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TREE STRUCTURAL AND SPECIES DIVERSITIES IN OKWANGWO FOREST, CROSS RIVER STATE, NIGERIA

***Adeyemi, A.A., Ibe, A.E. and Okedimma, F.C.**

Department of Forestry and Wildlife Technology, Federal University of Technology, Owerri, Nigeria

**Corresponding Author's e-mail: adeyemiadesoji@yahoo.com; phone: +234 803 208 2627*

ABSTRACT

For sound forest management decisions, appraisal of flora species and forest structure is crucial for any meaningful conservation work. We assessed tree species distribution in Okwangwo Forest, Nigeria. Systematic sampling technique was adopted for plot selection. 24 transects, measuring 1000m long at 500 m intervals were laid. Four sample plots of 0.25 ha were located alternately at 250m intervals along each transect, making 96 plots (24 ha) in all. The diameters of all the trees with dbh ≥10 cm were measured. All measured trees were identified to species level. Data were analyzed using descriptive statistics such as means, frequencies, percentages and charts. Also, species relative densities and richness were computed. Tree species were grouped into abundance classes. A total of 125 tree species belonging to 36 families and 96 genera were recorded in the area with Margalef's index of species richness of 2.2754. Most (99) of the tree species encountered were threatened/endangered, 23 species were rare with only 3 tree species (Brachystegia eurycoma, Bailonella toxisperma and Ceiba pentandra) being abundant in the area. Frequent and occasional species were not encountered in the area. Leguminoseae was the most represented family with 14.84% (19 species) with Styraceae, Polygonaceae, Papilionioideae, Sapindaceae, Connaraceae, Flacourtiaceae, Tiliaceae, Asparagaceae, Ochnaceae, Bignoniaceae, Mimosoideae, Piperaceae, Anisophyllaceae and Violaceae being the least with one species each. The mean basal area of 111.32 m^2/ha recorded in the area was higher than the value suggested for a well-stocked and managed forest in Nigeria. There were more trees in the lower diameter classes than in the larger classes. The result of soil physical and chemical properties was also impressive with potential for site quality improvement going by the good stand structure.

INTRODUCTION

Sustainable management techniques are required to maintain the biodiversity and productivity of tropical forest ecosystems (Reddy and Ugle, 2008), and this can only be possible through a genuine information about the status and distribution of tree species, which form the frame for other life forms. The Okwangwo forest is an area generally believed to be rich in plant and animal species, not present in other parts of Nigeria (Oates *et al*., 2007). This forest possesses vast features of a typical tropical rainforest ecosystem (Sunderland *et al*., 2003). The area harbours some African threatened species that are of paramount conservation relevance. Some of these tree species included *Terminalia ivorensis, Pterocarpus soyauxii*, *Melicia excelsa*, *Bailonella toxisperma and Afzelia bipindensis* (Sunderland *et al*., 2003). Besides the tree species, the forest equally contains animals of conservation significance. Amongst these are the *Mandrillus leucophaeus*, *Cercopithecus preussi* (Grove and Maisel, 1999). The Cross River gorilla (*Gorilla gorilla diehli*) is also endemic to the area (Ndah *et al.,* 2012).

The control of man's assess to this ecosystem may support biodiversity conservation, and this would be impracticable without adequate knowledge of tree species there in. The ever-increasing demand for forest goods and services has brought about intense pressure on the forest ecosystem, thereby leading to rapid degradation of forest and loss of biological species in natural habitat. Many of the once diverse natural forests have been lost to the plantation of exotic species and agricultural practices. Consequently, there are severe ecological and environmental changes, reducing the stabilizing functions of the forest. Having information on the status of Okwangwo forest becomes necessary as this may facilitate the formulation of sustainable forest management strategies for this all-important ecosystem.

Although, biodiversity is conventionally measured in terms of genetics, species and ecosystem diversity (Kayode and Ogunleye, 2008; Edet *et al*., 2011; Adeyemi *et al*., 2013; Bello *et al*., 2013), Nigeria's rich biodiversity is highly influenced by its enormous anthropogenic forces and the floral diversity has however been poorly documented. And information on Okwangwo forest status appears non-existent. Hence, there is need to ascertain the status of tree species in the area to ensure sustainable forest management planning.

MATERIALS AND METHODS

The *Okwangwo* forest is located on latitude 6°17'00''N and longitude 9°14'00"E at an elevation of between 150 and 1,700 m above sea level. It is made up of the former *Boshi*, *Okwangwo* and *Boshi* Extension Forest Reserves. The forest has an area of about 92,000 ha. It is separated from the *Oban* forest to the south by about 50 km, and lies south-west of the *Obudu* Plateau and immediately to the east of the *Afi* River Forest Reserve. It is separated from this reserve by the *Mbe* Mountains Community Forest. The *Takamanda* Forest Reserve in the Republic of Cameroon shares a border with the *Okwangwo* forest to the east (Fig. 1).

