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Original Article

Population, diversity, and structure of trees in Omo Biosphere Reserve, Ogun state, Southwestern Nigeria

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ABSTRACT

The population and structure of trees in Omo Biosphere Reserve (OBR) were assessed. Systematic cluster sampling technique was used to select eight 50 m × 50 m temporary sample plots. All trees encountered were identified and classified to species level. Total height and diameter at breast height (DBH) of all identified trees were measured. Data were used to compute a number of trees (NT)/ha, basal area (BA), stem volume (SV), species diversity index (SDI), and similarity index. All tree species were grouped into diameter classes (small ≤40 cm, medium= 41–60 cm, and large >60 cm). Data were analyzed using descriptive statistics, ANOVA, and Pearson correlation analysis at $\alpha_{0.05}$. OBR had total species composition (78.0 ± 0.115 species/ha). The most common species was *Strombosia pustulata* (58.0 ± 0.10/ha) followed by *Funtumia elastica* (57.00 ± 0.10/ha) and *Scottelia coriacea* (52.00 ± 0.00/ha). The mean DBH for OBR is 39.59 ± 5.41 cm. NT for OBR is 595.0 ± 2.10/ha. BA and SV values in OBR are 47.0 ± 1.50 m^2/ha and 229.0 ± 0.35 m^3/ha, respectively. SDI and species evenness (E) values were 3.7 and 0.81, respectively. Diameter distribution displayed an inverted J-shaped structure in OBR. About 78% of trees encountered in OBR belonged to DBH class 10–20 cm, while 14.8% were above 48 cm. BA and DBH had positive and strong correlation (0.9) in the reserve. There were few large trees in the reserve, although population and structure indicated high species diversity.

Keywords: Floristic composition, *In situ* conservation and species diversity, lowland rainforest, stand structure

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INTRODUCTION

The rainforest ecological zone is the most densely populated area of Nigeria and the main source of timber for both local consumption and export, probably due to the large concentration of important timber species found in them. In Nigeria, the assessment of long-term changes in the rainforest is made possible by investigations initiated by the Forestry Research Institute of Nigeria and its precursor organizations. Some of the investigations dated back to the 1920s, but most were carried out between 1950 and 1960. Their main objective was on how to generate empirical data on exploited forests. As a result of that, many inviolate plots were established within forest reserves in various parts of the country for the purpose of scientific studies. Omo Biosphere Reserve (OBR) was established in 1949 as one of the inviolate plots. However, their data have provided some basis for addressing some important ecological issues of stand development. The floristic information will also assist in conservation management and other land use planning efforts.[1] This study, therefore, aimed at utilizing these quantitative ecological analyses to obtain the tree population, structure, and diversity of OBR in Ogun state, Nigeria.

MATERIALS AND METHODS

The Study Sites

This study was carried out in OBR, located in area J4, Ijebu East Local Government Area of Ogun. It is located on latitude 6°35ˈ and 7°05ˈN and longitude 4°05ˈand 4°40ˈE. The temperature of the area ranges between 25°C in October and 31°C in January (Warmest).

Data Collection Method

Systematic cluster sampling technique was used for plot location. The 200 m × 500 m area, referred to as clusters,

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was partitioned into 200 m × 200 m tracts. The tracts were 100 m apart. The clusters were located within the reserve where human interference on the vegetation is relatively low. Each tract was further divided into temporary sample plots of 50 m × 50 m. Four of such temporary plots were selected for trees enumeration. The two clusters of four tracts contain four sample plots each totaling eight plots.

Data Analysis

Basal area (BA) calculation

BA of all trees in the sample plots was calculated using the formula:

$$BA = \frac{\pi D^2}{4} \quad (1)$$

Where, BA = Basal area (m^2), D = DBH (cm), and pie (π) = 3.142.

The total BA for each of the sample plots was obtained by adding the BA of all trees in the plot while mean BA for the plot was obtained by dividing the total BA by the number of sample plots.

BA per hectare was obtained by multiplying mean basal per plot with the number of 50 M × 50 m plots in a hectare.

$$BAha^{-1} = BAp \times 4 \quad (2)$$

Where, $BAha^{-1}$ = Basal area per hectare

Volume calculation

The volume of individual trees was estimated using the equation developed for tree volume estimation in lowland rainforest ecosystem of Southwest Nigeria by FORMECU (1997).[2] This equation is expressed as follows:

$$V = e^{-8.433+2.331Ln(D)} \quad (3)$$

Where, V = Volume of tree (m^3) and D = DBH (m).

