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Original Article

Tree species diversity and structure of Shasha Forest Reserve, Nigeria

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ABSTRACT

An inventory of the entire tree species ≥10 cm diameter at breast height (DBH) was carried out in Shasha Forest Reserve, Osun State, Nigeria. This study was carried out to ascertain the tree species diversity and structure. Data were collected from eight sample plots 50 × 50 m in two tracts located through cluster sampling technique. In all, an average total of 295 stems distributed among 66 tree species and 28 families were encountered. High value of Shannon-Wiener index H′ value 3.73 and evenness of 0.89 were obtained for the plot. Mean DBH of 21 cm and dominant DBH of 36.5 cm were also obtained for the forest. The highest percentage of the tree population was found in the smallest diameter (10–19.9 cm) class. At present, only few trees are attained at merchantable size of 48 cm DBH and size classes' ≥90 cm DBH were no longer available. The population structure pattern is inverted J shape which is an indication that population decreases with increase in diameter classes. The 10 dominant tree species contributed about 41% of the total ecological importance value and *Strombosia postulata* was the most abundant tree for species with 38 frequencies. The study calls for traumatic steps on sustainable management of the reserve due to its diversity status and application of *in situ* and *ex situ* conservation strategies will be appropriate in conservation of the germplasm of the reserve.

Keywords: Density, dominance, ecosystem, inventory and structure

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INTRODUCTION

Nigeria forest ecosystem has been identified as the reservoir of genetic diversity and potential variability. However, with population pressure and the need to satisfy the demands for food, fuelwood, shelter, and developmental projects, millions of hectares of forests have been cleared and the wood burnt off or used as firewood.[1,2] It was reported that the protected forest reserves of Nigeria are mainly located in the southern part of the country and it occupied 93,345 km^2 in 1993, that is, 9.6% of the total land area of the country.[3] This area by 1994 had increased to 11.4% and later reduced to 10% in 1995. Oriola[4] also reported that the rainforest of Southern Nigeria had been degraded to secondary forest through pressure on the forest reserves due to high population density, shifting cultivation and annual bush burning, and changing the forest into derived savanna. Furthermore, Salami[3] reported on high pressure and overexploitation of the rich biodiversity in Nigeria rainforest through uncontrolled logging and conversion of forest land into agricultural plantations and as a result of this, the area covered by rainforest is rapidly shrinking at alarming rate.

Adekunle *et al*.[1,5] put it straight that the loss of forest genetic resources means the loss of their potential value to man in the supply of timber, herbs, wildlife conservation, erosion control, weather amelioration, and other non-timber forest products. This study was carried out in Shasha Forest Reserve, southwest of Nigeria with a view to determine tree species diversity status, growth, and biodiversity parameters and recommend conservation approach to the sustainable management of the forest reserve. The study also went further on the distribution of trees into size and ecological importance value.

METHODOLOGY

The study was conducted in Shasha Forest Reserve located in Ife South Local Government area of Osun State. It lies