The ground is rugged, with rocky ridges and outcrops. The highest points are in the *Sankwala* Mountains in the north (1,700 m) and in the *Mbe* Mountains in the south-west (1,000m). Annual rainfall may be as much as 4,280 mm, mostly falling between March and November. The forest is drained by the *Oyi*, *Bemi* and *Okon* rivers, tributaries of the Cross River. There are about 39 villages with an estimated population of 29,000 along the edges of the forest.

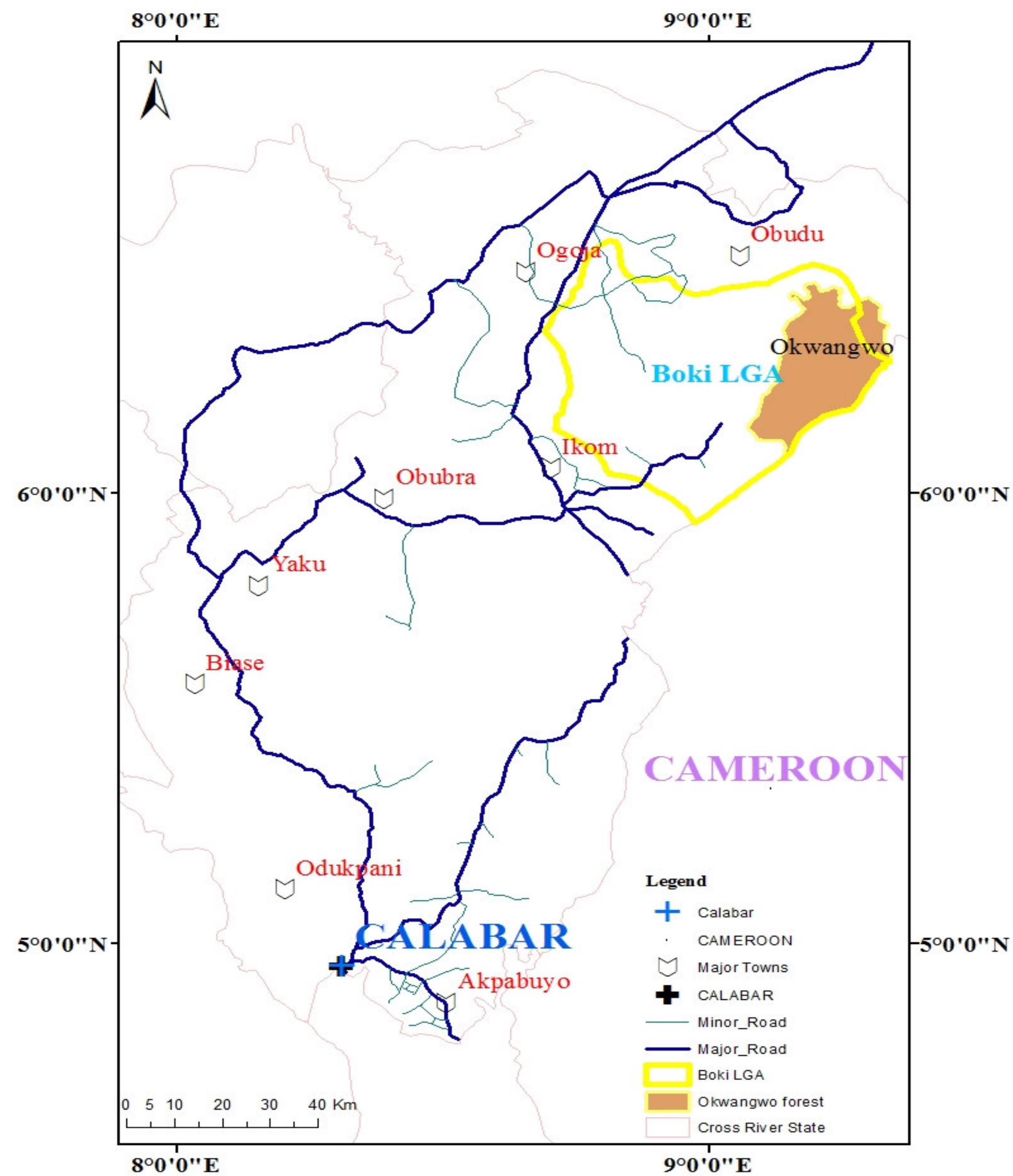


Fig. 1: Map of Cross River State showing the study area

Data Collection

Systematic sampling technique was used in sample plot selection. Twenty-four (24) transects of 1000 m long, each evenly distributed over the entire area, were marked at 50m intervals. Four plots of 0.25ha were alternately laid at 250 m intervals along each of the transects (Fig.2). A total of 96 sample plots (24 ha) were used for the study.