Total plot volume was obtained by adding the volume of individual trees encountered in the plots. Mean volume for sample plots was calculated by dividing the total plot by the number of sample plots.

Volume per hectare was obtained by multiplying mean volume per plot with the number of 50 m × 50 m plots in a hectare.

Tree Species Classification and Diversity Indices

All the trees encountered were assigned to families and the number of species in each family was obtained for tree species diversity classification. Frequency of occurrence was obtained for species abundance/richness. This was repeated for all plants encountered in the sample plots for the site. The following biodiversity indices were used to obtain tree species richness and evenness within the forest. They were used as indices for comparing biodiversity as indication of biodiversity loss. Species relative density number of individual per hectare was obtained using the formula below:

$$RD = \left[\frac{n_i}{N}\right] \times 100 \quad (4)$$

Where, RD = relative density, n_i = number of individuals of species i, and N = total number of individuals in the entire population.

Species diversity is the number of different species in a particular area. This was obtained using a mathematical formula that takes into account the species richness and abundance of each species in the ecological community. The equation for the Shannon-Wiener diversity index given by Price[3] will be used:

$$H^1 = \sum_{i=1}^{S} p_i Lnp_i \quad (5)$$

Where, H^1 is the Shannon diversity index, S is the total number of species in the community, p_i is the proportion of a species to the total number of plants in the community, and Ln is the natural logarithm.

Species evenness (E) measures the distribution of the number of individual in each species. It was determined using Shannon's equitability (E_H):

$$E = \frac{H^1}{Ln(S)} \quad (6)$$

Where, S is the total number of species in each community.

Simpson concentration (λ) index

$$\lambda = \sum \left(\frac{ni}{Ni}\right)^2 \quad (7)$$

RESULTS AND DISCUSSION

This study revealed the species composition in OBR, Ogun state, Nigeria. The variations in species diversity in the study site might be due to anthropogenic activities, especially overexploitation. This forest has a world biosphere status, thus containing large number of plant families and tree species. It was observed that there was high value of Shannon index which is an indication that many species recorded have similar frequencies of occurrence. The Shannon diversity index obtained for the study site (3.55) which is within the general limit of 1.5 and 3.5 reported by Adekunle and Akinlemibola.[4] This showed that the site was able to support high heterogeneity of tree species. High diversity indices obtained in the site are an indication to the difference in the dominance of the most common species. The high evenness in the study site indicated little dominance by any single species and repeated coexistence of species over all plots. Tables 1 and 2 showed both species diversity and growth variables of the OBR ecosystem. There is high correlation between disturbance and plant species richness and generally from Table 3, it appears that all the variables are positively correlated with each other. The high species density occurrence in OBR is a result of current biodiversity conservation status (Biosphere reserve) [Table 4].

Table 1: Results of tree species diversity indices in Omo Forest Reserve

Diversity indices	Omo forest
Species	78.00
Individuals	595.00
Dominance	0.05
Shannon index	3.55
Sorensen index	0.95
Evenness	0.81
Margalef	12.05

Table 2: Tree growth variables of Omo Forest Reserve in Ogun state, Nigeria

Growth variables	Omo forest
Mean DBH (cm)	39.59±5.41
Dominant DBH (cm)	63.50
Max. DBH (cm)	270.00
Min. DBH (cm	12.00
Mean height (m)	32.56±4.23
Dominant height (m)	86.00
Max. height (m)	38.00
Min. height (m)	9.66
Tree volume (m^3/ha)	2474.26
Basal area (m^2/ha)	46.98
N/ha	595.00

DBH: Diameter at breast height

In the study site, a considerable number of individuals were found in the lower diameter classes, for example, 54.7% of the individuals were found in DBH class 10–19.9 cm and 59.7. The number of individuals within the largest diameter class ≥100 cm ranged between 2.35%. The diameter was 270 cm DBH (*Entandrophragma angolense*).

The conformity of the population structure of trees in OBR with this reverse J-shaped structure clearly reflects the potential of these forest reserves to regenerate overtime [Figure 1]. As the larger population of the trees fall in the lowest diameter size class, the amount of merchantable trees (DBH >48 cm) is very low and it is an indication that the forest is yet to reach climax stage. Importance value index (IVI) is used to determine the overall importance of each species in the forest ecosystem. The value index of the enumerated species in the study site fell in the range of 0.05% and 12.8%. The larger population of the trees belongs to lower DBH classes. Akinyemi[5] reported that low ecological status of species could be attributed to lack of dominance by any one of the species, suggesting positive interactions among tree species. Feyera[6] also reported that the low IVI may imply that most species in a forest are rare. As such, this forest serves the vital function in conservation of plant species that have become very rare or extinct elsewhere.