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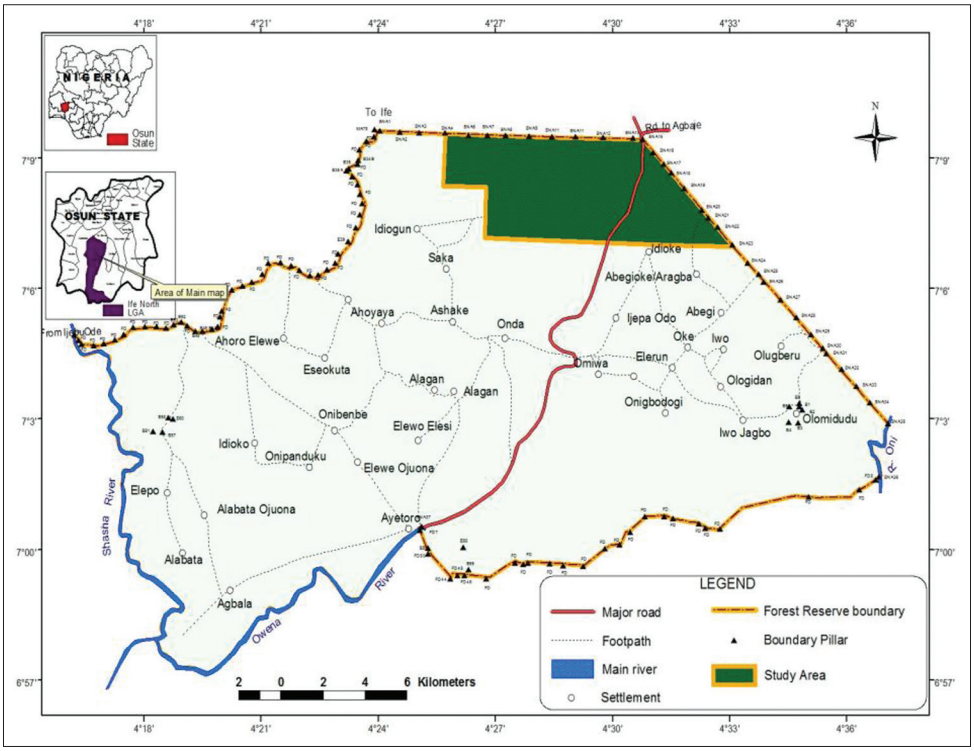

Figure 1: Shasha Forest Reserve

between latitude 9° 4' and 9° 50'N and longitude 3° 54' and 4° 6'E [Figure 1]. The altitude of the forest is 122 m. The soil type is the ferruginous tropical soil on crystalline acidic rock; the topography is gently undulating plain.[6] The rainy season starts from February to November. The climate of the area can also be described as typical of the humid rainforest with total mean annual distribution with two peaks in June and August. Temperature ranges between 23.14°C in September (coolest) and 28.05°C in January (the hottest). The annual mean temperature for the reserve is at 25.4°C. Relative humidity for the reserve also varied between 66.27% in January and 98.96% in October. Mean annual relative humidity for the area is 85.04%. Shasha Forest Reserves vegetation is classified by Keay[7] along with the rest of the Nigerian high forest as tropical lowland rainforest. Jones[8] recognized the forest type as dry lowland, distinct from the wet forest of the southern part of the Omo Forest Reserve.

Data Collection

Systematic cluster sampling technique was used for plot location in the forest. The 200 × 500 m area referred to as clusters was partitioned into 200 × 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 × 50 m. Four temporary plots were selected for tree enumeration. This method was adopted by Adekunle, Adekunle and Olagoke, Akinnagbe, FORMECU, and Ozoike.[6,9-12]

Tree Species Enumeration

All living trees with diameter (diameter at breast height [DBH]) ≥10 cm on each temporary field plot were identified, recorded, and grouped into families. The botanical names of every living tree encountered in the study sites were recorded. In cases, where a tree's botanical name was not known at the spot, such a tree was identified by its common name and later brought to Forestry Herbarium at FRIN, Ibadan.

Tree Growth Variable Measurement

Tree growth variable measurement was limited to all trees with a diameter ≥10 cm at breast height over bark as employed by FORMECU.[11] For this study, the following tree growth data were collected in each sample plot for further analysis.

I. DBH (breast height is the stem diameter over-bark position of 1.3 m above the ground level) (cm).
II. Total height (m) of all the standing trees using Spiegel Relaskop.

Data Analysis

Tree species were categorized into life form using forest structural analysis of the size class distributions which were classified for distinct categories, namely, smaller (10–20 cm DBH), medium (21–50 cm DBH), large (51–100 cm DBH), and largest (>100 cm DBH). The stems were further classified into 10 diameter classes to show graphical pattern of tree population distribution. To examine the relationship among the growth variables, Pearson correlation coefficient was adopted.[13]

Tree Species Diversity Indices

The following indices were employed: [5,14,15]

i. Shannon–Wiener diversity index

$$H' = \sum_{i=1}^{s} P_i Ln(P_i) \quad (1)$$

ii. Pielou's species evenness index

$$E = \frac{H'}{LnS} \quad (2)$$

iii. Simpson concentration index

$$A = \sum \left(\frac{n_i}{N_i} \right)^2 \quad (3)$$

Where: H' is the Shannon–Weiner diversity index; S and N_i are the total number of in the community; P_i is the proportion of S made up of the i^{th} species, E is the species evenness, n_i is the number of individual in species, and Ln is natural logarithm.