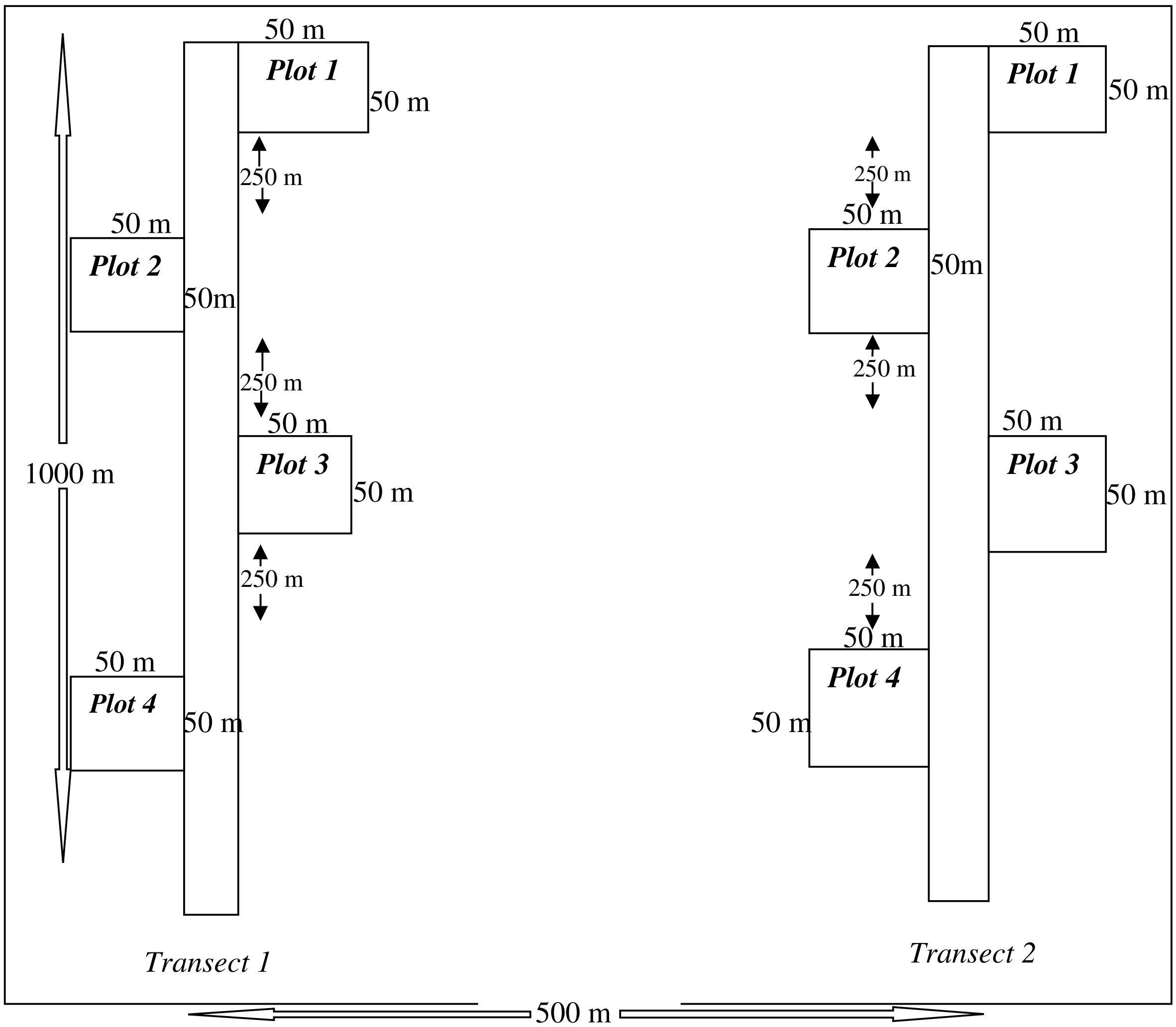


Fig. 2**:** Sample plots' layout using systematic (line transect) sampling technique

Data Collection

Only trees with dbh ≥ 10 cm in each of the sample plots were enumerated and measured. Trees were identified to species level. The soil samples were collected randomly from two depths: 0-15cm and 15-30cm in different locations of the forest. The samples were air-dried, bulked and then analyzed for physico-chemical parameters.

Data Analysis

Basal Area Computation

The basal area (m^2) of all measured trees in the sample plots were computed using:

$$BA = \frac{\pi \ dbh^2}{4} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

π = 3.143. where BA = basal area, dbh = diameter at breast height

The plot basal area for each of the sample plots was obtained by adding the Basal area of all the trees in the plot. A mean basal area per plot for all the sample plots in the area was computed. The mean value was then multiply by 4 to obtain the mean basal area/ha for the study area, since there were four 50 m × 50 m (0.25 ha) plots in a hectare.

Stem Diameter Classification

The measured tree dbh in the sample plots were grouped into four diameter classes viz: 10-30 cm, 30-60 cm, 60-90 cm and >90 cm, and the frequencies of the trees in each of the category were computed.

