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WOODY PLANT SPECIES DIVERSITY AND STRUCTURE OF IGBO OLODUMARE AND IGBO GBOPO SACRED GROVES IN SOUTHWESTERN NIGERIA.

[1]Oyelowo, O.J.*, [2]Sulaiman, O.N., [1]Kareem A.A., [1]Olatidoye, O.R., [1]Olaoti-Laaro, S.O.

1 Forestry Research Institute of Nigeria

2 Federal College of Forestry, Ibadan

tayooyelowo@yahoo.com

ABSTRACT

Indigenous forestsor sacred groves (SGs) are gaining interest globally, because of the significant roles they play in biodiversity conservation. They are spiritual or cultural forests protected by the strength of religious beliefs or taboos housing gods and goddesses.However, many SGs have not been extensively studied due to their sacredness and accessibility. The present study investigated the tree speciesand structure of Igbo Olodumare and Igbo Gbopo SGs in southwestern Nigeria to establish a basis for optimal conservation. The primary data collected from temporary sample plots of 25 × 25m were laid out systematically across the study sites. On each plot, all growing trees with a breast height (dbh) $\geq$ 10 cmwere named to species level.All trees were grouped into families and relative densities. The total no of individuals encountered in the groves was 320. The 40 tree species accessed were distributed among 15 families. In the two SGs, most of the species were found in the Sterculiaceae family(7 and 5), followed by Moraceae(1 and 4), and Bignonaceae(3 and 1), all in Igbo-Olodumare and Igbo Gbopo respectively. The highest mean dbh was found in Igbo-Olodumare (35.7 cm), and Igbo-Gbopo with a mean dbh of 19.0cm. Igbo-Olodumare had a diversity index of 2.76 and Igbo-Gbopo (2.51)with similarity indices of 0.4314.The population structure of the SGs was nearly or typically inverted J-shaped curve, with Igbo-Olodumare and Igbo-Gbopo having the maximum frequency in the diameter classes of 20–29.99 cm and 10–19.99 cm, respectively.Maintaining the cultural values of the SGs is a strategy for their effective conservation. Conservation policies should therefore acknowledge cultural values and local practices to reduce the loss of biodiversity. The study offers information on the composition andstructures of the two sacred groves. This knowledge might be useful to natives and conservationists for the management of their resources.

Keywords: Sacred grove, structure, composition, flora, Igbo Olodumare, Igbo Gbopo

Introduction

The world's tropical rainforests are terrestrial ecosystems with rich biodiversity (Onyekwelu *et al.* 2008, FAO 2011, and IUCN 2010). They are the most species-rich and diverse forests on earth, estimated to contain at least 50% of the plants and animal species (Myers, 1986). This is especially true for wet tropical forests, where for example, some 700 tree species have been identified in 10 selected 1- hectare plots in Borneo (UNEP, 1995). This destruction of natural forests is alarming and is increasing daily. According to Kumar *et. al.*(2002), because of heavy anthropogenic pressure, many tropical forests need management intervention to preserve and/or enhance their biodiversity, productivity, and sustainability.

Nigeria forests support, a diverse array of vegetation, which is determined by biotic and abiotic factors. According to a report on forest resources conducted by the Federal Department of Forestry (1988), Nigeria's forest estate has been severely reduced.

According to estimates, about 974,674 haof forest reserves are productive, and 2,342,147 ha of free areas are partially productive. Unfortunately, only a fragment of the country's tropical rainforest (21% of the rainforest ecosystem and 2% of the country's land mass) has been established into forest reserves (Udo *et al.,* 2009). According to Salami (2006), the rate of deforestation in Nigeria's southwest geopolitical zone is estimated to be 1.36% annually.There are growing concerns about developing new global, regional, and national programmes for conserving and managing forest biodiversity (Köhl*et al*,2015).

One of these global conservation interests is the conservation of SGs or community forests. SGs are spiritual or cultural forests protected by the strength of religious beliefs or taboos housing gods and goddesses.According to Khan *et al.* (2008), sacred groves are virgin forests that have been purposefully preserved by the local community, they are home to a diverse range of wildlife and are protected by the indigenous people because of their cultural and religious taboos. Kokou (1997)described a sacred grove as a forest where locals practice rituals to interact with the dead and spirits.There have also been numerous laws passed periodically governing the conservation of biodiversity, such as "The Biological Diversity Act 2002" in India. In addition to these official regulations, indigenous tribes around the world engaged in a variety of traditional conservation activities that aided in the conservation and protection of biodiversity. The regulations and rules that were put in place by the community were intended to enhance biodiversity and let Earth maintain to fulfil its mothership function. (Abaye-Boaten, 1997, Dudley and Stilton 1999).