Forest Structure Computation

i. Basal area

The basal area of all trees in the sample plots was calculated using Equation 6.

$$BA = \frac{\pi D^2}{4} \quad (6)$$

Where, BA = Basal area (m^2), D = Diameter at breast height (cm), and π= pie (3.142). The total BA for each plot was obtained by adding all trees BA in the plot.

ii. Volume

The volume of each tree was calculated in every plot using

$$V = e^{-8.433+2.331Ln(D)} \quad (7)$$

Where, V = Tree volume (m^3).[9]

Relative Density

Relative density (RD %) of each species was computed following the equation of Brashears *et al.* (2004).

$$RD = \frac{n_i}{N} \times 100 \quad (8)$$

Relative Dominance

Relative dominance (RD_0 %) of each species was estimated using the following equation:

$$RD_0 = \frac{\left(\sum BA_i \times 100 \right)}{\sum BA_i} \quad (9)$$

Where, RD_0 is the relative dominance of the species; BA_i is the basal area of all the individual trees belonging to a particular species i; and BA_n is the basal area of the stand.

Importance Value Index

The sum of the RD and RD_0 divided by 2 gave the importance value of index for each species.[16,17] This was used to express the share of each species in the tree community.[18]

$$IVI = \frac{RD \times RD_0}{2} \quad (10)$$

Family Importance Value (FIV)

This was used to estimate a family's share in the forest community. It is defined as the sum of its relative dominance (RD_0) and density (RD) divided by 2.

To examine the relationship among the growth variables, Pearson correlation coefficient was adopted.

RESULTS AND DISCUSSION

The tree growth variables obtained at Shasha Forest Reserve per hectare are presented in Table 1. The stand density was 295/ha. The stand basal area and volume were 15.69 m^2/ha and 213.52 m^3/ha, respectively. The mean tree height and dominant height in the study area were 15.10 m and 20.00 m, respectively, while the mean DBH, dominant DBH, and max. DBH were 21.09 cm, 36.5 cm, and 40 cm, respectively.

The result of species diversity indices [Table 2] revealed that 66 tree species were encountered in the study area with 295 individuals. The species dominance index was 0.03 with Shannon–Wiener index value 3.73 and evenness E = 0.89. This high value of H is an indication that the ecosystem is highly diversified harboring various species. The high E value implies that no single tree species was having absolute dominance value in the plot; rather, many trees shared the values within the reserve. Hence, high evenness value of the reserve is an indication that setting conservation or locating conservation plots will not be a problem at all.[19]

Table 3 presents the number of species encountered, their frequency, relative density, dominance, basal area, and ecological importance value index. In all, 295 stems per hectare were encountered, distributed among 66 trees species and 28 families. *Strombosia pustulata* had the highest frequency (38 stems per hectare) and this is followed by *Musanga cecropioides* that occur 17 times/h, *Macaranga barteri* (16 trees per hectare), and *Myrianthus arboreus* (13 trees per hectare). All of these can be regarded as the dominant tree species in the reserve. Twenty-two trees (33% of the total species) were encountered only once in the reserve and they can

Table 1: Tree growth variables

Growth variables	Values
Mean DBH (cm)	21.09±0.86
Dominant DBH (cm)	36.50
Max. DBH (cm)	40.00
Min. DBH (cm)	10.00
Mean height (m)	15.10±0.66
Dominant height (m)	20.00
Max. height (m)	27.50
Min. height (m)	7.60
Tree volume (m^3/ha)	213.52
BA (m^2/ha)	15.69
N/ha	295.00

DBH: Diameter at breast height, BA: Basal area

Table 2: Tree species diversity indices

Diversity indices	Values
Species	66.00
Individuals	295.00
Dominance	0.03
Shannon index	3.73
Sorensen index	0.96
Evenness	0.89
Margalef	11.43

be referred to as rare species in the reserve. Only 17 or about 26% of the trees species were actually having frequency >5 stems per hectare in the reserve.