Species Relative Density

Relative density (%) of each tree species in the area was calculated using:

$$RD(\%) = \frac{\text{Number of individual tree species}}{\text{Total number of trees sampled}} \times 100 \ldots 2$$

The various species were scored according to their relative densities (RD) as follows: abundant (RD ≥ 5.00), frequent (4.00 ≤ RD ≤ 4.99), occasional (3.00 ≤ RD ≤ 3.99), rare (1.00 ≤ RD ≤ 2.99) and threatened/endangered (RD < 1.00) as adopted by Edet *et al*. (2011).

Tree Species Richness

Tree species richness in the area was computed using Margalef's index of species richness (Margalef, 1958) as:

$$d = \frac{S}{\sqrt{N}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

Where, *d* = Margalef's index of species richness; S = the number of species encountered; N = the total number of individuals of all the tree species.

Descriptive Statistics

Data on soil physico-chemical parameters were analyzed using descriptive statistics (such as mean and standard deviation.

RESULTS

A total of 125 tree species belonging to 36 families and 96 genera were encountered in the area. *Brachystegia eurycoma*, *Bailonella toxisperma* and *Ceiba pentandra* were the most dominant species within the area (Table 1). The Margalef's index of species richness was 2.2754. The abundance status for each of the tree species encountered is presented in Fig. 3. Most (99 tree species), representing 79.7% of the total tree species were threatened/endangered. About 18% (23 tree species) of the species were rare. Only 2.3% (3 tree species) were abundant. No tree species in the frequent or occasional classes were recorded in the area.

Table 1: Tree species composition and abundance in the study area

Species	Family	Frequency	RD	Status
Afrostyrax lepidophyllus	*Styraceae*	27	0.89	Endangered
Afzelia bipindensis	*Leguminosae*	25	0.83	Endangered
Albizia ferruginea	*Leguminosae*	16	0.53	Endangered
Albizia gummifera	*Leguminosae*	38	1.26	Rare
Albizia lebbeck	*Leguminosae*	26	0.86	Endangered
Albizia zygia	*Leguminosae*	21	0.70	Endangered
Alchornia laxiflora	*Euphorbiaceae*	47	1.56	Rare
Alstonia boonei	*Apocynaceae*	26	0.86	Endangered
Alstonia congensis	*Apocynaceae*	25	0.83	Endangered
Angylocalyx oligophyllus	*Leguminosae*	43	1.42	Rare
Anthocleista djalonensis	*Leganiaceae*	12	0.40	Endangered
Anthocleista vogelei	*Leganiaceae*	40	1.33	Rare
Anthonotha fragrans	*Leguminosae*	13	0.43	Endangered
Anthonotha macrophylla	*Leguminosae*	31	1.03	Rare
Antiaris Africana	*Moraceae*	42	1.39	Rare
Antrocaryon klaineanum	*Annacardiaceae*	59	1.95	Rare
Antrocaryon micraster	*Annacardiaceae*	22	0.73	Endangered
Bailonella toxisperma	*Sapotaceae*	200	6.63	Abundant
Baphia nitida	*Papilionioideae*	33	1.09	Rare
Blighia sapida	*Sapindaceae*	55	1.82	Rare
Bombax buonopozense	*Bombaceae*	29	0.96	Rare
Brachystegia eurycoma	*Leguminosae*	207	6.86	Abundant
Brachystegia nigerica	*Leguminosae*	34	1.13	Rare

Table 1 contd.

Calophyllum inophyllum	*Annonaceae*	29	0.96	Endangered
Canarium schweinfurthii	*Buseraceae*	16	0.53	Endangered

Carpolobia alba	*Polygalaceae*	11	0.36	Endangered
Carpolobia lutea	*Polygalaceae*	17	0.56	Endangered
Ceiba pentandra	*Bombacaceae*	163	5.40	Abundant
Celtis philippensis	*Urticaceae*	15	0.50	Endangered
Chrysophyllum albidum	*Sapotaceae*	69	2.29	Rare
Cnetis ferruginea	*Connaraceae*	18	0.60	Endangered
Cola acuminate	*Sterculiaceae*	19	0.63	Endangered
Cola gigantean	*Sterculiaceae*	27	0.89	Endangered
Cola lepidota	*Sterculiaceae*	10	0.33	Endangered
Cola millenii	*Sterculiaceae*	21	0.70	Endangered
Cola pachycarpa	*Sterculiaceae*	18	0.60	Endangered
Compostylus ovalis	*Flacourtiaceae*	14	0.46	Endangered
Croton penduliflorus	*Euphorbiaceae*	24	0.80	Endangered
Cuviera acutiflora	*Rubiaceae*	16	0.53	Endangered
Cyrtogonne argentia	*Euphorbiaceae*	17	0.56	Endangered
Dacryodes edulis	*Burseraceae*	32	1.06	Rare
Daniella ogea	*Leguminosae*	15	0.50	Endangered
Delonix regia	*Fabaceae*	21	0.70	Endangered
Deplatsia dewevrei	*Tiliaceae*	10	0.33	Endangered
Dialium guineensis	*Leguminosae*	20	0.66	Endangered
Didymosalpinx parviflora	*Rubiaceae*	7	0.23	Endangered
Diospyros mespiliformis	*Ebenaceae*	23	0.76	Endangered
Diospyros heudelotii	*Ebenaceae*	13	0.43	Endangered
Diospyros melocarpa	*Ebenaceae*	27	0.89	Endangered
Diospyros nigerica	*Ebenaceae*	11	0.36	Endangered

Table 1 contd.

