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Assessment of Growth Characteristics, Diversity and Structure of Tree Species in Opara Forest Reserve, Oyo State, Southwest Nigeria

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ABSTRACT: Having information about the existing stands and their structure within a forest is important, as it helps in understanding the biodiversity depth and climate change adaptation potential. Therefore, the objective of this study was to assess the growth characteristics, diversity and structure of tree species in the Opara Forest Reserve on the Nigeria-Benin Republic Fringes in Oyo State, Southwest Nigeria using appropriate standard techniques. A total of 218 trees were enumerated and assessed. The results indicated that the forest reserve is primarily characterized by the prevalence of savanna species. The dominant species within the study area consists of 80 stands of *Anogeissus leiocarpus*; *Vitellaria paradoxa* exhibits the highest mean diameter at breast height (dbh), measuring 100.09 cm and *Acacia faidherbia* had highest value in height. The forest reserve is characterised by the dominance of trees within the 6-10 metre height range. In conclusion, the forest reserve exhibits a moderate level of species variety with favourable growth characteristics and the average height of the trees are typical of a savanna forest.

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Tropical forests are an essential ecological niche for diverse organisms, contributing to overall biodiversity and facilitating the interconnectedness of various life forms. These forests provide a wide range of natural resources that support local communities and play a crucial role in supporting human survival, economic well-being, environmental production, and balance (Nirmal *et al*., 2011). According to Purvis *et al*. (2000), biodiversity is a unifying concept encompassing biological variations at several levels, including genetics, species, ecosystems, landscapes, and associated ecological processes. Adekunle *et al*. (2004) reported that rainforests typically exhibit a higher number of tree species per hectare, ranging from 100 to 300, in comparison to temperate forests. Tropical rainforests have been identified as the most intricate ecosystems on Earth in terms of tree composition and species diversity (Humphrey, 2015). Nigeria has experienced shortcomings due to the failure to consistently replace harvested trees as

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intended by the government and neglecting the administration of forest reserves. According to Oyinloye (2008), this has led to escalating risks faced by forest reserves, encompassing both indigenous and non-native plant species, due to human activities. The escalation of biotic activities resulting from population growth and urbanization constitutes a significant contributing factor to the overexploitation of natural resources in forested areas (Maliyat and Datt, 2010). The forest has served as a consistent provider of timber, charcoal, and arable land, resulting in its current state of depletion (Ikehi *et al*., 2015). Trees offer numerous ecological services, such as species conservation, soil erosion mitigation, and providing habitats for various flora and fauna. However, the excessive exploitation of floristic composition has led to the swift depletion of tree diversity, a phenomenon widely acknowledged as a significant global environmental and economic concern (Mani and Parthasarthy, 2006; Armenteras *et al*., 2009).

Sustainable development necessitates the coexistence of humans and forest biodiversity (Ogwu *et al*., 2016). Hence, assessing the present state of species variety, composition, and abundance is crucial to safeguard the preservation of tree diversity and abundance within our forest ecosystem. Furthermore, the assessment of the tree population in a forest reserve is an important part of climate change studies because it offers insights into the effects of climate change on ecosystems as well as the contribution of forests to mitigating climate change through carbon sequestration and biodiversity preservation. A notable obstacle in comprehending the operational dynamics of forest ecosystems in Nigeria is the scarcity of regular data regarding stand conditions. Nevertheless, the attainment of sustainable forest management necessitates the availability of up-to-date and dependable data regarding the growth status of forest stands.

This information is crucial for forest managers, as it enables them to furnish precise and timely reports on the existing volume of increasing stock. Hence, the objective of this study was to assess the and growth characteristics, diversity and structure of the tree species in the Opara Forest Reserve on the Nigeria-Benin Republic Fringes in Oyo State, Southwest Nigeria.

MATERIALS AND METHODS

Location of the study area: Opara forest reserve is located in Oyo State, southwest Nigeria on the border of the Benin Republic. It is situated on Latitude 8°4'59.99" and Longitude 2°49'59.99". The estimated terrain elevation above sea level is 269 metres. Opara forest reserve, spans three Local Government Areas of Oyo State (Atisbo, Saki, and Iwajowa), and occupies about 73% of all the total hectares of the forest reserves, at 248,640 (ha).