Likewise, Table 3 presents a checklist of the species families in the reserve. Twenty-eight families were encountered and families of *Apocynaceae, Ebenaceae, Moraceae,* and *Sterculiaceae* were represented with six tree species per hectare each in the reserve and form the most dominant families in the study area. Sixteen families or 57.14% of the families were represented with only one tree species per hectare. These families can as well be regarded as rare in the reserve. Nine families or 32% were having trees more than 2 trees per hectare. Adekunle, *et al*. and EtuKudo[5,20] noted that there are usually several species in tropical rainforest ecosystem and some may occur only one per hectare.

Tree Species Structures in the Shasha Forest Reserve

The highest proportion of the tree population occurred at the lowest girth class and decreases as the diameter class increases. The higher DBH classes of ≥90 cm were no longer having any representative. This result revealed overexploitation of the timber resources of the reserve. The distribution curve obtained for the reserve is an inverted J-shaped curve [Figure 2] which is typical of tropical natural forest. This is expected of a tropical rainforest ecosystem.[21] This curve revealed a healthy succession, if the reserve is conserved and timber

Table 3: Family and tree species richness in Shasha Forest Reserve

Family	Name	MDBH (cm)	MHt (m)	Fre /ha	RD	Rdo	IVI	PiLnPi	BA (m^2/ha)	Vol (m^3/ha)
Alangiaceae	*Cussonia bancoensis*	17.67	10.72	1	0.358423	0.91892	0.638671	−0.02018	0.144179	0.26
Anacardiaceae	*Lannea welwitschii*	16.52	11.39	1	0.358423	0.969985	0.664204	−0.02018	0.152191	0.24
Annonaceae	*Cleistopholis patens*	23.24	20.53	4	1.433692	2.712203	2.072947	−0.06086	0.425545	3.48
	Hexalobus crispiflorus	15.21	8.64	6	1.971326	0.417344	1.194335	−0.0774	0.065481	0.94
Apocynaceae	*Alstonia boonei*	27.40	18.20	3	0.896057	1.08413	0.990094	−0.04225	0.1701	3.22
	Funtumia elastica	30.00	17.00	8	2.688172	0.225287	1.456729	−0.09721	0.035348	9.61
	Holarrhena floribunda	29.50	18.38	4	1.433692	1.941472	1.687582	−0.06086	0.304617	5.03
	Hunteria umbellata	30.00	19.25	4	1.25448	0.455079	0.85478	−0.05493	0.071402	5.44
	Rauvolfia vomitoria	10.00	13.00	1	0.179211	0.025032	0.102122	−0.01133	0.003928	0.10
	Voacanga africana	10	22.0	1	0.179211	10.29598	5.237597	−0.01133	1.61544	0.17

(*Contd...*)

Table 3: (*Continued*)