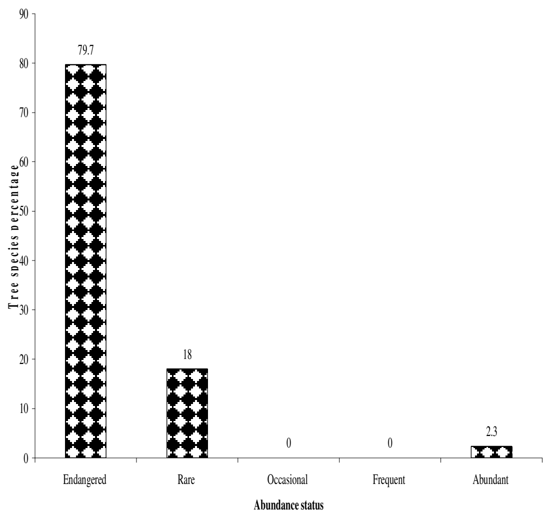
Diospyros zenkerii	*Ebenaceae*	9	0.30	Endangered
Dracaena arborea	*Asparagaceae*	24	0.80	Endangered
Duboscia macrocarpa	*Moraceae*	31	1.03	Rare
Entandrophragma angolense	*Meliaceae*	30	0.99	Endangered
Entandrophragma cylindricum	*Meliaceae*	26	0.86	Endangered
Ficus umbelatum	*Moraceae*	7	0.23	Endangered
Fiscus exasperata	*Moraceae*	12	0.40	Endangered
Funtumia Africana	*Apocynaceae*	57	1.89	Rare
Funtumia elastic	*Apocynaceae*	18	0.60	Endangered
Garcinia kola	*Guttiferae*	19	0.63	Endangered
Garcinia manni	*Guttiferae*	10	0.33	Endangered
Grosseria vignei	*Euphorbiaceae*	6	0.20	Endangered
Guarea glomerulata	*Meliaceae*	11	0.36	Endangered
Harungana madagascariensis	*Guttiferae*	21	0.70	Endangered
Heinsia crinata	*Myristicaceae*	33	1.09	Rare
Hymenodictyon biafranum	*Myristicaceae*	18	0.60	Endangered
Irvingia gaboneensis	*Irvingiaceae*	44	1.46	Rare
Irvingia grandifolia	*Meliaceae*	9	0.30	Endangered
Irvingia wombulu	*Irvingiaceae*	13	0.43	Endangered
Khaya grandifolia	*Meliaceae*	21	0.70	Endangered
Khaya ivorensis	*Meliaceae*	56	1.86	Rare
Klainedoxa gabonensis	*Irvingiaceae*	8	0.27	Endangered
Leptobychia pallid	*Sterculiaceae*	12	0.40	Endangered
Lophira alata	*Ochnaceae*	5	0.17	Endangered
Lovoa trichiloides	*Meliaceae*	15	0.50	Endangered
Maesobotrya dusenii	*Euphorbiaceae*	9	0.30	Endangered
Maesobotrya staudtii	*Euphorbiaceae*	17	0.56	Endangered

Table 1 contd.

Mammea africanum	*Guttiferae*	4	0.13	Endangered
Mangifera indica	*Anacardiaceae*	14	0.46	Endangered
Massularia acuminate	*Rubiaceae*	28	0.93	Endangered
Melicia excels	*Moraceae*	70	2.32	Rare
Melicia zygia	*Moraceae*	7	0.23	Endangered
Monodora myristica	*Annonaceae*	14	0.46	Endangered
Morinda lucida	*Rubiaceae*	5	0.93	Endangered
Musanga cecropioides	*Urticaceae*	19	2.32	Rare
Myriathus arboreus	*Moraceae*	7	0.23	Endangered
Nauclea latifolia	*Rubiaceae*	20	0.66	Endangered
Nauclea diderrichii	*Rubiaceae*	33	1.09	Rare
Newbouldia laevis	*Bignoniaceae*	5	0.17	Endangered
Newtonia duparquetiana	*Mimosoideae*	12	0.40	Endangered
Parinari chrysophylla	*Rubiaceae*	10	0.33	Endangered
Parkia bicolor	*Leguminosae*	37	1.23	Rare
Pentaclethra macrophylla	*Leguminosae*	15	0.50	Endangered
Piptandeniastrum africanum	*Leguminosae*	4	0.13	Endangered
Pleiocarpa talbotii	*Apocynaceae*	8	0.27	Endangered
Poga oleosa	*Anisophylleceae*	21	0.70	Endangered
Pterocarpus soyauxii	*Fabaceae*	16	0.53	Endangered
Pterocarpus erinaceus	*Fabaceae*	6	0.20	Endangered
Pterocarpus mildbraedii	*Leguminosae*	14	0.46	Endangered
Pterocarpus osun	*Leguminosae*	65	2.15	Rare
Pycnanthus angolensis	*Myristicaceae*	9	0.30	Endangered
Pycnanthus microcephalus	*Myristicaceae*	3	0.10	Endangered
Rauvolfia vomitoria	*Apocynaceae*	15	0.50	Endangered
Rhicinodendron heudelotii	*Euphorbiaceae*	3	0.10	Endangered
Rinorea oblongifolia	*Violaceae*	20	0.66	Endangered