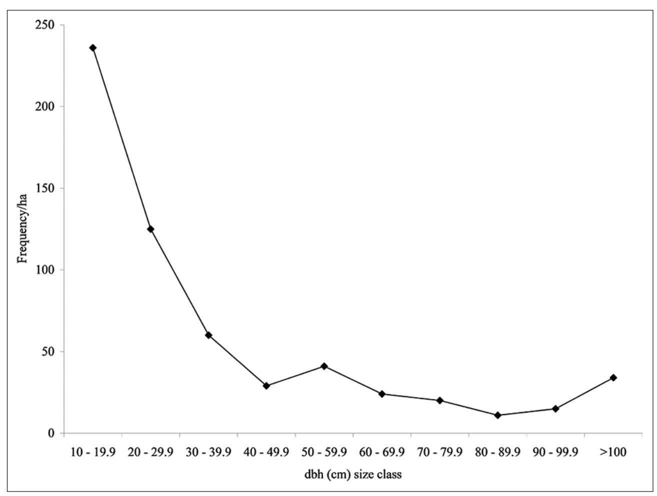

Figure 1: Tree diameter distribution of the study site

Table 3: Correlation matrix for tree growth variables in the study sites

Study sites	Growth variables	DBH (cm)	Height (m)	BA (m^2)	Vol. (m^3)
Omo Forest Reserve	DBH (cm)	1			
	Height (m)	0.15	1		
	BA (m^2)	0.90	0.12	1	
	Vol. (m^3)	0.79	0.16	0.48	1

BA: Basal area, DBH: Diameter at breast height

Table 4: Family and tree species richness in Omo Forest Reserve

Family	Name	MDBH (cm)	MHt (m)	N/ha	Relative density	Rdo	Importance value index	PiLnPi	Basal area/ha	Vol (m^3/ha)
Annonaceae	*Cleistopholis patens*	26.00	26.00	1.00	0.17	0.03	0.10	−0.01	0.01	1.38
	Enantia chlorantha	17.00	17.00	1.00	0.09	0.01	0.05	−0.01	0.01	0.39
	Hexalobus cripticiformis	20.55	23.86	1.00	0.09	0.23	0.16	−0.01	0.11	0.79
	Xylopia aethiopica	30.00	28.90	2.00	0.26	0.81	0.54	−0.02	0.38	4.09
Apocynaceae	*Alstonia boonei*	69.00	50.25	2.00	0.35	1.11	0.73	−0.02	0.52	37.58
	Funtumia elastica	38.00	30.64	57.00	9.83	0.91	5.37	−0.23	0.43	198.10
	Holarrhena floribunda	45.00	45.00	6.00	0.96	0.08	0.52	−0.04	0.04	42.95
	Hunteria umbellata	95.00	9.50	6.00	0.96	0.38	0.67	−0.04	0.18	40.41
	Picralima nitida	59.27	41.57	15.00	2.52	4.48	3.50	−0.09	2.11	172.06
	Voacanga africana	16.50	15.00	2.00	0.26	2.32	1.29	−0.02	1.09	0.64
Asteraceae	*Ericoelum macrocarpum*	200.00	20.00	1.00	0.09	1.67	0.88	−0.01	0.79	62.84
Bignoniaceae	*Spathodea campanulata*	18.75	11.25	2.00	0.35	0.06	0.21	−0.02	0.03	0.62
Bombacaceae	*Ceiba pentandra*	20.80	22.20	3.00	0.52	0.09	0.31	−0.03	0.04	2.26
Boraginaceae	*Cordia millenii*	43.67	34.67	8.00	1.31	0.24	0.77	−0.06	0.11	41.55
Cactaceae	*Cactus spp.*	32.75	31.38	2.00	0.26	0.24	0.25	−0.02	0.11	5.29
Caesalpinioideae	*Anthonotha macrophylla*	19.90	14.82	5.00	0.87	0.18	0.53	−0.04	0.09	2.30
	Stemonocoleus micranthus	17.67	19.37	2.00	0.35	0.19	0.27	−0.02	0.09	0.95
Capparaceae	*Buchholzia coriaceae*	17.00	19.33	4.00	0.70	0.04	0.37	−0.03	0.02	1.76
Combretaceae	*Terminalia superba*	29.33	29.67	2.00	0.35	7.03	3.69	−0.02	3.30	4.01
Ebenaceae	*Diospyros barteri*	12.00	10.75	2.00	0.35	0.02	0.19	−0.02	0.01	0.24
	Diospyros canaliculata	17.07	16.83	23.00	4.00	0.59	2.30	−0.13	0.28	8.86
	Diospyros dendo	16.48	16.62	28.00	4.87	0.69	2.78	−0.15	0.32	9.93
	Diospyros gilgiana	16.00	16.00	1.00	0.09	0.01	0.05	−0.01	0.01	0.32
	Diospyros suaveolens	13.78	15.67	4.00	0.78	0.08	0.43	−0.04	0.04	0.93
	Diospyros mespiliformis	16.00	19.13	12.00	2.09	0.30	1.20	−0.08	0.14	4.62
	Diospyros nigerica	15.19	17.79	37.00	6.44	0.77	3.61	−0.18	0.36	11.93
	Diospyros piscatorial	16.58	21.33	6.00	1.04	0.15	0.60	−0.05	0.07	2.76
	Diospyros principum	13.20	17.40	3.00	0.44	0.04	0.24	−0.02	0.02	0.71