Family	Name	MDBH (cm)	MHt (m)	Fre /ha	RD	Rdo	IVI	PiLnPi	BA (m^2/ha)	Vol (m^3/ha)
Bignoniaceae	*Spathodea campanulata*	20.76	17.41	4	1.25448	9.187947	5.221214	−0.05493	1.441589	2.36
Boraginaceae	*Cordia millenii*	25.42	19.50	3	0.896057	2.046856	1.471457	−0.04225	0.321152	2.97
Caesalpinioideae	*Hylodendron gabunense*	25.00	7.00	4	1.433692	0.156449	0.79507	−0.06086	0.024547	1.37
	Anthonotha macrophylla	12.33	7.08	3	1.075269	0.233297	0.654283	−0.04874	0.036604	0.25
Capparaceae	*Buchholzia coriacea*	18.03	8.58	3	1.075269	0.535291	0.80528	−0.04874	0.083987	0.66
Combretaceae	*Terminalia superba*	19.90	13.47	6	1.971326	0.792912	1.382119	−0.0774	0.124408	2.51
Compositae	*Canthium hispidum*	18.25	12.50	2	0.716846	0.440811	0.578829	−0.0354	0.069163	0.65
Ebenaceae	*Diospyros canaliculata*	17.61	11.83	3	1.612903	1.719439	1.666171	−0.06657	0.26978	0.86
	Diospyros dendo	17.71	14.57	9	3.225806	0.618287	1.922047	−0.11077	0.097009	3.23
	Diospyros mespiliformis	18.75	12.00	4	1.25448	0.377731	0.816106	−0.05493	0.059266	1.33
	Diospyros piscatorial	25.86	11.86	2	0.716846	1.471123	1.093984	−0.0354	0.230819	1.25
	Diospyros suaveolens	25.00	16.00	4	1.25448	0.156449	0.705465	−0.05493	0.024547	3.14
	Diospyros mespiliformis	16.50	13.88	1	0.179211	1.163481	0.671346	−0.01133	0.18255	0.30
Euphorbiaceae	*Drypetes gilgiana*	16.00	12.17	8	2.867384	0.198753	1.533068	−0.10184	0.031184	1.96
	Drypetes paxii	22.00	14.50	1	0.179211	0.121154	0.150183	−0.01133	0.019009	0.55
	Drypetes principum	12.00	6.00	1	0.358423	0.108388	0.233405	−0.02018	0.017006	0.07
	Macaranga barteri	17.71	16.29	16	5.555556	0.030289	2.792922	−0.16058	0.004752	6.42
	Ricinodendron heudelotii	19.50	10.75	9	3.225806	0.403013	1.81441	−0.11077	0.063233	2.89
Flacourtiaceae	*Scottelia coriacea*	22.50	20.53	2	0.716846	2.270891	1.493868	−0.0354	0.356303	1.63
Melastomataceae	*Memecylon candidum*	32.09	19.30	1	0.179211	10.29598	5.237597	−0.01133	1.61544	1.56
Meliaceae	*Ekebergia senegalensis*	16.00	14.00	1	0.179211	0.130166	0.154689	−0.01133	0.020423	0.28
	Entandrophragma angolense	11.00	8.00	1	0.358423	0.030289	0.194356	−0.02018	0.004752	0.08
	Guarea cedrata	28.36	21.23	5	1.612903	2.626344	2.119623	−0.06657	0.412073	6.71
	Trichilia monadelpha	40.00	26.00	10	3.405018	0.80152	2.103269	−0.11509	0.125759	32.68
	Trichilia welwitschii	10.00	8.00	4	1.25448	0.025032	0.639756	−0.05493	0.003928	0.25

(*Contd...*)

Table 3: (*Continued*)

