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WOODY SPECIES DIVERSITY AND REGENERATION PATTERNS IN OSUN-OSOGBO SACRED GROVE, NIGERIA

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ABSTRACT

Osun-Osogbo Sacred Grove in Nigeria is one of the major biodiversity hotspots in sub-Saharan Africa with high plant diversity that has suffered considerable human-induced disturbance in the recent times. Therefore, this study aimed to quantify the canopy species diversity and regeneration pattern in the Sacred Grove. Three (0.09ha) plots were sampled in each identified forest type (old-growth, secondary-regrowth, and riparian forests) for the inventory of tree / sapling stems, and nested quadrats (5 x 5m^2) for seedlings. All stems enumerated were identified to species level. Data on diameter-at-breast height (dbh) and number of individuals per species were collected by plot. The patterns of tree (dbh ≥ 10 cm) distribution and regenerating (dbh ≤ 10 cm) population were examined using Detrended Correspondence Analysis (DCA) while the regeneration status of the grove was assessed by comparing the Importance Value Indices (IVI) of the current stocking and regenerating populations of the tree species. A total of 75 vascular species representing 66 genera and 30 families were identified. Fabaceae (13 spp), Apocynaceae (8 spp.), Euphorbaceae (7 spp.) and Rubiaceae (7 spp.) contributed 47.5% of the flora. The first two component axes of DCA (79.59%) delineated three community assemblages along disturbance gradient in the tree population. In addition, the first two component axes of DCA (107.70%) identified four communities along composition and disturbance gradients in the regenerating population. Analysis of IVI indicated that Dialium guineense (4.11), Funtumia elastic (6.08) and Cola millenii (5.06) were dominant and the most widely distributed tree species in the Grove. Osun Sacred Grove is rich in vascular species diversity with diameter distribution showing poor growth and inadequate self- replacement of emergent tree species. Gap creation and appropriate cultural practices should be undertaken to improve the regeneration of the emergent species.

Keywords: Plant distribution, Sacred grove, Species diversity, Vascular plant, Plant regeneration

Introduction

Osun-Osogbo sacred grove is one of the few remaining natural tropical dry forest in West Africa, though faced with rapid urbanization and simultaneous loss of the natural area (Divine Grace Consult, 1999). It presents a great opportunity for the study of forest plant resources which have suffered human impacts. As a consequence of the substantial intact vegetation, UNESCO identified the Grove as a global priority area for conservation and listed it as a UNESCO World Heritage Site on the bases of its near pristine environment and cultural value in July 2005. Dependence of the local people on Osun Grove plant resources and ecosystem services contributes to forest degradation because of the belief that trees are naturally endowed and would continue to self-regenerate even if destroyed. This prompted the need for the study on plant diversity and distribution within the Grove to ascertain the degree of regeneration of canopy species. Moreover, given the alarming rate at which Nigerian flora are disappearing, it is imperative that data on forest composition and regeneration in the Sacred Grove be acquired (Falade, 2015).

One of the prime utilities of sacred groves is the protection and occasional supply of medicinal plants on a sustainable basis. Sacred groves are closely related to the social and cultural life of a people and a number of cultural rites and religious rituals have perpetuated the status of a sacred grove. This has ensured the protection of the vegetation of the sacred grove in pristine condition (Sukumaran *et al.*, 2008). Many of the plant species are critical in fulfilling cultural, spiritual and religious needs. Therefore, the loss of plant species could be a threat to some cultural and religious practices among the local people because they play a significant role in fulfilling ritual and spiritual needs (Falade, 2015).

Vascular plants contribute substantially to the biodiversity of tropical dry forests while their diversity and composition are affected by forest disturbance (Larrea and Werner, 2010). Spatial structure of the tree and understory layers is an important factor that regulates several dynamic processes in forest ecosystems (Zagidullina and Tikhodeyeva, 2006). Understanding the processes remains a critical gap in developing conservation plans for tropical plant communities. The successful conservation of forest ultimately depends upon an understanding of the forest ecosystem dynamics. There is limited information on species composition of canopy and understory in Osun Grove. The species composition of the understory layer represents the pool from which tree are recruited into the canopy layer. Furthermore, understory species composition may be a good predictor of the future canopy species composition (Pena-Claros, 2003 and Hart and Kupfer, 2011). Hence, both growth and survival are crucial for successful regeneration. Gilliam *et al.*, (1994) on the other hand, view the herb layer as a dynamic assemblage of resident and transient species. The resident species are those plants, such as annuals, herbaceous perennials, and long-lived shrubs, whose life history characteristics confine them to this stratum. In contrast, the transient species are plants, such as large shrubs and trees, which have the potential to eventually emerge into higher strata.

The rich plant diversity and regeneration of Osun Grove are not adequately documented although there were a few attempts (Divine Grace Consult, 1999). The present study is, therefore, undertaken to inventory and analyse the vascular species in the Grove with the aim of elucidating the tree species diversity and recruitment of seedlings and saplings. The study assessed the regeneration status of canopy tree species in the Grove; while identifying the major factors militating against natural regeneration of the species.

Materials and Methods

The Osun River drains its basin in a north-south direction and passes out of the Grove south-eastwards. The underlying rocks of the river-bed are of Precambrian

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formation and are exposed in several parts of the grove during the dry season when the river cuts into pools/lakes.

