis	African mahogany	Meliaceae
Moringa oleifera	Drumstick tree	Moringaceae
Albizia lebbeck	Silk plant	Fabaceae
Delonix regia	Flame of the forest	Fabaceae
Gliricidia sepium	Forest lilac	Fabaceae
Piliostigma thonningii	Camel's foot	Fabaceae
Vernonia amygdalina	Bitter leaf	Asteraceae
Parinari macrophylla	Gingerbread plum	Chrysobalanaceae
Anacardium occidentale	Cashew	Anacardiaceae
Azadirachta indica	Neem	Meliaceae
Tamarindus indica	Tamarind	Fabaceae
Diospyros mespiliformis	African ebony	Ebenaceae

Source: Field survey 2021

Table 2: Families and their number of tree species

Families	Number of tree species
Anacardiaceae	1
Asteraceae	1
Chrysobalanaceae	1
Ebenaceae	1
Fabaceae	5
Meliaceae	2
Moringaceae	1
Myrtaceae	1

Source: Field survey 2021

Table 3: Total count of trees within the study area

Tree Species	Site A	Site B	Total
Albizia lebbeck	66	0	66
Anacardium occidentale	9	0	9
Azadirachta indica	0	22	22
Delonix regia	122	0	122
Diospyros mespiliformis	0	1	1
Eucalyptus camaldulensis	672	66	738
Gliricidia sepium	3	0	3
Khaya senegalensis	399	0	399
Moringa oleifera	178	0	178
Parinari macrophylla	19	0	19
Piliostigma thonningii	26	0	26
Tamarindus indica	0	3	3
Vernonia amygdalina	22	0	22
Total	1516	92	1608

Source: Field survey 2021

Timber-producing trees dominated the species. The economic roles of these tree species include medicinal, auxiliary purposes and food. Biofuels may also be extracted from some of them while others are used to beautify the environment. Table 2 presented the families and the number of tree species belonging to each family. A total of 8 families were identified. Table 3 represented the total count of tree flora in the study area. The Myrtaceae family had the highest number of individuals with a total number of 738. Table 4 represented the tree species in the study area and their respective relative densities (RD), relative abundance (Pi), Margalef species richness index (d) and Shannon-Wiener diversity (H). *Eucalyptus camaldulensis* had the highest relative density of 45.90 followed by *Khaya senegalensis* with 24.81.

Table 4: Tree species, their relative density, relative abundance, Margalef species richness and Shannon-Wiener diversity indices

Tree Species	RD	Pi	d	H
Albizia lebbeck	4.10	0.0410	8.8043	0.1310
Anacardium occidentale	0.56	0.0056	1.0836	0.0290
Azadirachta indica	1.37	0.0137	2.8445	0.0588
Delonix regia	7.59	0.0759	16.3896	0.1957
Diospyros mespiliformis	0.06	0.0006	0.0	0.0045
Eucalyptus camaldulensis	45.90	0.4590	99.8273	0.3574
Gliricidia sepium	0.19	0.0019	0.2709	0.0119
Khaya senegalensis	24.81	0.2481	53.9095	0.3458
Moringa oleifera	11.07	0.1107	23.9748	0.2436
Parinari macrophylla	1.18	0.0118	2.4381	0.0524
Piliostigma thonningii	1.62	0.0162	3.3863	0.0668
Tamarindus indica	0.19	0.0019	0.2709	0.0119
Vernonia amygdalina	1.37	0.0137	2.8445	0.0588

RD: Relative density, Pi: Relative abundance, d: Margalef species richness index and H: Shannon-wiener diversity

Table 5: Families, their relative density, relative abundance, Margalef species richness index and Shannon-Wiener diversity

Families	RD	Pi	d	H
Anacardiaceae	7.69	0.0769	0	0.1973
Asteraceae	7.69	0.0769	0	0.1973
Chrysobalanaceae	7.69	0.0769	0	0.1973
Ebenaceae	7.69	0.0769	0	0.1973
Fabaceae	38.46	0.3846	1.5595	0.3675
Meliaceae	15.38	0.1538	0.3899	0.2879
Moringaceae	7.69	0.0769	0	0.1973
Myrtaceae	7.69	0.0769	0	0.1973

RD: Relative density, Pi: Relative abundance, d: Margalef species richness index and H: Shannon-Wiener diversity

Table 6: Margalef species richness and Shannon-Wiener diversity indices for each site

Site	Margalef	Shannon-Wiener
A	1.6385	0.0409
B	2.6538	0.2765

Table 7: Tree growth variables obtained in the study areas

Variable	Values
Basal area (m^2)	10.683
Basal area (m^2)/ha	21.366
Average DBH (m)	0.068
Average height (m)	5.9

Table 5 presented the families of the trees and their respective relative densities (RD), relative abundance (Pi), Margalef species richness index (d) and Shannon-Wiener diversity (H). The Fabaceae family was the most abundant family followed by the Meliaceae family. Table 6 represented the computed values of Margalef species richness and Shannon-Wiener diversity for sites A and B. Table 7 represented the comparison of the level of diversity between sites A and B and computed values of Sørensen’s coefficient for comparing their similarities.

Table 8 showed that there were relatively few trees with large DBH values greater than 0.50 m (DBH>0.50 m).

A comparison of the level of diversity and Sørensen’s coefficient for similarities between sites showed that the Sørensen index (50%) was 25% indicating that the two sites were not similar.

Table 8 showed the population of tree species, the average DBH of tree species and the average height of tree species. Site A has the highest population of tree species with a total of 1516, while site B has 92 populations of tree species.