The communities of Oba-Ile in Osun State set aside, patches of forest, closed to settlements as sacred lands into which entry was strictly prohibited, except for cultural or spiritual purposes (Oyelowo, 2014). These protected areas or lands are collectively referred to as sacred or fetish groves. The traditional religious and cultural practices thus helped significantly to regulate and restrict the use of the resources in these very representative land areas(Godson, 1998).Okali and Amubode, (1991), identified four factors attributed to the impactful management of biodiversity in the Oboto community, Ondo State, Nigeria; firm commitment to the established village structure,with its distinct line of authority and assignment of responsibilities; a high level of respect for the traditional law; increasing understanding of the local ecology and conditions, incorporating this understanding into local land use, game-hunting and conservation practices; and a high value attached to medicinal plants.

The research done by Sukumaran *etal*., (2008) revealed that the SG of Kanya Kuri district, India represents the remnants of relics and unique vegetation of the tropical forests. The SGs' floristic composition suggests that the region once had climax vegetation.(Vartak*et al*., 1986). These groves, therefore, play an importantpart in the tree species that have become extremely rare or extinct elsewhere. However, this paper presents the flora compositionandthe structure of two SGs in Southwestern Nigeria to serve as a basis for impactfulconservation.

Materials and Methods

Areas of Study

The study area is part of the tropical rainforest ecosystem occurring in southwest Nigeria. The ecological zone is a continuous belt around the world between Lat 24^{o}S and 24^{o}N

and Longitude 10°E and 20°W. The tropical rainforest in southwest Nigeria starts a few kilometres inland and runs along the coastal flora to the derived and Guinea savanna vegetation. In its broadest extent, it measures 300 km (Okojie, 1994).

The soils vary in physical and chemical properties, but they exhibit some common characteristics, According to Onyekwelu et al. (2008), the soils in the severely weathered areas of basement complex formations in the rainforest ecological zone of south-western Nigeria are largely ferruginous tropical soils.

Igbo Olodumare Sacred Grove

Igbo Olodumare is located nearOke-Igbo, Ondo State.It is recognized for its spiritual worth covering the 7-ha area (Onyekwelu and Olusola, 2014).It is located within the Lat. 7°55¹52.89¹¹Nand Log 4°14¹56.2611E.The people'smain occupations are farming, hunting, and other small-scale businesses. Some are also artisans, traditionalists, and herbalists. The forest is significant for its spiritual value, and that demons and spirits existed in the grove.

Igbo-Gbopo Sacred Grove

Igbo-Gbopo is in the Aye community in Ejigbo Local Government. It is considered one of the oldest villages in the Local Government Area. It is located within the Lat. 7°55'36.36"Nand 4°15'10.55"E.The object of devotion in the Igbo Gbopo forest is River Yemo, which takes its source and meanders through the grove.

Vegetation studies

Four temporary sample plots of 50 × 50 m were laid out systematically across the study sites for data collection.All living trees on each plot that had a diameter at breast height (dbh) ≥10 cm were identified tospecies level. All trees were grouped into families and relative density for tree species diversity classification, and diameter class distribution. All trees found in the plots on a species basis were extrapolated by multiplying itby the number of plots ha^{-1} to obtain the abundance of the species.Trees that were impossible to identify in the field, part of such trees (Leaves, bark, and fruits) were collected and identified at the Forestry Research Institute of Nigeria (FRIN) herbarium, Ibadan.

Analysis of Data

The data collected, species count, and measurements were processed into a suitable form for statistical analysis.

Basal Area Calculation:

All trees in the sample plots were calculated using the basal area formulas.:

$$BA = \frac{\pi D^2}{4} \quad \text{----------} \quad \text{- (}eqn.\text{ l)}$$

Where:

BA = Basal Area (m^2)
D = Diameter at breast height (cm)
p = Pie (3.142).

The total basal area for each of the sample plots is obtained by the sum of the BA of all trees in the plot.