The soils are of depositional nature towards the banks of the river and at the lower slopes (Adebisi, 1999). The Osun Grove experiences two seasons; the rainy and dry seasons. The rainy season is between March and October while the dry season lasts from November to early March. The mean annual rainfall is above 1000mm and relative humidity is generally high; often greater than 60% during the day and less than 70% at night. Temperature is generally high, 22-35^{0}C and the effect of harmattan is usually mild in the Grove.

The Grove has mature undisturbed forest canopy which supports a rich and diverse flora and fauna. Some parts (termed secondary regrowth forest) were reportedly cleared in 1950's and used for agricultural purpose but later abandoned. Interviews with local residents indicated that low-intensity agriculture, supplemented with introduced species and fruit crops, was the previous land-use in this secondary re-growth forest area. Farms were reportedly small, in the order of 0.4 – 0.8 ha. The location of the secondary re-growth forest was identified with the help of local guides and verified with satellite images taken on google-earth in which the boundary between the old-growth forest and secondary regrowth area is clearly visible (Figure 1). The Old-growth forest was further verified by the absence of introduced species (*Gmelina arborea* and *Mangifera indica*).

The Grove is located between Latitudes 7^{o}45 ′0″ and 7^{0}45′ 30″ N; and Longitude 4^{o}32′ 35″ and 4^o 33′ 20″ E (Figure 1). The Osun Grove was divided into two zones (the core and buffer zones) for convenience of conservation and management. The study was carried out in the core zone of the Grove, which has an area of about 75ha, with a 30ha buffer zone.

Selection of the sample plots and sample size

The vegetation map of the Grove was prepared using program ArcGIS 9.0 (ESRI) based on geographical coordinates taken during reconnaissance surveys. Nine (0.09ha) sample plots were randomly selected on the basis of identified forest types (Old-growth, Secondary-regrowth and Riparian forests) in the core of the Grove giving a sampling intensity of 3.24%. In each forest type, three (0.09ha) sample plots were demarcated, at least 10m apart and 20m into the interior from the edge of major road or trails. The spatial coordinates of each plot were obtained using a portable Global Positioning System (GPS).

Data collection

Plant stems were sampled by stratifying each plot into three major plant developmental stages (tree, sapling and seedling). Trees were defined as woody stems greater than 10cm diameter-at-breast height (dbh) (dbh≥10cm and height≥1.5m). Saplings were woody stems less than 10 cm dbh, but greater than 5cm dbh, with height greater than 1.5 m (5≤dbh≤10cm and height≥1.5m), while seedlings were woody stems less than 5cm but greater than 1.0 cm dbh (1.0≤dbh≤5cm). For the enumeration and measurement of tree stems, Plots (30m x 30m) were laid running east to west of the Grove. For sapling stems, nested transects of 30 x 0.5 m were laid within each plot and for seedlings, 5 x 5 m^2 quadrats were established at the four corners of the 30 x 30 m^2 plots while nested transects of 5.0m x 0.2m were established within 5m x 5m quadrats because subsamples within a plot were required for computation of relative frequency. All plants were measured for

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diameter-at-breast height (dbh). The circumference (to the nearest cm) of each tree stem was measured at 1.3 m above ground with the use of metre tape (caliper was used for seedlings) and converted to diameter at breast height. Most of the plants were identified to species level (following Keay, 1989).

Data Analysis

The plant were sorted into species and families while data from all plots in each forest type were pooled to compute relative density (stems/ha), relative frequency (stems/ha) and basal area (m^2/ha)

The Importance Value Index (IVI) was determined following Gilliam *et al.* (1995) and Houchanou *et al*. (2013).

Tree species variability as well as the major assemblages and patterns of distribution and regenerating populations among forest types were investigated using Detrended Correspondence Analysis (DCA). The regeneration status of the grove was assessed by comparing the Importance Value Index (IVI) of the present tree population with the regenerating population (saplings and seedlings) of canopy tree species.