Sampling techniques: A multistage sampling procedure was used in selecting the community and the enclave selected for this study. The Aiyegun axis of the forest reserve, which is domiciled in Iwajowa Local Government area, was selected based on the concentration of diverse tree species due to heavy deforestation in the major parts of the forest reserve (Olajuyigbe *et al*., 2023).

A systematic sampling technique was adopted on the study site. A baseline of 1000 meters was established, 20 meters away from the forest's edge. After that, 2 line transects were set at 200 meters intervals along the baseline, and five plots of 30 m x 30 m were alternately laid on each transect, making a total of 10 sample plots.

Method of data collection: A total enumeration of all the trees in the sample plots was carried out. Data were collected on dbh (cm), and total height (m), and these parameters were used to compute basal area (m^2) and volume (m^3).

Diameter measurements of all trees (over bark) at breast height (1.3 m above ground, DBH) were measured with diameter tape to an accuracy of 0.1 cm. the total height of the trees were measured with the aid of Speigel relascope.

Data analysis: The data collected from the study, diameter at breast height (Dbh), and height were subjected to descriptive analysis.

Tree Species Diversity: From each site, the Shannon index was employed in determining species diversity and richness:

Shannon-Weiner index (H): which is the measure of diversity within site according to Shannon and Wiener (1949)

$$H' = -\sum_{i=1}^{s} p_i \, 1n(p_i)$$

Where Pi = S/N, S = number of individuals of one species, N = total number of all individuals in the site, and Ln = logarithm to base.

Forest Structure Analysis

Basal area: the basal area of all trees in the sample plots was calculated using the formula:

$$BA = \frac{\pi D^2}{4}$$

Where, BA = Basal area (m^2), D = Diameter at breast height (cm) and π = pie. The total basal area for each plot was obtained by adding all the trees' basal areas.

Volume: the volume of each tree was calculated in every plot using Newton's formula:

$$V = BA \times Height$$

Where, V = Tree volume (m^3), BA is the basal area (m^2).