Diversity index and tree species classification

All plant species encountered were classified into families and frequency. Their frequencies of occurrence were obtained to ascertain species abundance/richness of floral composition on species evenness. The diversity and evenness of the forest in each sacred grove were measured using the following biodiversity indexes.

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The species relative dominance (RDo %): This was obtained using the Formula given by Brashear *et al* (2004)

$$RDo = \frac{\sum Bai \times 100}{\sum Ban} \quad \text{----------} \quad (eqn.\ 2)$$

Where:

RD_O = Relative Dominance
B_{ai} = Basal area of individual tree belonging to tree species ith
B_{an} = Stand basal area

Species relative density (RD): Refers to the number of individuals of a given species divided by the total number of individuals of all Species that were found.

$$RD = \frac{ni \times 100}{N} \quad \text{----------} \quad (eqn.\ 3)$$

RD = relative density
n_i= number of individual species
N = total number of individuals in the entire population.

$$Relative\ Frequency\ (RF) = \frac{No\ of\ occurrence\ of\ the\ species}{No\ of\ occurrence\ Of\ all\ the\ Species} \times 100$$

---------- (*eqn.* 4)

The relationship between the RD and RD_0 gives Important Value Index (IVI)

$$\textbf{Important Value Index} = \frac{RD + RDo}{2} \quad \text{----------} \quad (eqn.\ 5)$$

Diversity index: Each sacred grove was assessed using the Simpson (1949)

$$I = \frac{\sum(ni-1)}{N\ (N-1)} \quad \text{----------} \quad (eqn.\ 6)$$

Where I = Simpson's diversity index

n_i = Number of individuals of ith species enumerated.
N = Total number of species enumerated

The Simpson original diversity index has a value between 0 and 1,meaning that the lower the value calculated, the higher the diversity. With the inverse form, the higher the value, the higher the diversity. The inversed Simpson diversity index is given as follows.

$$I = \frac{N\ (N-1)}{\sum\{ni\ (ni-1)\}} \quad \text{----------}$$
(eqn.7)

Species evenness (E) in each ecosystem will be calculated by adopting Shannon's equitability (E_H) as stated by Kent and Coker (1992):

$$EH = \frac{\sum Piln\ (P1)}{Ln(s)} \quad \text{----------}$$
(*eqn.* 8)

Where:

S = the total number of species in the habitat

P_1 = proportion S (species in the family) made up of the ith species

Ln = natural logarithm

Sörensen's species similarity index (SI) of Nath *et al.*, (2005) between any two sites was calculated using the:

$$S1 = (2c/a\ |\ b)\ x100 \quad \text{----------} \quad (eqn.\ 9)$$

Where: C = number of species in sites a & b

a, b = number of species at sites a and b

Results and Discussions

The present study reveals SG's uniqueness in biodiversity conservation, especially trees. Although SGs are small compared to government-protected areas, they harbour rare endangered, economic, and medicinal plants. According to Sujana and Sivaperuman (2008), ignoring the groves'conservation would result in the extinction ofboth plant and

cultural varieties. The study measured the diversity, richness, and tree species distribution in the SG, which is situated in the tropical rainforest of southwest Nigeria. The two SGs are Igbo-Olodumare and Igbo-Gbopo inOke Igbo and Aye Town respectively. In Table 1, the total no of individualtreesfound in the groves was 320.

The highest mean dbh was found in Igbo-Olodumare, at 35.7 cm, while Igbo-Gbopo with mean dbh of 19.0cm. The high diversity index in Igbo-Olodumare (2.76) andIgbo-Gbopo(2.51), might be due to the protective measures adopted by the two communities, which revealed a relatively undisturbed forest ecosystem. Mayer and Harms, (2009) affirmed that species diversity is an important index in community ecology; hence, the composition of species and diversity can be used as indicators of previous management practices in forested areas (Hunter, 1999; Kneeshaw *et. al*., 2000).