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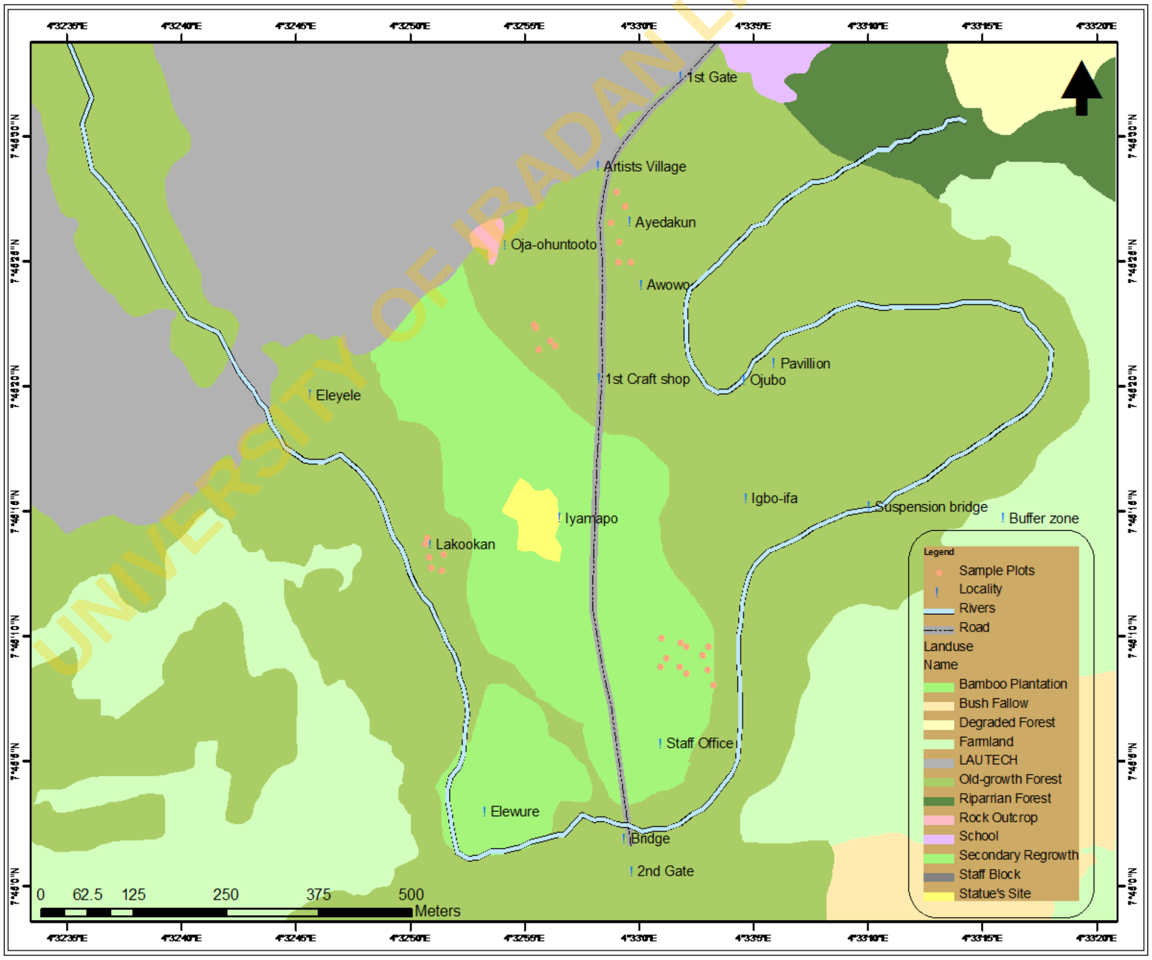

Figure 1. Map of Osun Sacred Grove showing the vegetation types and location of sample plots

RESULTS

Seventy-five plant species representing 66 genera and 30 families were identified within the Grove (Table 1). The most represented families were Fabaceae (12 genera and 13 species), Apocynaceae (8 genera and 7 species), Euphorbiaceae (5 genera and 6 species), Rubiaceae (5 genera and 7 species) and Malvaceae (3 genera and 3 species). Thirteen (13) species, each with at least 100 stems/ha, accounted for 68% of the stem population. These species include *Cola millenii*, *Baphia nitida*, *Dialium guineense*, *Nauclea latifolia*, and *Funtumia elastica*. Also, about 4 species with at least 200 stems/ha accounted for 37.0% of the stem population. Forty (40) of the species had less than 20 stems/ha.

Table 1. Family, species and abundance of vascular plants in Osun Sacred Grove, Osogbo

Family	Species	No. of Genera	No. of Species	Abundance	%
Anacardiaceae		1	1		
	Spondias mombin			5	0.105
Apocynaceae		9	9		
	Alstonia congensis			1	0.042
	Funtumia elastic			194	4.236
	Holarrhena floribunda			2	0.084
	Landolphia hirsute			3	0.127
	Motandra guineensis			124	4.15
	Maranthochloa cuspidate			29	0.614
	Secamore afzelia			37	0.508
	Tabernaemontana pachysiphon			1	0.021
	Cnestlis ferruginea			41	0.868
Araceae		1	1		
	Culcasia scandens			579	12.82
Bignoniaceae		2	2		
	Markhamia tomentosa			78	1.736
	Newbouldia laevis			23	0.55
Capparidaceae		2	2		
	Boscia angustifolia			13	0.317
	Euadenia trifoliate			3	0.105
Chrysobalanaceae		2	2		
	Afrolicania elaeosperma			100	3.304
	Parinari robusta			35	0.741
Combretaceae		1	1		
	Terminalia ivorensis			1	0.042
Euphorbiaceae		5	6		

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	Alchornea laxiflora			174	2.097
	Drypetes gilgiana			29	0.127
	D. molunduana			12	0.847
	Hymenocardia acida			2	0.084
	Harungana madagascariensis			1	0.021
	Phyllanthus muellerianus			6	0.211
Fabaceae		12	13		
	Abrus prescatorius			128	0.571
	Albizia adianthifolia			3	0.042
	Albizia zygia			118	0.317
	Baphia nitida			247	5.253
	Brachystegia eurycoma			174	3.939
	Dialium guineense			196	4.448
	Entada gigas			24	0.614
	Leptodemis micrantha			6	0.254
	Lonchocarpus cyanescens			2	0.084
	Mucuna flagellipes			9	0.381
	Pericopsis laxiflora			292	6.587
	Piptadeniastrum africanum			5	0.105
	Pterocarpus erinaceus			2	0.084
Gentianaceae		1	1		
	Anthocleista vogelii			2	0.042
Icacinaceae		1	1		
	Icacina trichantha			82	1.736
Lecythidaceae		2	3		
	Anthonotha macrophylla			1	0.042
	Napoleona imperialis			3	0.084
	N. vogelii			97	2.118
Malvaceae		3	3		
	Grewia flaveraence			2	0.042
	Ceiba pentandra			6	0.127
	Bombax buonopozence			1	0.021
Maranthaceae		1	1		
	Maranthochloa cuspidata			29	0.614
Melliaceae		1	1		
	Trichilia priuereana			1	0.042
Menispermaceae		1	1		