Table 8: Population, average DBH, height and species total of trees in the study area

	Site A			Site B			
	Population	Average DBH (m)	Average height (m)	Population	Average DBH (m)	Average height (m)	Specie Total
Albizia lebbeck	66	0.068	6.3	0	-	-	66
Anacardium occidentale	9	0.054	5.1	0	-	-	9
Azadirachta indica	0	-	-	22	0.086	7.8	22
Delonix regia	122	0.039	4.8	0	-	-	122
Diospyros mespiliformis	0	-	-	1	0.067	4.3	1
Eucalyptus camaldulensis	672	0.037	7.1	66	0.042	5.1	738
Gliricidia sepium	3	0.042	4.6	0	-	-	3
Khaya senegalensis	399	0.053	6.8	0	-	-	399
Moringa oleifera	178	0.030	5.9	0	-	-	178
Parinari macrophylla	19	0.029	4.3	0	-	-	19
Piliostigma thonningii	26	0.038	4.1	0	-	-	26
Tamarindus indica	0	-	-	3	2.30	14.3	3
Vernonia amygdalina	22	0.032	4.7	0	-	-	22
Total	1516			92			1608

Source: Field Survey 2021

Eucalyptus camaldulensis has the highest population representation in both sites while *Diospyros mespiliformis* has the least representation of the individual population. *Albizia lebbeck* species have the highest DBH of (0.068) in site A and *Tamarindus indica* with DBH of (2.30) have the highest DBH in site B. While *Parinari macrophylla* has the least DBH representation in site A and *Eucalyptus camaldulensis* has the least DBH in site B. The result of DBH shows that the average tree species at site B has higher DBH, the species are more mature than those in site A.

In site, A *Eucalyptus camaldulensis* has the highest average height and *Tamarindus indica* has the highest average height in site B. while *Piliostigma thonningii* has the lowest height in sight A and *Diospyros mespiliformis* has the lowest height in site B. The result showed that the species in the site were taller than the species in site A.

DISCUSSION

The result from this study shows that there were diverse tree species in the study area and they provide essential services to the inhabitants. Omoro *et al.*[3] reported that early humans depended on natural woodlands for foods such as fruit and nuts. However, the flora of the study area is under threat from anthropogenic activities. Omoro *et al.*[3] and Matilo *et al.*[13] reported the loss of tree diversity is created by over-exploitation and is recognized as a major environmental and economic problem around the world. The attitude of the inhabitants of the study area towards the conservation of trees is poor and it requires urgent attention. Gutschick and Bassirirad[14] observed that the conservation of tree species is basic to human welfare and survival. Jara-Guerrero *et al.*[15] reported that anthropogenic activities produce chronic disturbances by of low intensity. Activities like selective logging and free-range grazing drive a loss of woody species richness. That is, chronic disturbances are generating environmental modifications through the lessening of large trees, thus favoring the establishment of a small group of species that better tolerate drought which implies exclusion of particular species and showed a weak effect on species richness. When the species richness is high, it is an indication that the diversity value is also high. Most of the species had a relative density of less than 1.00 and may be considered threatened or endangered. Wardle *et al.*[16] also recorded anthropogenic activities affecting the abundance of species.

The most abundant family is Fabaceae having a relative density of 38.46. This is in line with Ajayi *et al.*[5], who reported the Fabaceae family as the most abundant in a forest reserve. Most individual species identified were dicotyledonous trees this may likely be due to the long tap roots which they used to source water deep down in the soil.

Results suggest that site A had the highest species richness and was more diverse compared to site B. Sørensen's coefficient indicates that there is no similarity between sites A and B though they are adjacent to each other. The constraints to tree availability in the study area as include building constructions, unlawful felling of trees and lack of orientation of the inhabitants on the uses of trees. Wardle *et al.*[17] also recorded anthropogenic activities affecting the abundance of species. For planning conservation strategies, there is a need to determine the few essential measurable properties, such as number of species and basal area, that best describe the arboretum and the adjacent farm and to document quantitative findings by Sagar and Singh[18]. The arboretum should be adequately stocked with mixture of indigenous and exotic tree species. Conservative measures should be put in place to checkmate the disappearance indigenous trees as well as promote the cultivation of more trees. Awareness and orientation should be given to the inhabitants on the sustainable uses of trees as well as the negative effects of unlawful felling of trees. The trees must be properly labelled with the summaries of their values. The study is limited to the arboretum and adjacent farm of Federal University Dutsin-Ma, Katsina State.

CONCLUSION

The tree sampled in the study area was in the state of rapid decrease. Hence, the study therefore, is inclined to describe tree composition in the study area as poor. Some of indigenous trees are now endangered. It was observed that anthropogenic activities are the major reasons behind the rapid decrease. Field observation showed that the trees were not properly managed. Diversity and abundance of tree species are fundamental to total forest biodiversity and data on tree species diversity and abundance will serve as baseline information to know the status of the tree species in the study area, which is basic in understanding regeneration processes, such as tree growth, mortality, under-story development and the spread of disturbance.

SIGNIFICANCE STATEMENT

This study discovered there were 8 families and 13 tree species present in the study area and Fabaceae families were the most abundant. Knowledge of tree species diversity and abundance will serve as baseline information to know the status of the tree species in the study area, which is basic in understanding regeneration processes and the spread of disturbances. Moreover, it will provide baseline research data to different stakeholders of the study area and help to those who want to raise economic species for different purposes. There is a need to describe tree species abundance and diversity quantitatively to enhance overall productivity. This study is of priority to individuals willing to go into full-time forest/plantation establishment or agroforestry farming systems.

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