Family	Name	MDBH (cm)	MHt (m)	Freq /ha	RD	Rdo	IVI	PiLnPi	BA (m^2/ha)	Vol (m^3/ha)
Mimosoideae	*Albizia lebbeck*	19.00	18.50	1	0.358423	0.18874	0.273582	−0.02018	0.029613	0.52
Moraceae	*Bosqueia angolensis*	26.67	20.33	2	0.537634	0.586246	0.56194	−0.0281	0.091982	2.27
	Ficus exasperata	21.33	23.60	1	0.358423	1.783771	1.071097	−0.02018	0.279874	0.84
	Ficus mucuso	23.78	16.61	1	0.179211	1.372122	0.775667	−0.01133	0.215286	0.74
	Milicia Excelsa	22.40	11.22	2	0.537634	3.572353	2.054994	−0.0281	0.560502	0.88
Urticaceae	*Musanga cecropioides*	24.15	19.42	17	5.913978	2.132715	4.023347	−0.16724	0.334623	15.12
	Myrianthus arboreus	15.00	10.00	13	4.659498	0.056322	2.35791	−0.14287	0.008837	2.30
Myristicaceae	*Pycnanthus angolensis*	35.44	21.69	7	2.329749	7.300794	4.815272	−0.08758	1.145495	14.98
Olacaceae	*Strombosia pustulata*	23.05	10.76	38	13.44086	2.855635	8.148248	−0.26974	0.448049	17.06
Papilionoideae	*Baphia nitida*	16.00	7.50	3	1.075269	0.402012	0.73864	−0.04874	0.063076	0.45
Passifloraceae	*Barteria fistulosa*	13.83	8.58	3	1.075269	0.311146	0.693207	−0.04874	0.048819	0.39
Rubiaceae	*Corynanthe pachyceras*	18.33	24.50	6	2.150538	0.566721	1.35863	−0.08257	0.088919	3.88
	Crossopteryx febrifuga	18.00	9.00	3	1.075269	0.186738	0.631003	−0.04874	0.029299	0.69
	Rothmannia hispida	22.71	16.80	1	0.179211	1.049086	0.614149	−0.01133	0.164602	0.68
Rutaceae	*Zanthoxylum zanthoxyloides*	33	25.5	2	0.537634	3.572353	2.054994	−0.0281	0.560502	4.36
Sapindaceae	*Allophylus africanus*	11.00	5.60	1	0.179211	0.030289	0.10475	−0.01133	0.004752	0.05
	Lecaniodis cuscupanioides	20.88	15.88	1	0.179211	0.586246	0.382729	−0.01133	0.091982	0.54
Sapotaceae	*Aningeria robusta*	33.80	23.50	5	1.792115	3.051385	2.42175	−0.07207	0.478762	10.54
	Chrysophyllum albidum	25.67	19.83	1	0.358423	1.080876	0.719649	−0.02018	0.169589	1.03
	Chytranthus atroviolaceus	23.00	17.29	2	0.716846	1.20153	0.959188	−0.0354	0.18852	1.44
	Malacantha alnifolia	11.00	13.00	4	1.433692	0.397005	0.915349	−0.06086	0.06229	0.49
Simaroubaceae	*Hannoa ferruginea*	17.25	15.44	1	0.179211	0.647324	0.413268	−0.01133	0.101565	0.36
Sterculiaceae	*Cola gigantean*	16.00	9.50	9	3.046595	0.130166	1.58838	−0.10636	0.020423	1.72
	Cola millenii	11.00	6.36	1	0.358423	0.339182	0.348802	−0.02018	0.053218	0.06
	Cola nigerica	25.00	20.40	6	1.971326	1.018547	1.494936	−0.0774	0.15981	6.01
Malvaceae	*Mansonia altissima*	22.00	16.50	4	1.25448	2.414949	1.834715	−0.05493	0.378906	2.51
	Sterculia rhinopetala	22.82	18.55	8	2.867384	1.591776	2.22958	−0.10184	0.24975	6.07

(*Contd...*)

Table 3: (*Continued*)

Family	Name	MDBH (cm)	MHt (m)	Freq /ha	RD	Rdo	IVI	PiLnPi	BA (m^2/ha)	Vol (m^3/ha)
	Triplochiton scleroxylon	28.33	21.00	1	0.358423	0.643069	0.500746	−0.02018	0.100897	1.32
Ulmaceae	*Celtis georgiana*	14.00	11.00	1	0.179211	0.049062	0.114137	−0.01133	0.007698	0.17
	Celtis mildbraedii	36.83	20.38	3	1.075269	3.899715	2.487492	−0.04874	0.611865	6.51
	Celtis zenkeri	23.15	17.08	7	2.329749	1.989283	2.159516	−0.08758	0.312118	5.03
Total		1392.24	996.88	295	99.99993	99.99442	99.99725	3.67289	15.68917	213.52