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	Sphenocentrum jollyanum			84	1.948
Moraceae		2	2		
	Antiaris toxicaria			16	0.635
	Ficus capensis			2	0.042
Olacaceae		1	1		
	Olax subscorpioides			5	0.148
Oleaceaa		1	1		
	Linociera nilotica			1	0.042
Palmea		1	1		
	Elaeis guineensis			6	0.127
Passifloraceae		1	1		
	Adenia cissampelioides			1	0.021
Phyllanthaceae		1	1		
	Margaritaria discoideus			4	0.127
Polygalaceae		1	1		
	Carpolobia lutea			34	0.847
Rubiaceae		5	7		
	Canthium mannii			31	0.021
	C. horizontale			43	1.673
	Morinda lucida			2	0.042
	Nauclea latifolia			151	7.752
	Oxyanthus tubiflora			88	1.821
	Rothmannia urcelifolia			8	0.317
	R. hispida			1	0.042
Sapindaceae		2	3		
	Lecaniodiscus cupanioides			81	2.393
	Blighia unijugata			3	0.19
	B. sapida			1	0.021
Sterculiaceae		2	3		
	Cola hispida			19	0.423
	C. millenii			525	12.412
	Triplochiton scleroxylon			1	0.042
Ulmaceae		1	1		
	Celtis zenkeri			16	0.423
Verbaneceae		1	1		
	Gmelina arborea			9	0.3177
Violaceae		1	1		
	Rinorea dentate			63	1.037
Unknown				21	5.719

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30	65	72	4141	99.9707

The important value indices (IVI) of top ten tree species, with dbh ≥ 10 cm, ranged from 0.67 to

Table 2. The Importance Value Indices (IVI) of top ten tree species (dbh ≥ 10 cm) in three forest types of Osun Sacred Grove, Osogbo

Species	Old-growth	Regrowth	Riparian	∑IVI
Markhamia tomentosa	0.21	-	2.33	2.54
Dialium guineense	0.21	0.88	1.29-	2.38
Funtumia elastica	0.22	1.97	-	2.19
Rinorea dentata	1.51	-	-	1.51
Cola millenii	0.32	0.50	-	0.81
Celtis zenkeri	0.79	-	-	0.79
Eriodendron anfractuosum	0.28	0.45	-	0.73
Brachystegia eurycoma	0.46	-	0.19	0.65
Gmelina arborea	-	0.69	-	0.69
Boscia angustifolia	0.33	0.34	-	0.67

Key:
∑IVI = Sum of species Important Value Indices

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The important value indices (IVI) of top ten tree species, with dbh ≥ 10 cm, ranged from 0.67 to 2.54. Out of the 32 species of tree population (dbh ≥ 10 cm), *Dialium guineense* was the most widely distributed species, occurred in the three land use types, followed by *Cola millenii*, *Funtumia elastica* and *Markhamia tomentosa*. *Markhamia tomentosa* had the highest IVI (2.54) followed by *Dialium guineense* (2.38), *Funtumia elastica* (2.19) *Rinorea dentata* (1.51) and *Cola millenii* (0.81) (Table 2). The species with high IVI are most widely distributed species, except *Markhamia tomentosa* and this is because of its large basal area. Important value indices could be significantly influenced by tree diameter (basal area).

The tree species (dbh ≥ 10 cm) with the highest average densities were *Funtumia elastica* (69 stems/ha), *Dialium guineense* (52 stems/ha) and *Cola millenii* (40 stems/ha).Hence, *Cola millenii*, *Dialium guineense*, *Funtumia elastica* and *Markhamia tomentosa* are of ecologically importantance and the most widely distributed in the Grove.

Tree community assemblages (DBH>10cm)

For the tree population (dbh>10cm), the first DCA axis explained 59.78% of the variation in species composition and their IVI among the plots, while the second axis explained 19.81% of the variations (Table 3). Overall, the first two axes accounted for over 79.59% of the variation in importance value of species composition among plots.

The first DCA axis identified three community assemblages and three small scattered groups of species (Figure 2). DCA is meant to elucidate distribution pattern of species and also between species and site. Community I include *Rothmannia urcelliformis* and *Newbouldia laevis* (dbh ≥ 10 cm) were found in Riparian forest (Figure 2).

Community II were species found in Re-growth forest and *Ficus capensis* and *Gmelina arborea* were abundant Regrowth forest (Figure 2). Community III were species clustered and restricted to Old-growth and they include *Harungana madagascariensis*, *Margaritaria discoidea* and *Olax subscorpioides* (dbh ≥ 10 cm) (Figure 2).

Out of the 32 species found in tree (dbh>10cm) population, 16 belonged to the family Fabaceae while 8 were in Euphorbiaceae. Some tree species exclusively restricted to Old-growth while few are restricted to Riparian forests. Specifically, *Bombax buonopozenze* and *Anthocleista vogelii*, *Harungana madagascariensis*, *Margaritaria discoideus* and *Olax subscorpioides*, *Tabernaemontana pachysiphon* and *Napoleona imperialis* were restricted to Old-growth forest. This implies that these tree species are site specific.