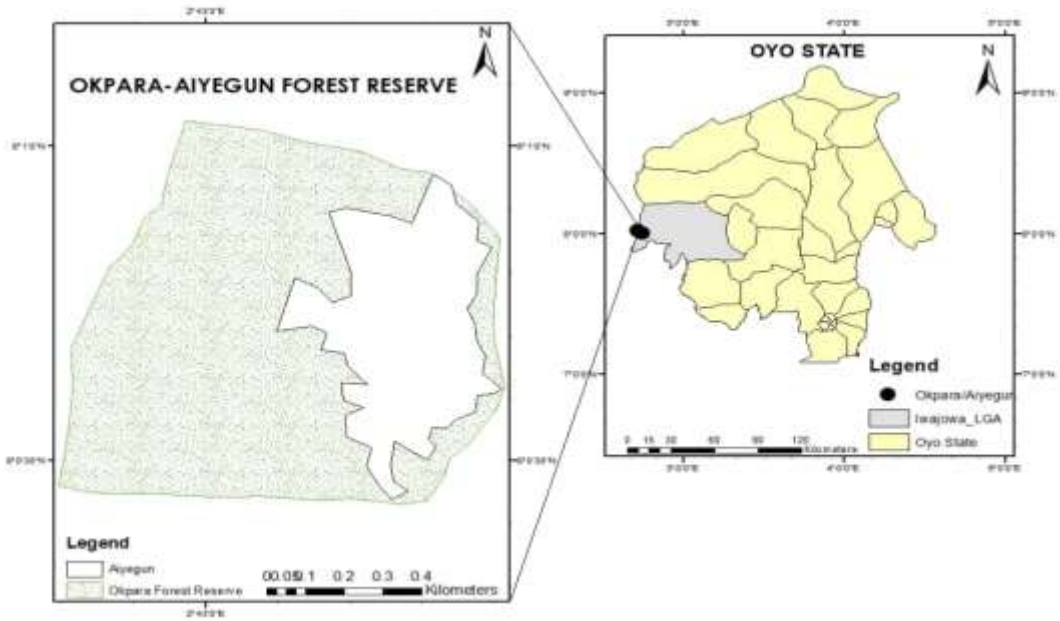

Fig. 1: Map of the study area

RESULTS AND DISCUSSION

Biodiversity indices are a valuable tool to compare forest composition and similarity of different species. The higher the value of an ecological index, the higher the species richness (IIRS 2002). Results showed that the composition of the reserve is mainly dominated by savanna species (Table 1). *Anogeissus leiocarpus* is the dominant species with 80 stands, followed by *Daniellia oliveri,* which has 38. Eleven (11) tree species were represented only once in the study area. *Vitellaria paradoxa* has the highest mean dbh of 100.09 cm, followed by *Blighia sapida*, which has 90.3 cm, while the least dbh was found in *Dichrostachys cinerea* with 29.1 cm. *Acacia faidherbia* is the tallest tree at 12.4 m, followed by *Anthocleista vogelii* at 12.3 m, while the shortest was *Gmelina arborea* at 2.1 m. The highest basal area was *Anogeissus leiocarpus*, with 26.72 $m^{2,}$ while *Dichrostachys cinerea* had the least, with 0.07 m^2. The volume followed a similar trend with the basal area as *Anogeissus leiocarpus* had the highest volume, and *Dichrostachys cinerea* had the least.

Table 1: Summary of the tree growth parameters in the study area

S/N	Species	Freq.	DBH (cm)	Height (m)	BA (m^2)	Vol (m^3)
1	*Acacia faidherbia*	1	86.10	**12.4**	0.58	7.22
2	*Albizia spp*	6	62.93	11.0	1.97	22.57
3	*A. leiocarpus*	**80**	59.24	9.2	**26.72**	**282.17**
4	*Anthocleista vogelii*	1	60.50	12.3	0.29	3.54
5	*Azadirachta indica*	20	50.51	8.4	5.40	54.40
6	*Blighia sapida*	2	90.30	8.6	1.28	11.02
7	*Bridelia ferruginea*	3	54.90	9.2	0.85	8.36
8	*Burkea africana*	3	64.53	10.7	1.02	11.22
9	*Daniellia oliveri*	38	51.93	9.1	10.57	116.34
10	*Dialium guinensis*	5	59.90	7.7	1.82	17.87
11	*D. cinerea*	1	29.10	3.7	0.07	0.25
12	*Ficus capensis*	1	31.90	5.8	0.08	0.46
13	*Gmelina arborea*	1	43.40	2.1	0.15	0.31
14	*Isoberlinia doka*	1	65.40	8.5	0.34	2.86
15	*I. tomentosa*	1	60.50	7.8	0.29	2.24
16	*Lophira alata*	1	40.10	10.8	0.13	1.36
17	*Mangifera indica*	1	86.80	9.5	0.59	5.62
18	*Nauclea latifolia*	1	38.10	5.6	0.11	0.64
19	*Parkia biglobosa*	14	57.79	8.4	4.09	40.61
20	*Piliostiga thonnigii*	4	45.25	7.9	0.66	5.04
21	*P. angolensis*	3	56.83	7.3	0.85	6.22
22	*Spondias mombin*	4	32.60	8.0	0.40	3.56
23	*T. avicennioides*	3	78.33	10.8	1.52	16.37
24	*Unknown*	2	40.50	4.7	0.27	1.29
25	*Vitellaria paradoxa*	20	**100.09**	10.4	16.59	178.47
26	*Vitex doniana*	1	73.20	10.1	0.42	4.25
Total		218			77.05	804.25