Table 1 contd.

Roystonea regia	*Palmae*	8	0.27	Endangered
Spondias mombin	*Annacardiaceae*	17	0.56	Endangered
Stemenocoleus micrathus	*Leguminosae*	6	0.20	Endangered
Sterculia tragacantha	*Sterculiaceae*	29	0.96	Endangered
Tectea afzeli	*Rutaceae*	9	0.30	Endangered
Terma guineensis	*Ulmaceae*	8	0.27	Endangered
Termialia superb	*Combretaceae*	11	0.36	Endangered
Terminalia ivorensis	*Combretaceae*	18	0.60	Endangered
Tetrapleura tetraptera	*Leguminosae*	8	0.27	Endangered
Treculia Africana	*Moraceae*	15	0.50	Endangered
Trichilia gilgiana	*Meliaceae*	3	0.10	Endangered
Triplochiton scleroxylon	*Sterculiaceae*	10	0.33	Endangered
Uapaca acuminate	*Euphorbiaceae*	10	0.33	Endangered
Vitex doniania	*Verbenaceae*	5	0.17	Endangered
Vitex simplicifolia	*Verbenaceae*	10	0.33	Endangered
Xylopia acutiflora	*Annonaceae*	11	0.36	Endangered
Xylopia aethiopica	*Annonaceae*	8	0.27	Endangered
Xylopia Africana	*Annonaceae*	21	0.70	Endangered
Xylopia staudtii	*Annonaceae*	10	0.33	Endangered
zanthoxylum rubescens	*Rutaceae*	2	0.07	Endangered
Zanthoxylum zanthoxyloides	*Rutaceae*	10	0.33	Endangered
Zenkerella citran	*Leguminosae*	10	0.33	Endangered
Total		**3018**	**100**	



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ig. 3: Tree species status in the study area

Family composition of the tree species in the area is presented in Table 2. Most of the species (19) belonged to the family *Leguminosae* followed by *Meliaceae* and *Euphorbiaceae* (with 9 species each). The families with the least species representations were *Styraceae*, *Polygonaceae*, *Papilionioideae*, *Sapindaceae*, *Connaraceae*, *Flacourtiaceae*, *Tiliaceae*, *Asparagaceae*, *Ochnaceae*, *Bignoniaceae*, *Mimosoideae*, *Piperaceae*, *Anisophyllaceae* and *Violaceae* with one species each.

Table 2: Showing family composition of the tree species

Family	Species represented	Percentage (%)
Anisophyllaceae	1	0.78
Annacardiaceae	4	3.13
Annonaceae	6	4.69
Apocynaceae	6	4.69
Asparagaceae	1	0.78
Bignoniaceae	1	0.78
Bombacaceae	2	1.56
Burseraceae	2	1.56
Combretaceae	2	1.56
Connaraceae	1	0.78
Ebenaceae	6	4.69
Euphorbiaceae	9	7.03
Fabaceae	3	2.34
Flacourtiaceae	1	0.78
Guttiferae	4	3.13
Irvingiaceae	3	2.34
Leguminosae	19	14.84
Meliaceae	9	7.03
Mimosoideae	1	0.78
Moraceae	8	6.25
Myristicaceae	4	3.13
Ochnaceae	1	0.78
Palmae	1	0.78
Papilionioideae	1	1.56

Polygalaceae	3	2.34
Rubiaceae	4	0.78
Rutaceae	3	2.34
Sapindaceae	1	0.78
Sapotaceae	2	1.56
Sterculiaceae	8	6.25
Styraceae	1	0.78
Tiliaceae	1	0.78
Ulmaceae	1	0.78
Urticaceae	2	1.56
Verbenaceae	2	1.56
Violaceae	1	0.78
Total	**125**	**100**

The diameter distribution of tree species in the study area is as shown in Fig. 4. The result revealed that tree species within the diameter class of 10-30 cm were the most frequently occurring in the area at 65 trees/ha. This was followed by trees in the diameter class 31-60 cm and 61-90 cm with 35 and 32 trees/ha respectively. The least number of stems (16 trees/ha) in the diameter class of ≥ 90 cm were encountered in the area. The result further revealed that the relationship between number of trees per hectare (N/ha) and diameter growth (dbh) in the area was exponential (Fig. 4).