IVI: Importance value index, BA: Basal area

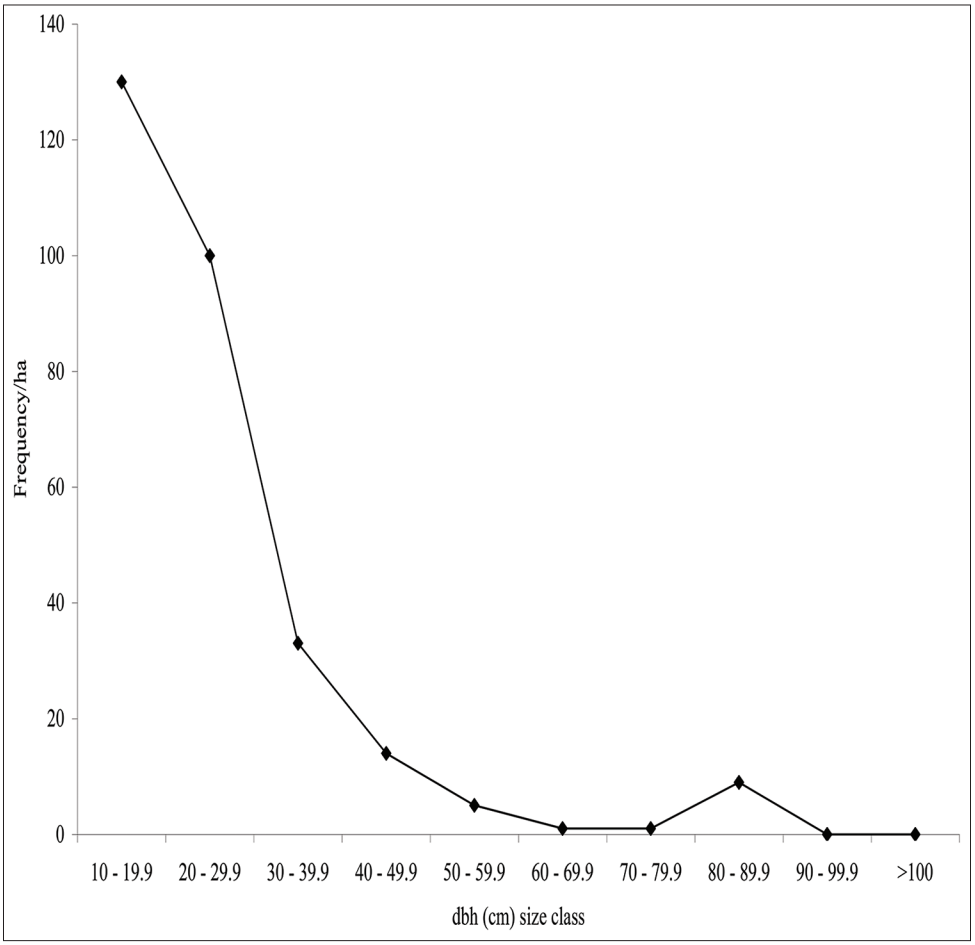

Figure 2: Tree diameter distribution

exploitation is suspended for the forest to rejuvenate back to former status.[19]

Ecological Dominance of the Tree Species in Shasha Forest Reserve

The total basal area per hectare in the forest is 15.69 m^2 [Table 1]. This value is lower than the expected value (25 m^2/ ha) recommended by Adekunle *et al*., Alder and Abayomi[5,21] for a fully stocked forest. *Memecylon candidum* and *Voacanga africana* had the highest basal area of 1.61 m^2 per hectare each. About 93.9% of the trees had basal area <1 m^2/hectare. *Strombosia pustulata* had the highest ecological dominance value index of 8.14% followed by *Spathodea campanulata* and *Voacanga africana* with 5% each. *Spathodea campanulata* also have the highest relative dominance in the reserve.

CONCLUSION

The results of this study revealed a habitat that has passed through unsustainable management and overexploitation of forest resources by man. Sixty-six tree species and 28 families encountered in this study as a proportion that the reserve is rich in species diversity. The inverted J-shaped curve encountered in this study was an indication that large proportion of the tree species was located among the lower diameter classes. The result also revealed the kind of wood resource that can readily be sourced for in the reserve for the purpose of expert and domestic use. Due to high diversity of flora in the reserve, the reserve is recommended for *in situ* conservation of genetic forest resources since large percentage of the tree population is below the merchantable size of 48 cm DBH for exploitation. In other to derive economic returns for the management of the reserve, it is suggested to be managed for provision of other non-timber products such as tourism, wildlife conservation, botanical garden, and watershed management, and local communities could only be allowed to carry out non-destructive activities such as gathering of wild edible fruits, snails, and herbs for medical purposes. Conversion of the reserve to exotic or agricultural plantations should not be entertained due to high biodiversity richness of the reserve as revealed by the study.

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