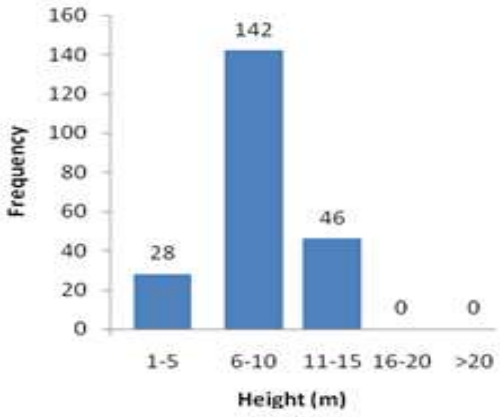

Fig 2: Height class distribution of the trees in the study area

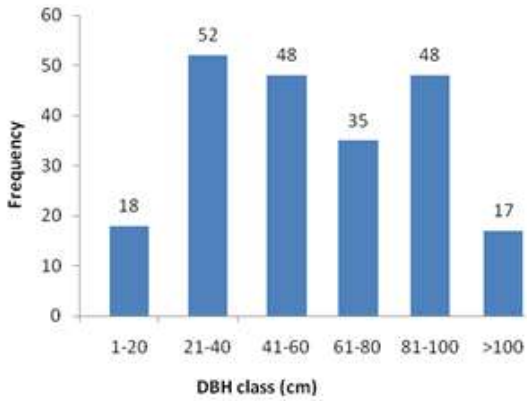

Fig. 3: Diameter class distribution of the trees in the study area

Results in Figure 2 showed that trees in the 6-10 m class are dominant in the study area. There is no tree in the height class of 16 and above despite being an old forest reserve, indicating that the forest reserve is comprised of savanna vegetation. Results in Figure 3 showed that the diameter class followed a normal distribution pattern as few trees were found in the lowest and highest diameter class. The majority of the category fell into the middle class.

Table 2: Species diversity indices of the study area

Index	Value
No of species	26
Individuals	218
Dominance	0.2
Evenness	0.8
Shannon	2.21

Results in Table 2 revealed that the forest reserve comprised twenty-six (26) different species, with two hundred and eighteen (218) individuals. The

dominance is 0.2, indicating that no particular species is excessively dominant, while the evenness is also high. Shannon's diversity result of 2.21 is moderate, and the results are similar to what is obtained in other forest reserves. According to Adekunle (2006) and Onyekwelu *et al*. (2008), Shannon's diversity values of most natural forests in Nigeria are between 3.34 - 3.66, while others can be 2.82 -3.31. The results obtained in this current study revealed a lower value than reported in some tropical forests in southwest Nigeria.

Table 3: Statistical summary of the growth parameters

	DBH (cm)	Height (m)	BA (cm^2)	Vol. (m^3)
N	218	218	218	218
Min	6.4	2.1	0.01	0.03
Max	125.3	15.7	1.23	16.25
Mean	60.38	9.04	0.35	3.69
Std. error	1.98	0.18	0.02	0.25

Investigating and getting information on tree species diversity, composition, and structure in the ecosystem is very important in assessing the sustainability of forests, species conservation, and ecosystem management (Sushma *et al.*, 2016). The investigation in southwest forest reserves indicates that tree species diversity in the tropical rainforest is gradually losing its biodiversity status (Adekunle, 2006). Forest reserve research shows that tree species diversity, richness, and abundance have been disrupted (Adekunle *et al*., 2013). This applies to the tropical forests in southwest Nigeria, as observed from this study. The results in Table 3 showed the summary of the statistics of trees in the study area. The minimum diameter was 6.4 cm, while the maximum was 125.3 cm. The minimum height was 2.1 m, while the tallest tree was 15.7 m tall. The minimum basal area was 0.01 m^2, and the maximum was 1.23 m^2. The minimum and maximum volumes were 0.03 m^3 and 16.25 m^3, respectively.

Conclusion: The tree species diversity, structure, and growth characteristics of trees in Opara Forest Reserve was investigated. A total of two hundred and eighteen trees were assessed and a Shannon wiener index of 2.21; the forest reserve has moderate species diversity and encouraging growth characteristics despite evidence of encroachment by farmers and illegal fellers. The reserve can regain its former stability with ample time and proper management. However, there should be adequate monitoring to checkmate illegal activity in the reserve and enrichment planting should be encouraged to complement the natural regeneration.

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