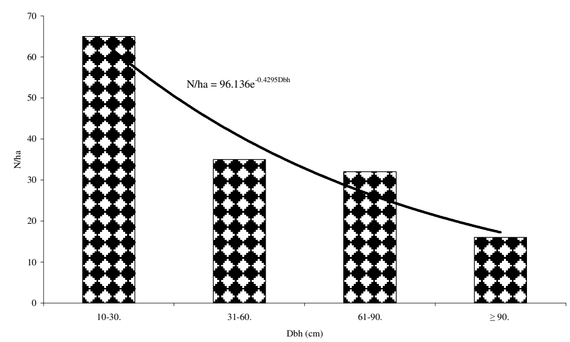

Fig. 4: Tree species diameter distribution in the study area

Table 3 presents mean tree basal area per hectare in the 24 sampling transects in the area. The mean basal area/ha for all the transects ranged between 57.41 m^2/ha and 272.58 m^2/ha with the least and highest basal area per hectare recorded in 9 and 23 respectively. An overall mean basal area/ha of 111.32 m^2 was recorded in the study area.

Table 3: Mean Tree basal area/ha in the 24 sampling transects

Transect	Plots (size = 0.25ha)	Mean BA/ha (m^2)
1	4	63.87
2	4	124.38
3	4	106.78
4	4	169.51
5	4	53.04
6	4	87.84
7	4	180.75
8	4	91.07
9	4	57.41
10	4	116.92
11	4	78.76
12	4	121.23
13	4	157.71
14	4	92.18
15	4	142.51
16	4	97.45
17	4	146.61
18	4	68.06
19	4	122.99
20	4	55.68
21	4	117.35
22	4	78.40
23	4	272.58
24	4	68.59
Overall Mean		**111.32**

The summary of descriptive statistics for soil chemical properties in the study area is presented in Table 4. The soil pH ranged between 4.04 and 4.61 with a mean value of 4.26 ± 0.24. Organic carbon, OC (%) ranged between 0.87 and 1.79 with a mean value of 1.49 ± 0.33. With respect to organic matter, OM (%), the mean value was 2.76 ± 0.95 in the study area. The soil total nitrogen values ranged between 0.11 and 0.33% with a mean of 0.17 ± 0.08. Details of the result for soil chemical properties are shown in Table 4.

Table 4: Descriptive statistics for soil chemical properties in the area

Physical properties	**Minimum**	**Maximum**	**Mean** ± SD
pH	4.04	4.61	4.26 ± 0.24
OC (%)	0.87	1.79	1.49 ± 0.33
OM (%)	1.58	3.85	2.76 ± 0.95
TN (%)	0.11	0.33	0.17 ± 0.08
AVP	3.71	6.52	5.03 ± 1.13
Ca	1.39	3.71	2.10 ± 0.92
Mg	0.23	1.60	0.67 ± 0.51
Na	3.33	4.98	4.00 ± 0.70
K	2.12	3.82	3.25 ± 0.63
H	0.16	0.75	0.48 ± 0.24
Al	0.37	1.02	0.59 ± 0.23
B	0.54	0.81	0.66 ± 0.10
Mn	10.90	18.60	15.47 ± 2.94
Zn	10.40	15.20	12.17 ± 1.73
Pb	8.10	14.20	10.63 ± 2.14
Fe	10.60	23.10	16.72 ± 4.93
Si	0.56	1.90	1.33 ± 0.45
TEB	1.05	2.91	1.85 ± 0.63
TEA	0.27	0.53	0.37 ± 0.98
CEC	4.67	7.62	6.28 ± 1.28
BS	58.20	90.90	76.12 ± 11.47

Table 5 shows the result of soil physical properties in the study area. The mean percentage sand, Silt and Clay in the area were 77.60 ± 9.96, 7.24 ± 6.36 and 15.16 ± 10.14 respectively. The mean bulk density, Porosity and moisture content were 1.37 ± 0.21 g/cm^3, 51.37 ± 8.91% and 13.40 ± 3.03%.

Table 5: Descriptive statistics result of soil physical properties in the study area

Physical properties	**Minimum**	**Maximum**	**Mean** ± SD
Sand (%)	68.20	96.81	77.60 ± 9.96
Silt (%)	0.86	19.56	7.24 ± 6.36
Clay (%)	2.32	26.79	15.16 ± 10.14
Bulk density (g/cm^3)	1.06	1.62	1.37 ± 0.21
Porosity (%)	38.14	63.02	51.37 ± 8.91
Moisture content (%)	8.15	16.18	13.40 ± 3.03

DISCUSSION

Tree species of about 125 in 36 families and 96 genera typified a richer ecosystem in terms of tree species diversity when compared with the value of 102 species belonging to 35 families reported by Edet *et al*. (2011) for *Afi* Mountain Wildlife Sanctuary. The result of this study presented a value, which is also greater than that reported for a communal forest in Cross River State (Edet *et al*., 2011). Similarly, the area is richer in terms of tree species in comparison with 99 tree species belonging to 34 families recorded in *Takamanda* Rainforest of South-west, Cameroon (Egbe *et al*., 2012). In the same vein, it is higher than 118 tree species reported by Adeyemi *et al*. (2013) for the Oban Division of the Cross River National Park in Nigeria.