Table 1: Summary of Tree Diversity Indices in the SGs

	Igbo Olodumare	Igbo-Gbopo
No of Trees/Plot	214	106
No of Species/ha	100	76
No of family/ha	48	40
Mean dbh (cm)	35.7	19.0
Max. dbh (cm)	130.0	52.0
Mean BA (cm^2)	1367.66	328.31
Density/ha	856	424
IV (%)	4.00	5.26
Diversity index	2.764	2.5100
Species evenness	0.6347	0.6475
Similarity (0.4314)		

During the study in the two SGs, a total of 214 trees representing 25 tree species and 12 families were recorded in Igbo Olodumare SG (Table 2), while in Igbo-Gbopo SG,106 trees representing 19 tree species and 10 families were recorded (Table 3). The two SGs are almost similar in tree species and family composition when compared with the tropical rainforest as reported by Dike *et. al*. (1996), Vartak*et al.* (1986), and Oyelowo*et al*. (2012).The results of the study were low compared to the related study by Singh *et al.*, (2017), where 80 plant species from 44 families were recorded in India's Hariyali Devi SG.This difference may be explained by the dominance of some species over others. (Tsingalia, 1990).

Studies on the structure and density of the primary canopy tree species can aid in understanding the condition of species regeneration as well as the management history and forest ecology. (Tesfaye *et al*., 2010).*Sterculia rhinopetala* had the highest frequency of 38 in Igbo-Olodumare, followed by *Hildegardia barteri* (28*)*, with the Relative Dominance from 0.47% - 13.08%. But in Igbo Gbopo, *Lecaniodiscus cupanioides* had the highest frequency of 19, *Melicia guinensis, Mangefera indica, Cola acuminata, Cola gigantea, Cola nitida, Ficus exasperata* share the same frequency of 1, whilethe Relative Density ranged from 0.94% - 17.92%. In the two SG, *Sterculia rhinopetala* and *Lecaniodiscus cupanioides* are the dominant species recorded in Igbo Olodumare

and Igbo Gbopo respectively.The structure and composition of communities are determined at the local or regional level by dominant plant species, which are referred to as foundation species (Caro, 2010). According to Dickson and Gross (2013), an increase in the dominant plant abundance species may have contrasting effects on the co-occurring species. The dominance of the *Sterculia rhinopetala* and *Lecaniodiscus cupanioides* in the SG can cause a decline in species richness within the SG.

The Importance Values Index (IVI)indicates the ecological significance of a tree species (Husch, *et. al*., 2003).The ecological significance of the IVI is greater in plant distribution than in absolute density(Fosberg 1961).Kent and Coker, (1992) reported thatIVI is the combination ofRelative Frequency, Relative Density, and Relative Dominance. In Igbo-Olodumare, *Cola acuminata* had the minimum IVI of 0.49%, while *Sterculia rhinopetala* had the highest Important Value Index of 16.91%.(Table 2)*Albizia zygia* had the highest Important Value of 18.19%, while *Milicia guineensis* had the least Important Value of 0.59% (Table 3). Thespecies assessed that fell within the greatest Importance Value are also the leading dominant in the SG. They have higher relative density, relative frequency, and relative abundance in comparison with other species in the SG.

Table 2: Tree Species Diversity Indices of Igbo Olodumare Sacred Grove.

Family	Species	Freq.	Mean dbh (cm)	Max dbh (cm)	RDo (%)	RD (%)	IV (%)
Bombacaceae	*Bombax buonopozense*	1	48.0	48.0	0.6184	0.4673	0.5428
	Diospyros dendo	6	27.5	52.0	1.5864	2.8037	2.1951
Caesalpinioideae	*Afzeliaafricana*	2	21.5	32.0	0.3073	0.9346	0.6209
Mimosoideae	*Albizia zygia*	3	23.3	33.0	0.4922	1.4019	0.9470
Euphorbiaceae	*Bridelia micrantha*	12	29.6	54.0	3.4447	5.6075	4.5261
	Elaeophorbiadrupifera	4	31.3	42.0	1.1361	1.8692	1.5026
	Ricinodendronheudelotii	22	41.0	96.0	14.3078	10.2804	12.2941
Bignoniaceae	*Ceiba pentandra*	5	75.0	130.0	9.3819	2.3364	5.8592
	Newbouldialaevis	3	23.7	29.0	0.4646	1.4019	0.9332
	Spathodeacampanulata	8	17.6	29.0	0.7657	3.7383	2.2520
Annonaceae	*Cleistopholis patens*	7	23.4	32.0	1.0923	3.2710	2.1817
	Xylopia aethiopica	12	25.4	53.0	2.6385	5.6075	4.1230
Sterculiaceae	*Cola acuminata*	1	44.0	44.0	0.5196	0.4673	0.4934
	Cola hispida	24	22.3	51.0	3.8977	11.2150	7.5563
	Cola mildbread	1	65.0	65.0	1.1339	0.4673	0.8006
	Cola nitida	4	40.0	47.0	1.8137	1.8692	1.8414
	Hildegardiabarteri	28	48.3	98.0	21.8569	13.0841	17.4705
	Mansoniaaltissima	6	26.2	32.0	1.1302	2.8037	1.9670
	Sterculia rhinopetala	38	36.3	65.0	16.0660	17.7570	16.9115
Ebenaceae	*Diospyros crassiflora*	5	22.4	32.0	0.7230	2.3364	1.5297
Apocynaceae	*Hunteriaumbellate*	5	53.2	78.0	4.2104	2.3364	3.2734