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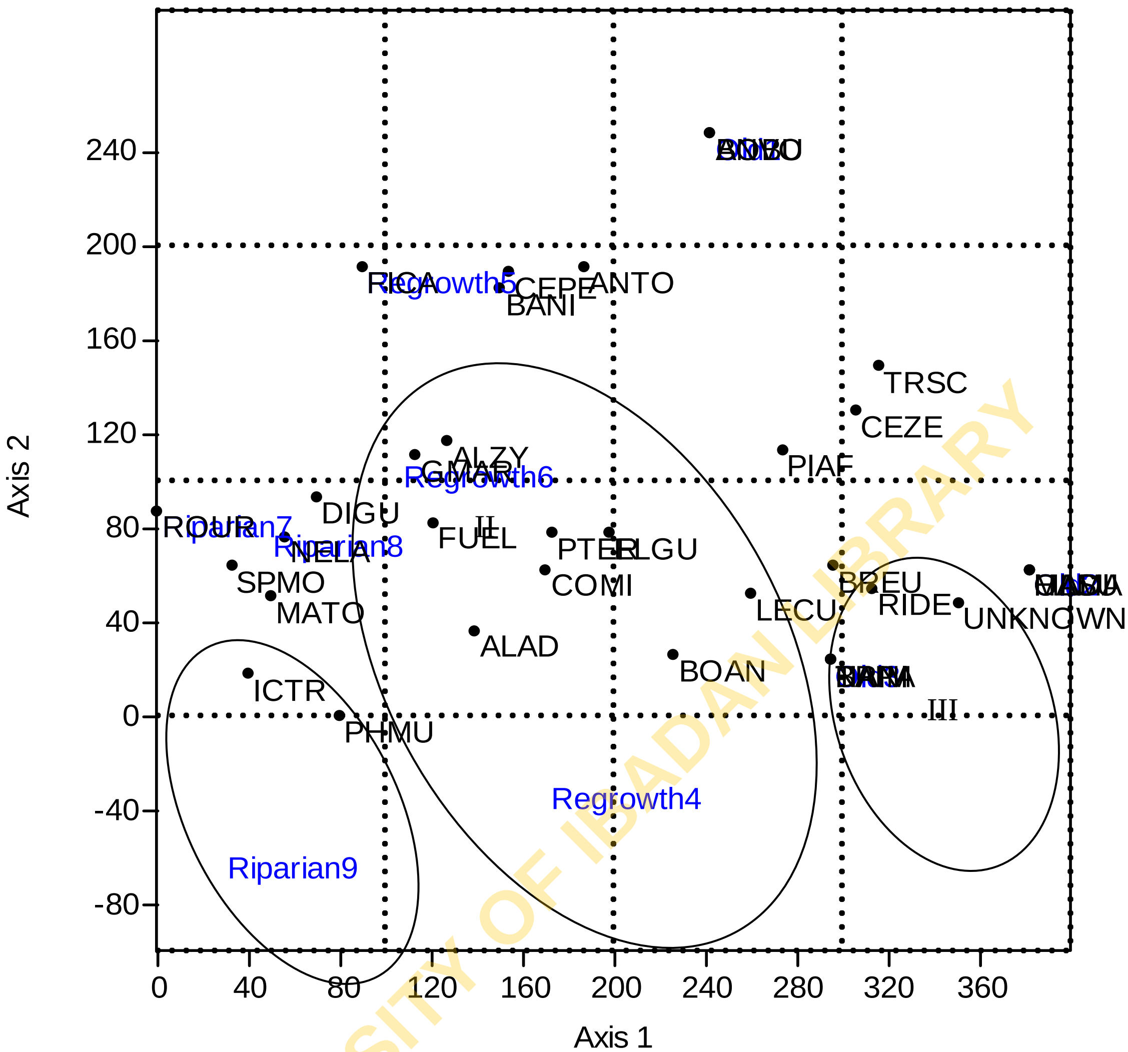

Key: ALAD, *albizia adianthifolia*; ALZY, *Albizi zygia*; ANVO, *Anthocleista vogelii*; ANTO, *Antiaris toxicaria*; BANI, *Baphia nitida*; BOBU, *Bombax buonopozense*; BOAN, *Boscia angustifolia*; BREU, *Brachystegia eurycoma*; CEPE, *Ceiba pentandra*; CEZE, *Celtis zenkeri*; COMI, *Cola millenii*; DIGU, *Dialium guineensis*; ELGU, *Elaeis guineensis*; FICA, *Ficus capensis*; FUEL, *Funtumia elastica*; GMAR, *Gmelina arborea*; HAMA, *Harungana madagascariensis*; ICTR, *Icacina trichantha*; LECU, *Lecaniodiscus cupanioides*; MADI, *Margaritaria discoideus*; MATO, *Markhamia tomentosa*; NAIM, *Napoleona imperialis*; NELA, *Newbouldia laevis*; OLSU, *Olax subscorpioide*; PHMU, *Phyllantus muelleriianus*; PIAF, *Piptadeniastrum africanum*; PTER, *Pterocarpus erinaceus*; RIDE, *Rinorea dentata*; ROUR, *Rothmannia urcelifolia*; SPMO, *Spondias mombin*; TAPA, *Tabernaemontana pachysiphon*; TRSC, *Triplochiton scleroxylon*; UNKNOWN

Figure 2. Grouping of canopy tree species in Osun Sacred Grove using Detrended Correspondence Analysis ordination.