This study has shown that *Okwangwo* forest is a biodiversity conservation unit known for its richness, endemism in flora and fauna. The richness in biodiversity makes it a gene bank for most species. Moreover, tree species richness recorded in this study is far greater than what was reported for other similar ecosystems in southern Nigeria. For instance, Ojo (2004) obtained 71 species for Abeku sector of *Omo* forest reserve in Ogun State. Adekunle and Olagoke (2008) recorded 99 tree species in bitumen-producing area of Ondo State. This finding corroborates the view of Adekunle (2006), who noted that the number of tree species is far greater in the tropical rainforest than in any other single forest community regardless of plot size. And this may explain the reason why *Okwangwo* is the only area, where some notably endangered wildlife species can still be found in the country. The most important being the Cross River Gorilla.

Threatened or endangered tree species that were identified in the course of this study include *Terminalia superba, Afzelia africana, Antiaris africana, Dialium spp and Alstonia boonei*. The effect of anthropogenic activities on growth and distribution of tree species may have played a role in the status of these species in the ecosystem, threatening the occurrence and development of certain species while favouring others. The *Leguminosae* was observed to be the most prevalent family. This may be due to their fast regeneration ability, associated with symbiotic properties, which may have enabled the species to easily establish within habitat types. This is similar to the findings of Deka *et al*. (2012), who stated that legumes were the most prominent species recorded in *Takamanda* forest. This may not be far from the fact that the two forests share some ecosystem characteristics, sharing geographical boundaries. The dominance *Leguminosae* could also be a result of habitat adaptation and relatively favourable environmental conditions, which encourage pollination, dispersal and eventual establishment of species. Similar situations were reported by Pausas and Austin (2001) on species richness in relation to environment. Austin *et al*. (1996) found that edaphic parameter (soil nutrients) played a major role in species richness and establishment in an ecosystem.

The mean basal area recorded in this study is greater than the value reported by Adekunle *et al*. (2004) in the moist forests of south-western Nigeria. The higher basal area may be due to the presence of adapted root architecture to absorb nutrients for growth. This is in line with the work of Parthasarathy (1999), who noted that the adaptation of particular species to an environment may enhance their growth and establishment. The mean basal area value was far more than 15 m^2/ha suggested for a well-stocked tropical forest in Nigeria.

Meliaceae and *Moraceae* also have ability to produce numerous seeds, which may be eventually established at suitable sites. The high number of species in rare and threatened/endangered categories may be due to human- use pressure, which influenced species growth and production. Similar case has been reported by Marshal and Swaine (1992) for plant communities on anthropogenically-disturbed sites in Chukotka Peninsula. The reasons for the poor establishment of some families, which showed low species representations, may also be attributed to competition for nutrients, limited light by canopy trees and destruction of undergrowth during tree snapped and logging on the forest floor. Egbe *et al*. (2012) reported a similar case in a disturbed and natural regeneration forest in Korup National Park of Cameroon.

The forest investigated in this study is characterized by abundance of trees with small dbh. This is similar to the finding of Jimoh *et al*. (2012), who noted that Oban Division of Cross River National Park was characterized by dominance of tree species in lower diameter classes. It gave an impression of the structure proposed for a natural forest by Husch *et al*. (2003).

CONCLUSION

This study has shown that *Okwangwo* forest has high species diversity. It can then be said that conservation efforts in the study area are worthwhile. Families noted with dominant species in the area are *Leguminosae* and *Meliaceae*. However most tree species encountered in the area are either rare or endangered, and only very few species can be said to be abundant in the area. These may have resulted from use pressure, mostly through illegal timber extractions as there were signs of logging in the area in recent past.

Also this study has established that continuous forest exploitation could lead to the loss of biodiversity and reduction in tree yields. As observed in the course of this study, there are still noticeable degrees of disturbance and anthropogenic activities that may affect tree diversity in the area. In spite of these factors, the area still remains the biodiversity hotspot in rainforest of Nigeria. This implies that effective conservation and sustainable forest management could make it possible for the forest to continue providing goods and services necessary for communities around the rainforest as the result of the study may not be fact from the efforts made by both state and the federal government of Nigeria with the state ban on logging for over eight years now.

It is therefore recommended that this forest should be given more attention to prevent further encroachment by desperate illegal loggers to curtain biodiversity loss and protect this important ecosystem. The management of the area should mostly concentrate on blocking known leakages, and make all culprits to face full wrath of the law. However, a more friendly measure like community forest participation should be considered as this gives a sense of belonging to all stakeholders.

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