(Contd...)

Table 4: (*Continued*)

Family	Name	MDBH (cm)	MHt (m)	N/ha	Relative density	Rdo	Importance value index	PiLnPi	Basal area/ha	Vol (m^3/ha)
Euphorbiaceae	*Drypetes floribunda*	12.00	12.00	1.00	0.09	0.01	0.05	−0.01	0.00	0.14
	Drypetes chevalieri	16.75	16.04	6.00	1.04	0.16	0.60	−0.05	0.08	2.12
	Drypetes aframensis	18.00	18.13	4.00	0.70	0.13	0.41	−0.03	0.06	1.85
	Drypetes floribunda	16.20	14.15	5.00	0.87	0.12	0.49	−0.04	0.06	1.46
	Drypetes gilgiana	21.89	23.39	14.00	2.44	0.67	1.56	−0.09	0.32	12.33
	Drypetes gossweileri	19.00	17.71	6.00	0.96	0.21	0.58	−0.04	0.10	3.01
	Drypetes guaveolens	19.00	10.25	1.00	0.09	0.03	0.06	−0.01	0.02	0.29
	Drypetes nigerica	20.40	23.30	1.00	0.17	0.21	0.19	−0.01	0.10	0.76
	Drypetes principum	24.00	24.00	5.00	0.87	0.02	0.45	−0.04	0.01	5.43
	Macaranga barteri	14.00	14.00	1.00	0.09	0.01	0.05	−0.01	0.00	0.22
	Ricinodendron heudelotii	21.49	23.16	11.00	1.91	2.32	2.12	−0.08	1.09	9.24
Fabaceae	*Hylodendron gabonenese*	18.50	23.75	1.00	0.09	0.03	0.06	−0.01	0.01	0.64
Flacourtiaceae	*Scottelia coriacea*	17.93	21.55	52.00	8.96	0.67	4.82	−0.22	0.32	28.30
Guttiferae	*Garcinia gnetoides*	12.00	12.00	4.00	0.61	0.01	0.31	−0.03	0.00	0.54
Irvinginaceae	*Irvingia gabonensis*	142.00	25.00	1.00	0.17	4.84	2.51	−0.01	2.27	39.60
Lauraceae	*Beilschmiedia mannii*	19.55	19.27	2.00	0.26	0.21	0.23	−0.02	0.10	1.16
Liliaceae	*Dracaena mannii*	20.33	22.33	2.00	0.26	0.05	0.16	−0.02	0.02	1.45
Melastomataeae	*Memecylon afzelii*	67.00	43.83	1.00	0.09	0.81	0.45	−0.01	0.38	15.45
Meliaceae	*Entandrophragma angolense*	270.00	27.00	1.00	0.09	3.05	1.57	−0.01	1.43	154.61
	Entandrophragma utile	16.00	16.00	1.00	0.09	0.01	0.05	−0.01	0.01	0.32
	Khaya ivorensis	12.00	12.00	3.00	0.44	0.01	0.22	−0.02	0.00	0.41
Moraceae	*Ficus mucoso*	21.17	22.55	1.00	0.09	2.42	1.26	−0.01	1.14	0.79
	Milicia excelsa	32.17	24.92	2.00	0.26	0.31	0.28	−0.02	0.14	4.05
	Musanga cecropioides	48.83	23.78	3.00	0.52	4.84	2.68	−0.03	2.27	13.36
	Myrianthus arboreus	158.67	40.00	9.00	1.57	4.97	3.27	−0.07	2.33	711.93
Myristicaceae	*Pycnanthus angolensis*	18.00	18.00	15.00	2.52	0.01	1.27	−0.09	0.01	6.87
	Staudtia stipitata	32.63	37.50	22.00	3.74	2.54	3.14	−0.12	1.19	69.00
Olacaceae	*Strombosia grandifolia*	29.75	39.50	8.00	1.31	0.11	0.71	−0.06	0.05	21.97
	Strombosia pustulata	13.67	17.67	58.00	10.01	0.02	5.02	−0.23	0.01	15.04

(Contd...)