	Picralima nitida	3	24.7	31.0	0.5062	1.4019	0.9540
Moraceae	*Milicia regia*	7	62.7	121.0	9.7995	3.2710	6.5353
Papilionoideae	*Milletiathonningii*	2	27.5	28.0	0.4061	0.9346	0.6703
Anacardiaceae	*Spondiasmombin*	5	31.6	52.0	1.7010	2.3364	2.0187

Table 3: Tree Species Diversity Indices of Igbo-Gbopo Sacred Grove.

Family	Species	Freq.	Mean dbh (cm)	Max dbh (cm)	RDo (%)	RD (%)	IV (%)
Sapindaceae	*Blighiasapida*	2	20.5	21.0	1.8982	1.8868	1.8925
	Trichilisiamonadelpha	2	15.0	16.0	1.0202	1.8868	1.4535
	Leucanodiscusscupaniodes	19	14.8	23.0	10.1887	17.9245	14.0566
Mimosoideae	*Albizia zygia*	11	30.6	52.0	26.0044	10.3774	18.1909
Anacardiaceae	*Mangifera indica*	1	13.0	13.0	0.3815	0.9434	0.6624
Sterculiaceae	*Cola acuminata*	1	16.0	16.0	0.5778	0.9434	0.7606
	Cola gigantea	1	29.0	29.0	1.8982	0.9434	1.4208
	Cola millenii	8	16.4	23.0	5.1214	7.5472	6.3343
	Cola nitida	1	20.0	20.0	0.9029	0.9434	0.9231
	Sterculia triagacantha	8	13.6	16.0	3.3925	7.5472	5.4698
Palmae	*Elaeisguineensis*	6	33.2	39.0	15.2379	5.6604	10.4491
Moraceae	*Ficus exasperata*	1	24.0	24.0	1.3001	0.9434	1.1218
	Miliciaexcelsa	7	20.6	28.0	7.4576	6.6038	7.0307
	Miliciaguinensis	1	10.0	10.0	0.2257	0.9434	0.5846
	Myrianthusarboreus	14	17.2	30.0	10.7101	13.2076	11.9588
Apocynaceae	*Holarrhena floribunda*	3	16.7	18.0	1.8870	2.8302	2.3586
Caesalpiniceae	*Hylodendrongabunense*	3	16.5	16.0	1.6635	2.8302	2.2468
Meliaceae	*Khaya grandifoliola*	15	15.9	21.0	8.7486	14.1509	11.4498
Bignonaceae	*Newbouldialaevis*	2	17.5	18.0	1.3836	1.8868	1.6352

Family composition represented in the SG.

A list of tree species and their families was represented in Fig.1. They were distributed among 15 families. Igbo Olodumare and Igbo-Gbopo had 12 and 10 families, respectively. In the two SG, Sterculiaceae had the highest no of species, followed by Moraceae, Euphorbiaceae, Bignonaceae and Sapindaceae.Ojo (2004) also reported Sterculiaceae and Euphorbiaceae that formed 86% of the stand in Abeku, Omo Forest Reserve. Adeyemi *et al.*, (2015) reported a similar study that the dominance of these families may partly be due to their capacity to give rise to multitudinous seeds which could promote their establishment in adapted habitats.Among the families with low species were Apocenaceae, Anacardiaceae, Caesalpinoideae, Meliaceae and so on.