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Out of 40 species found in sapling (dbh<10cm) population, *Cola millenii* and *Funtumia elastica* were most frequent occurring in the three land use types, followed by *Baphia nitida*, *Napoleona vogelii*, *Dialium guineense* and *Lecaniodiscus cupanioides* (Table 3). Among the sapling population, *Funtumia elastica* had the highest IVI (3.89) followed by *Baphia nitida* (2.24), *Napoleona vogelii* (1.66), *Cola millenii* (1.48) and *Lecaniodiscus cupanioides* (0.82). The IVI ranged from 0.37 to 3.89 among the top ten species in the regeneration population (Table 3).

The results show that Osun Grove was dominated by six sapling species: *Funtumia elastica*, *Baphia nitida*, *Napoleona vogelii*, *Cola millenii*, *Lecanioidiscus cupanioides* and *Dialium guineense*.

Out of 37 species found in seedling (dbh<10cm) population, *Cola millenii*, *Culcasia scandens* was the most frequent, occurring in the three land use types, followed by *Dialium guineense* and *Sphenocentrum jollyanum* that occurred in two land use types (Table 4). The Importance Value Index (IVI) was highest for *Cola millenii* (2.77) followed by *Culcasia scandens* (2.12), *Nauclea latifolia* (1.77), *Dialium guineense* (1.06) and *Sphenocentrum jollyanum* (1.06) (Table 4). Therefore, Osun grove was dominated by six seedling species *Culcasia scandens*, *Nauclea latifolia*, *Brachystegia eurycoma*, *Dialium guineense* and *Sphenocentrum jollyanum*.

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Table 3. The Importance Value Indices (IVI) of top ten sapling species (dbh ≤ 10 cm) in three forest types of Osun-Osogbo Sacred Grove

Species	Old-growth	Re-growth	Riparian	∑IVI
Funtumia elastica	0.49	0.97	2.43	3.89
Baphia nitida	0.03	1.63	0.58	2.24
Napoleona vogelii	0.07	0.06	1.56	1.66
Cola millenii	0.54	0.68	0.26	1.48
Lecaniodiscus cupanioides	0.63	0.19	-	0.82
Antiaris toxicaria	0.69	0.04	-	0.73
Dialium guineense	0.06	0.56	0.04	0.66
Markhamia tomentosa	0.11	-	0.47	0.58
Alchornea laxiflora	0.25	0.21	-	0.46
Canthium horizontalis	0.31	0.06	-	0.37

Key:
∑IVI = sum of species Importance Value Indices

Table 4. The Importance Value Indices (IVI) of top ten seedling species (dbh ≤ 5 cm) in three forest types of Osun Sacred Grove, Osogbo

Species	Old-growth	Re-growth	Riparian	∑IVI
Cola millenii	0.53	1.63	0.61	2.77
Culcasia scandens	0.24	0.87	1.01	2.12
Nauclea latifolia	0.77	-	-	1.77
Dialium guineense	0.14	0.77	0.15	1.06
Sphenocentrum jollyanum	0.74	0.12	0.21	1.07
Secamore afzelia	0.74	0.12	0.21	1.07
Pericopsis laxiflora	-	-	0.93	0.93
Napoleona vogelii	-	-	0.81	0.81
Alchornea laxiflora	0.55	0.26	0.01	0.82
Brachystegia eurycoma	0.16	0.05	0.6	0.81

Key:
∑IVI = sum of species Importance Value Indices

Regenerating community assemblage
Four species assemblages were identified at the first and second axes on the ordination space (Figure 3). The first axis separated sapling composition from seedlings expressing a composition gradient. The second axis separated Secondary-regrowth habitats from Old-growth and Riparian habitats, indicating a disturbance gradient.
Community I include species of sapling population exclusively found in Old-growth forest. Community II include species of sapling population exclusively found in Re-growth forest. *Anthocleista vogelii*, *Triplochiton scleroxylon*, *Gmelina arborea* and *Albizia zygia* were exclusively found in Regrowth forest. Also, Community III were species found in both Re-growth and Riparian forests. *Elaeis guineensis* were species exclusively found in Riparian forest.
Community IV were species exclusively found in Old-growth forest and they include *Boerhevia diffusa*, *Hymenocardia acida*, *Landolphia hirsute* and *Phyllanthus muellerianus*. These species could be site specific because their survival were enhance by the micro-climate of the Old-growth.

