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Tree species richness, diversity and structure of a strict conservation natural tropical rainforest ecosystem in Nigeria

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Abstract
Okomu National Park, though small in size (202.24km2), is one of the remaining strict natural conservation forests in Nigeria. Due to its particularly unique three distinct vegetation types (rainforest, savannah and swampy fringe), Okomu houses a lot of biodiversity. We investigated the tree species richness, diversity and abundance of the National park, with the aim of determining its contribution to biodiversity conservation. Trees with dbh ≥ 10cm were inventoried in 50m X 50m main plot. There were 507 stems ha-1, consisting of 97 species distributed among 75genera and 36 families. The diameter distribution curve revealed a J-inverse shape with trees within the diameter distribution of 10-20cm having the highest frequency (355 stems ha-1). The height distribution curve also showed that trees within height range of 10-15cm had the highest frequency of 312 stems ha-1. Total basal area and volume per hectare estimated were 25.26m2 and 267.07m3 respectively. Pielou's Evenness Index (0.86), Shannon-Weiner Index (3.94), Simpson Diversity Index (96.97) and other diversity indices were high showing that the park is a potential biodiversity hotspot. The Park is a mature forest from its vertical and horizontal structure and can be a major biodiversity hotspot with proper and adequate management.

Keywords: Rainforest, Biodiversity, National Park, Nigeria

Introduction

Forests in Nigeria have been subjected to continuous deforestation and degradation and Government forest reserve areas are no exception. This is due to weak forest policies and implementation, inadequate funding, poverty, ignorance, *etc*. The few places where mature forest can be found are the nation's National Parks, strict nature reserves and biosphere reserves. National Park, though meant for the preservation of wild animals, in most cases have intact and mature forest because of the laws guiding them. Inventory data obtainable from these forests can help provide baseline information forplanning and management purposes. Okomu National Park is one of the Parks containing the remaining lowland rainforest ecosystem in Nigeria. It is a mature forest housing a lot of biodiversity. The focus of management as with most protected areas has traditionally been on the conservation of wildlife species. Onojeghuo and Onojeghuo (2015) noted that the establishment of Okomu National Park (ONP) was gazetted within the core of Okomu forest reserve due to anthropogenic pressure leading to high rates of forest exploitation and expansion of human settlement around the reserve.

The sole purpose of the National Park therefore was to ensure the protection and survival of existing endangered wildlife within the reserve. The Park provided refuge for many threatened species, including the white-throated monkey (*Cercopithecus erythrogaster*) which is a major source of animal protein to people living in the surrounding communities and also sold commercially for financial benefits (Oates, 1995; Ajayi, 2011). In a study conducted by Morgan *et al.* (2011), the Park was classified as one of the exceptional priority conservation sites in Nigeria. However, there are very few published information on the forest component of the Park which is very essential for effective planning and management of the forest as well as its wildlife component. This study therefore sought to assess tree species richness, diversity and abundance within the Park and its forest structure.

Methodology

Study Area

Okomu National Park is located at the heart of Okomu forest reserve in Ovia South-

West Local Government, Edo State, Nigeria, with a total size of 202.24 km^2(Nigeria Park Service, 2016). The park lies between longitude 5.187 °E and 5.431 °E and latitude 6.278 °N and 6.435 °N, the boundary map is shown in Figure 1.

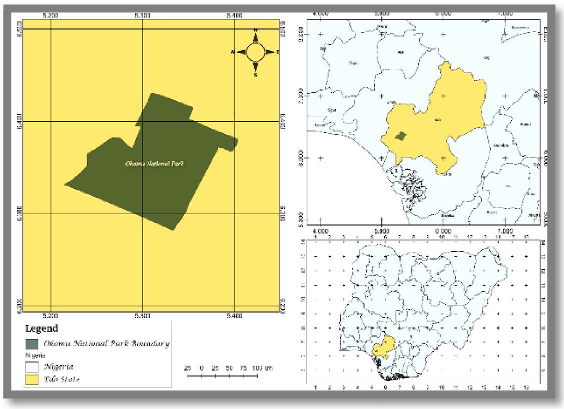

Figure 1: Boundary Map of Okomu National Park

Data Collection

In laying sample plots, line transect sampling method was used. A distance of 50 m was measured into the forest along each transect to avoid edge effect, while temporary sample plots were laid alternately with 50 m interval between alternate plots. A total of fourteen temporary plot size of 50 m X 50 m was laid. All living trees with dbh greater or equal to 10 cm were identified and enumerated within the plots. Some of the variables measured included:

diameter at breast height (*dbh*)
diameter at the base (*db*)
diameter at the middle (*dm*)
diameter at the top (*dt*)
total height (*h*)

Data Analyses

Basal area estimation

The basal area for trees in each plot was estimated using the formula (Equation 1):

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

Where BA is Basal area (m^2),
D is Diameter at breast height (m), and
π is 3.142 (constant)

For each plot, the total basal area of all trees was computed by summing up the basal area of all trees within the plot, which was used to estimate the basal area per hectare.

Volume estimation

The volume of each tree was estimated using Newton's formula (Equation 2):

$$V = \frac{\pi}{24} h \left(D_b^2 + 4D_m^2 + D_t^2\right) \quad \text{(Eqn.2)}$$

Where V is Volume (m^3),
his height (m),
D_b is Diameter at the base (m),
D_m is Diameter at the middle (m),
D_t is Diameter at the top (m), and
π is 3.142.

The volume of individual trees was summed up to obtain volume per plot which was extrapolated to volume per hectare.