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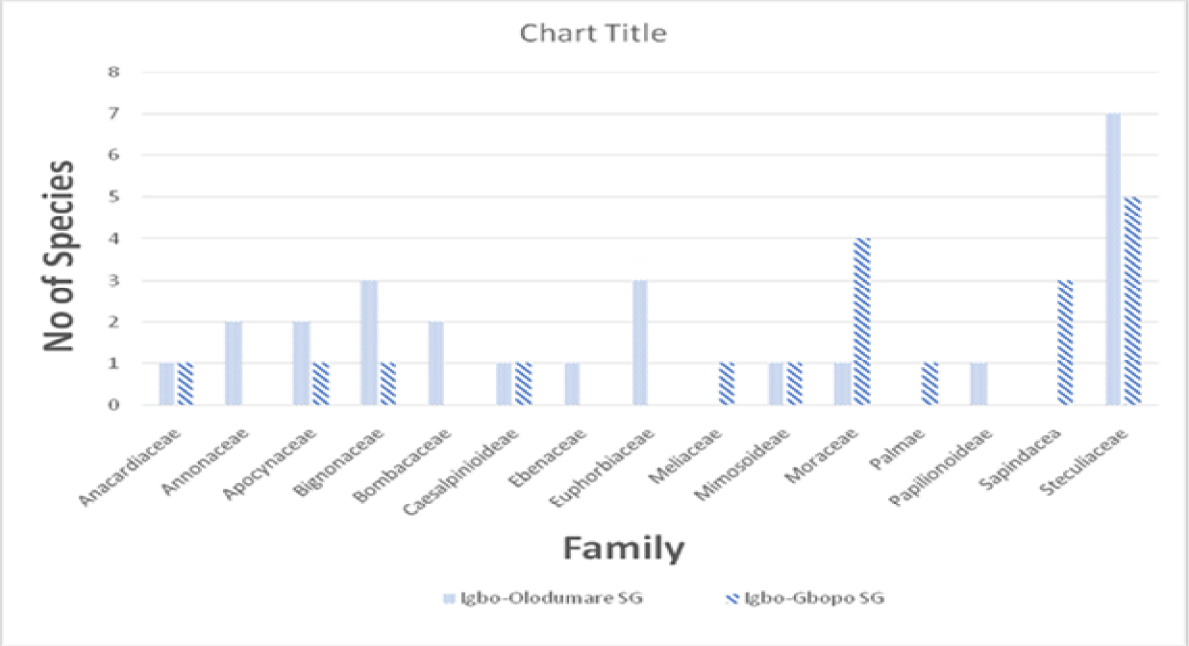

Fig. 1: Tree Family Diversity within the SGs

Similarity Indices of Tree Species of the SGs

Igbo Olodumare and IgboGbopo had similarity indices of 0.4314 (Table 1). The more similar are species' composition, the higher their similarity indices' values. This implies that the floristic composition of Igbo-Olodumare and Igbo Gbopo is quite low, that is the value of the similarity index is lower than 50%. The large variation in the similarity could be due to ecological factors. Random variation, historical factors, geographical distance, or environmental determinism could result in dissimilarity in species composition of contiguous forest ecosystems (Tuomisto *et al.*, 2003).

Diameter Class Distribution in the SGs

The results of the various diameter class sizes are presented in Fig.2 and Fig. 3. The structure of the population of the SGs was a nearly or typically inverted J-shaped curve. Igbo-Olodumare and Igbo-Gbopo recorded the highest frequency of 20-29.99cmand 10-19.99cm diameter classrespectively. The two SGs under examination contained the majority of the trees in the class with the lowest diameter (20 - 29.99 cm). Akinyemi *et al.* (2019) reported that the larger tree population in Omo Biosphere Reserve fall in the lowest diameter size class, the number of merchantable trees (DBH >48 cm) is very low, and it is an indication that the forest is yet to reach climax stage. Additionally, Oduwaiye *et al.* (1998) noted that the Okomu Permanent Sample Plots had the largest proportion of trees in the lowest diameter class, below 10 cm, across all plots evaluated.The population of treestructure in the two SGs is a reverse J-shaped structure, which indicates the potential of these groves to regenerate over time. The lower mean dbh recorded in Igbo-Gbopo might be credited to the previous clearing of the watershed area for farming activities. The neglect of the yearly festivals in Igbo-Gbopo ushered some community members into the riverbank to

engage in farming activities, this was later stopped.