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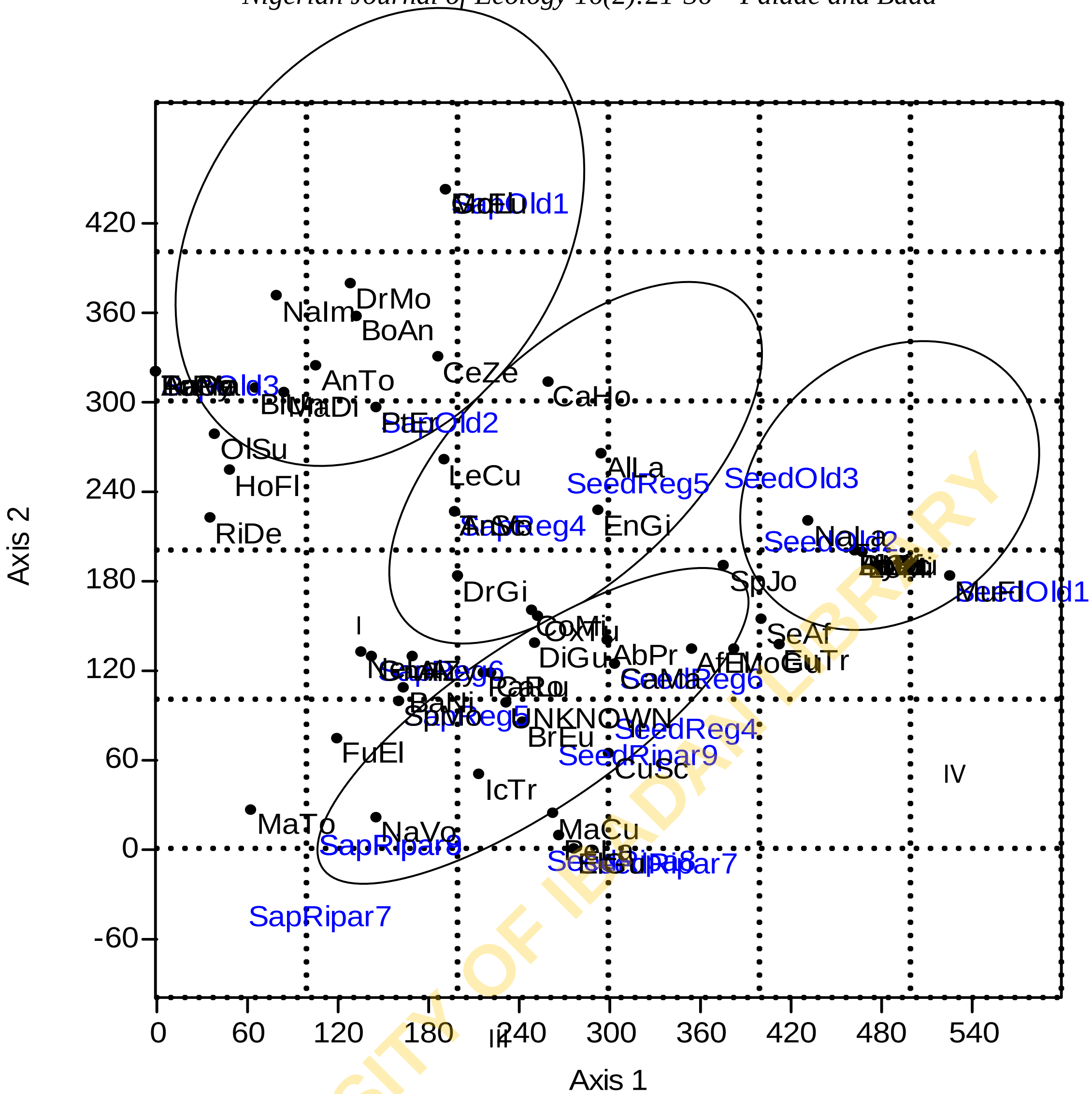

Key: AbPre, *Abrus prescatorius*; AfEl, *Afrolicania elaeosperma*; AlZy, *Albizia zygia*; AlLa, *Alchornea laxifolia*; AlCo, *Alstonia congensis*; AnVo, *Anthocleista vogelii*; AnMa, *Anthonotha macrophylla*; AnTo, *Antiaris toxicaria*; BaNi, *Baphia nitida*; BlUn, *Blighia unijugata*; BoDi, *Boerhevia diffusa* ; BoAn, *Boscia angustifolia*; BrEu, *Brachystegia eurycoma* ; CaHo, *Canthium horizontale* ; CaMa, *Canthium mannii*; CaLu, *Carpolobia lutea* ; CeZe, *Celtis zenkeri* ; CoMi, *Cola millenii* ; CuSc, *Culcasia scandens*; DiGu, *Dialium guineense*; DrGi, *Drypetes gilgiana* ; DrMo, *Drypetes molunduana* ; ElGu, *Elaeis guineensis* ; EnGi, *Entada giga* ; EuTr, *Euadenia trifoliata* ; FuEl, *Funtumia elastica* ; GmAr; *Gmelina arborea* ; GrFl, *Grewia flaveraence* ; HoFl, *Holarrhena floribunda* ; HyAc, *Hymenocardia acida* ; IcTr, *Icacina trichantha*; LaHi, *Landophia hirsute*; LeCu, *Lecaniodiscus cupanioides*; LeMi, *Leptodemis micrantha*; LiNi, *Linociera nilotica*; LoCy, *Lonchocarpus cyanescens*; MaCu, *Maranthochloa cuspidata*; MaDi, *Margaritaria discoideus*; MaTo, *Markhamia tomentosa*; MoGu, *Motandra guinensis*; MoLu, *Morinda lucida*; MuFl, *Mucuna flagellipes* ; NaIm, *Napoleona imperialis* ; NaVo, *Napoleona vogelii* ; NaLa, *Nauclea latifolia* ; NeLa, *Newbouldia laevi* ; OlSu, *Olax subscorpioides* ; OxTu, *Oxyanthus tubiflora* ; PaRo, *Parinari robusta* ; PeLa, *Pericopsis laxiflora* ; PhMu, *Phyllantus muellerianus* ; PtEr, *Pterocarpus erinaceus* ; RaCa, *Rauvolfia caffra* ; RiDe, *Rinorea dentata* ; SeAf, *Secamore afzelia* ; SpJo, *Sphenocentrum jollyanum*; SpMo, *Spondia mombin* ; TaPa, *Tabemaemantana pachysiphon* ; TrPr, *Trichilia priureana* ; TrSc, *Triplochiton scleroxylon* ; UnKn, Unknown

Figure 3. Grouping of regenerating species in Osun Osogbo Sacred Grove using Detrended Correspondence Analysis ordination.