Table 4: (*Continued*)

Family	Name	MDBH (cm)	MHt (m)	N/ha	Relative density	Rdo	Importance value index	PiLnPi	Basal area/ha	Vol (m^3/ha)
Papillionoideae	*Baphia nitida*	17.86	12.50	10.00	1.83	0.36	1.09	−0.07	0.17	3.13
Periplocaceae	*Cryptolepis sanguinolenta*	53.00	33.00	1.00	0.17	0.12	0.15	−0.01	0.06	7.28
Rubiaceae	*Canthium hispidum*	215.50	40.33	2.00	0.35	15.74	8.04	−0.02	7.39	294.24
	Coffea canephora	99.00	48.03	1.00	0.09	11.35	5.72	−0.01	5.33	36.98
	Corynanthe pachyceras	95.00	45.00	2.00	0.26	0.38	0.32	−0.02	0.18	63.80
	Holarrhena floribunda	21.00	21.00	1.00	0.09	0.02	0.05	−0.01	0.01	0.73
	Nauclea diderrichii	97.57	41.14	2.00	0.26	6.55	3.41	−0.02	3.08	61.53
	Zanthoxylum zanthoxyloides	16.50	14.89	1.00	0.17	4.84	2.51	−0.01	2.27	0.32
Sapindaceae	*Chytranthus macrobotrys*	15.90	46.00	3.00	0.44	0.02	0.23	−0.02	0.01	2.74
	Deinbollia pinnata	30.00	16.50	1.00	0.17	0.09	0.13	−0.01	0.04	1.17
Sapotaceae	*Aningueria robusta*	27.33	25.78	5.00	0.78	0.37	0.58	−0.04	0.17	7.56
Sterculiaceae	*Nesogordonia papaverifera*	15.37	14.92	4.00	0.61	0.20	0.41	−0.03	0.10	1.11
	Octolobus augustatus	23.69	21.33	7.00	1.22	0.81	1.01	−0.05	0.38	6.58
	Octolobus spectabilis	25.62	25.51	3.00	0.44	1.03	0.73	−0.02	0.48	3.95
	Cola gigantean	71.67	34.90	9.00	1.57	3.94	2.75	−0.07	1.85	126.73
	Sterculia rhinopetala	21.51	30.20	50.00	8.70	0.02	4.36	−0.21	0.01	54.88
Ulmaceae	*Celtis milbreadii*	22.50	27.00	3.00	0.44	0.05	0.24	−0.02	0.02	3.22
	Celtis whiltii	47.88	43.41	1.00	0.17	2.18	1.18	−0.01	1.02	7.82
	Celtis zenkeri	20.40	21.30	8.00	1.39	0.09	0.74	−0.06	0.04	5.57
	Holoptelea grandis	17.00	9.66	1.00	0.09	0.15	0.12	−0.01	0.07	0.22
Violaceae	*Rinorea spp.*	28.00	34.00	1.00	0.09	0.15	0.12	−0.01	0.07	2.09
Total		3087.72	1891.11	595.00	100.00	100.00	100.00	−3.48	46.98	2474.26

CONCLUSION

The result revealed a habitat undergoing regeneration processes and also the potential of *in situ* conservation strategy in nature conservation. The detailed analysis of the plant diversity has revealed the heterogeneity of the rainforest ecosystem as well as the degree of disturbance of the plant species communities. In general, this study has shown the importance of forest inventory as a veritable tool to reveal the ecosystem status. The method used which stems from the use of cluster sampling method has helped to present adequate representative of the tree stands with minimum cost. Human impacts through logging, cutting, cropping, and conversion of forest reserve into agricultural land are ongoing in the study site. The analysis also revealed the study sites rich in species diversity distributed among several genera and families. Most of the tree species were in the smallest diameter class; hence, they are not readily available for exploitation. With the heterogeneity nature of the study sites, this reserve is suitable for *in situ* conservation of tree genetic resources since majority of the trees are not readily available for exploitation. The forest should be managed to provide other services such as tourism, wildlife sanctuary, watershed management, and climatic amelioration. Entrance to the reserves by the communities should be only encouraged to collect non-timber forest products.

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