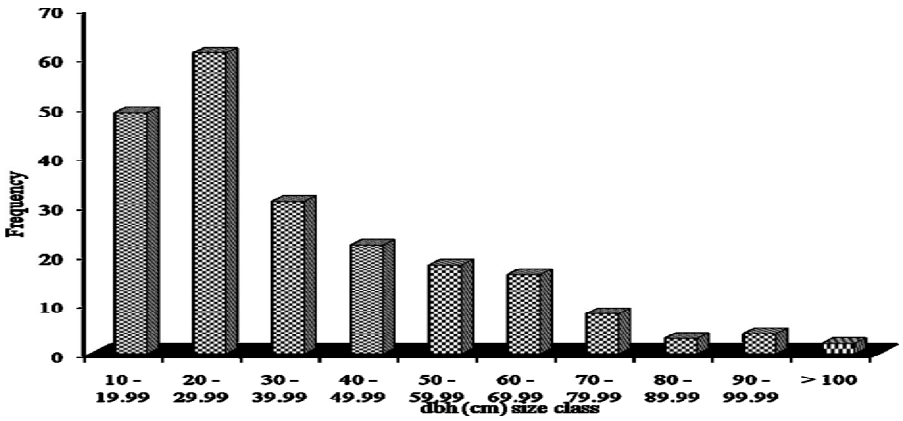

Fig.2: Diameter Distribution graph of Igbo Olodumare sacred grove.

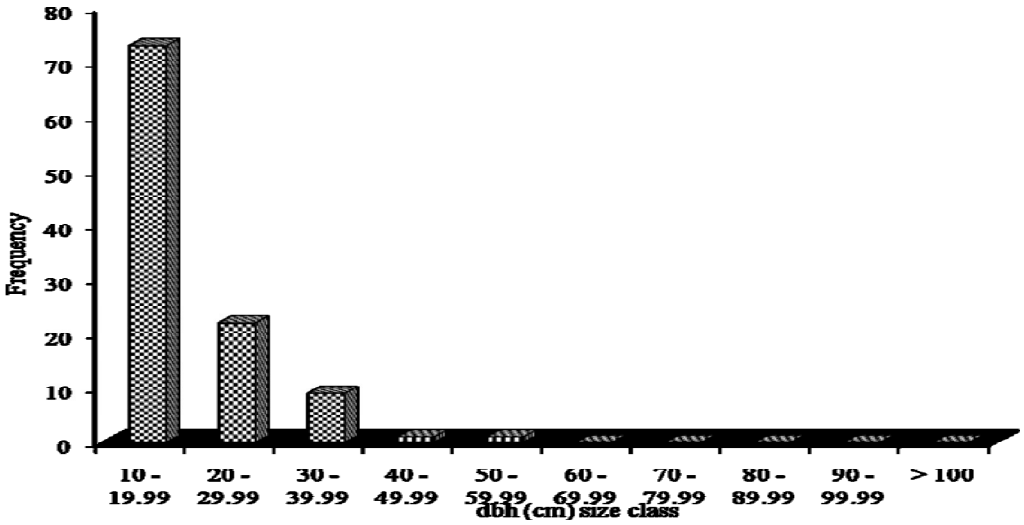

Fig.3: Diameter Distribution graph of Igbo Gbopo sacred grove, Aye

The distribution of plants in different age groups (reverse J-shaped curve) suggests that the sacred grove is a stable forest. Whitmore (1975) noted a high density of treesin the lower girth class that may be explained by the quick colonization and turnover of forest gaps. Similar results were alsosighted by Cao *et al.* (1996) for a rainforest in Southwest China, Jamir (2000) in the SG of Jaintia hills, Meghalaya city of India, andOyelowo (2014) in the SG of Southwestern Nigeria.

Conclusion and Recommendations

Despite the anthropogenic factors facing the conservation areas in Nigeria, the study has shown that Southwestern SGs that are remnantsof the rainforest are well protected. Igbo Olodumare and Igbo Gbopo SG are being conserved by the local communities through unwritten laws and taboos. The study

provided a checklist of the woody species and structures of two SGs in Southwestern Nigeria.Maintaining the cultural values of the SGs is a strategy for their effective conservation.Conservation policies should therefore acknowledge cultural values and local practices to reduce the loss of biodiversity.

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