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DISCUSSION

Plant population frequency of Osun-Osogbo sacred grove

This study involved enumeration of vascular plant species in Osun sacred grove. It identified 72 vascular plant species from 65 genera and 30 families. Families with high representation of species were Fabaceae (Legume), Apocynaceae, Euphorbiaceae, Rubiaceae. These four groups comprise about 50.0 % and 47.53 % of all encountered species and individuals, respectively. The proliferation of the species of these four families is probably due to the excellent dispersal capacities of their seeds. Tropical tree species vary in their ability to disperse seeds and the dispersal mode determine the long-term community structure of tropical forest (Seidler and Plotkin, 2006).

Fabaceae family has the highest proportion of the species and individuals of tree ≥ 10 cm dbh than any other family and formed 23% of stem population. In Fabaceae family, species with high number of individuals is *Baphia nitida* (247 individuals) with an autochorous dispersal mechanism through dehiscence of the fruit formed from a carpel. Flinging of seeds is common in the Fabaceae family. Next in number of individuals is *Dialium guineense* (196 individuals) with drupe dispersed by animals (monkeys, squirrels and bats). According to Richards (1996), legumes are the most numerous group of large trees with 115 species in West Africa. Followed by Apocynaceae family, which has 11% of stem population and majority of species use an autochorous dispersal mechanism through dehiscing capsules. Only a few species (3) have drupaceous fruits which are dispersed by animals. It is likely that several autochorous species also use animal dispersal through wool on the seeds. Species with high number of individuals is *Funtumia elastica* (194) with an autochorous dispersal mechanism through dehiscence of the fruit formed from a carpel.

Baphia nitida, *Brachystegia eurycoma*, *Cola millenii*, *Dialium guineense*, *Funtumia elastica* and *Rinorea dentata* had the highest number of individuals and most are light demanding species. They share certain characteristics which are probably responsible for the proliferation. Among these are prolific seed production, large seed size without an efficient dispersal mechanism and shade tolerant seedlings and juveniles. Probably more important than any of these features are traits related to growth in soils limited in essential elements.

The species with at least 100 stems/ha accounted for 68% of the stem population. These species included *Cola millenii*, *Baphia nitida*, *Dialium guineense*, *Nauclea latifolia*, and *Funtumia elastica*. Forty (40) of the species had less than 20 stems/ha. About 4 species with at least 200 stems/ha accounted for 37.0% of the stem population. The species included *Baphia nitida*, *Brachystegia eurycoma*, *Cola millenii*, *Culscasia scandens*, *Dialium guineense*, *Motandra guineensis* and *Pericopsis laxiflora*. A total of 16 species were common to the three forest types, 33 species exclusively found in Old-growth site, 5 species were restricted to Secondary regrowth and 3 species were only found in Riparian forest types.

Importance value indices of tree population (dbh ≥ 10 cm)

For tree species (dbh ≥ 10 cm), *Dialium guineense* occurred in the three land use types, followed by *Cola millenii*, *Funtumia elastica* and *Markhamia tomentosa* which occurred in two land use types. This indicates that these species have wide ecological niches and strong adaptability. These species could survive and adapt to all micro-climates that are available in the Grove. The Importance Value Index for tree species was high for *Markhamia tomentosa*, *Dialium guineense*, *Funtumia elastica* and *Cola millenii*. These four species were ecologically important and widely distributed tree species. They were trees of upper canopy and pioneer tree species. The species with high IVI are most widely distributed species, except *Markhamia tomentosa*. This species is not widely distributed though it has high IVI, this is because of its large basal area. IVI could be significantly influenced by tree diameter (basal area). In the ordination of tree population, the Secondary regrowth was the most proximal region to the Old-growth and Riparian being more distal.

Importance value indices of regeneration population (dbh ≤ 10 cm)

Importance Value Indices of *Funtumia elastic*, and *Cola millenii* were higher in sapling composition than in tree composition. The abundance of these two species significantly influence their IVI in regeneration population. However, *Funtumia elastica*, *Baphia nitida*, *Cola millenii*, *Dialium guineense* occurred and widely distributed in the three land use types. They are the most widely distributed and dominant species in the regeneration population. Therefore, these species are considered to be ecologically important in Osun sacred grove. When IVI>10 for a species in a given habitat, it is considered to be ecologically important in that habitat (Reitsma, 1988). The results show that Osun Grove was dominated by six sapling species: *Funtumia elastica*, *Baphia nitida*, *Cola millenii*, *Dialium guineense*, *Napoleona vogelii* and *Lecanioidiscus cupanioides*.Out of 37 seedling species *Cola millenii* was found the most frequent seedling species occurring in all the plots, followed by *Culcasia scandens* (8 plots), *Dialium guineense* and *Sphenocentrum jollyanum* (7 plots) (Table 14). The Importance Value Index (IVI) for seedling population was high for *Cola millenii*, *Culcasia scandens*, *Nauclea latifolia*, *Dialium guineense* and *Sphenocentrum jollyanum*. Therefore, seedling population of these six species are considered to be ecologically important in Osun sacred grove.

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