Diameter and Height Frequency Distribution

The Dbh obtained for each of the trees in each plot was used in classifying the trees in each plots into different diameter classes. The dbh was classified based on a 10 cm diameter class interval. In addition, heights of trees in the sample plots were classified based on a 5 m class interval. Based on this, the number of stems per plot and per hectare were generated.

Species and Family Frequency Distribution

The species and family distribution frequencies were also generated from the plots information. Number of trees per plot and hectare, height, dbh, volume and basal area were also computed for each species and family represented in the sample plots.

Species Richness and Biodiversity Indices

The following richness and biodiversity indices were computed.

Relative Density of Species (RD)

It is a measure of species richness which is used to estimate the ratio of individual of ith species to the total number of individual in the same population or community. It was estimated using Equation 3.

$$RD = \left(\frac{n_i}{N}\right) \times 100 \quad \text{(Eqn. 3)}$$

Where n_i is number of individual of each species (i.e., the number of individual of the ith species) and

N is total number of individual trees in the community

Relative Dominance (RD_o)

It measures the relative dominance of ith species in a community. It was estimated using Equation 4.

$$RD_o = \frac{(\sum BA_i \times 100)}{\sum BA_n} \quad \text{(Eqn. 4)}$$

Where $BA_i$is Basal area of all individual trees belonging to a particular species I and

BA_n is Basalarea of the stand

Important Value Index (IVI)

$$IVI = \frac{RD + RD_o}{2} \quad \text{(Eqn. 5)}$$

Where RD is Relative density of species and

$RD_o$is Relative Dominance

Family Importance Value (FIV)

$$FIV = \frac{RD \times RD_0}{2} \quad \text{(Eqn. 6)}$$

Where RD is Relative density of species and

$RD_o$is Relative Dominance

Shannon Weiner's Index (H′)

Shannon Weiner's Index gives information on community diversity. It is the fraction of individuals belonging to the ith species and it was estimated using the formula given in Equation 7.

$$H' = -\sum\left(\frac{n_i}{N} \times ln\frac{n_i}{N}\right) \quad \text{(Eqn. 7)}$$

Where $n_i$is number of individuals of each species (*i.e.*, the number of individuals of the ith species)

N is total number of individual tree in the community and

*ln*is natural log

Simpson Concentration Index (λ)

$$\lambda = \frac{\sum n_i(n_i - 1)}{N(N-1)} \quad \text{(Eqn. 8)}$$

Where n_i is number of individuals of each species (i.e., the number of individuals of the ith species) and

N is total number of individual tree in the community

Simpson Index (D)

Simpson Index (D) measures the probability that two individuals randomly selected from a sample will belong to the same species (Bibi and Ali, 2013). It is the fraction of all organisms which belong to a particular species in a populations and the formula is given in Equation 8.

$$D = \frac{\sum n(n-1)}{N(N-1)} \quad \text{(Eqn. 9)}$$

Where n is the total number of individuals of each species and

N is the total number of individuals in the community

Simpson Diversity Index (1-D)

Simpson Diversity also referred to as index of variability is used to measure variability within a population. A perfectly homogenous population will have an index value of zero, while that of a perfectly heterogeneous population will have a value of one. The formula is given in Equation 10.

$$Simpson\ Diversity\ Index = 1 - D \quad \text{(Eqn. 10)}$$

Where D is Simpson Index

Pielou's species evenness index (E)

It was derived by Pielou in 1966 from Shannon-Weiners Index and the value usually range from zero to one (Motwani, *et al*., 2014). Closeness of the value to one is an indication of species evenness. The formula for computation is presented in Equation 11.

$$E = \frac{H'}{H_{max}} = \frac{H'}{(lnS)} \quad \text{(Eqn.11)}$$

Where H′ is Shannon-Weiner's index,

*ln*is natural log and

S is total number of species in the community

Margalef's index of species richness (M)

Margalef's index is used when assessing species richness. According to Clifford and Stephenson (1975) species richness increases with number of species and in particular increases non-linearly and roughly logarithmically. It was estimated using Equation 12.

$$M = \frac{S-1}{lnN} \quad \text{(Eqn. 12)}$$

Where S is total number of species in the community,

*ln*is natural log and

N is the total number of individual tree in the community

Number 1 of Hill diversity index (N1)

$N1 = \varepsilon^{H}$ (Eqn. 13)

Where ε is exponential and

H is Shannon Weiner's index

Number 2 of Hill diversity index (N2)

$N2 = \frac{1}{\lambda}$ (Eqn. 14)

Where λ is Simpson Concentration Index

Results

Plot Summaries

There was wide range between the smallest and the largest dbh with the smallest being 10 cm while the dominant was 131.10 cm. The dominant height was 54 m with a plot mean of 18.02 mwhile the total basal area and volume per hectare for the entire plot was 25.26 m^2 and 264.07 m^3respectively as shown in Table 1.

Table 1: Plot Summaries

Variables	Values
Minimum Dbh (cm)	10
Mean Dbh (cm)	32.12±3.67
Dominant Dbh (cm)	131.10
Mean Height (m)	18.02±1.08
Dominant Height (m)	54.00
Total Basal Area per ha (m^2)	25.26
Total Volume per ha (m^3)	264.07
Tree Density (Stems ha^{-1})	507

Diameter and Height Distribution

The diameter distribution curve revealed that the number of stems in each diameter class was inversely proportional to diameter size resulting in a J-inverse shape graph as shown in Figure 1. Trees within the diameter distribution of 10-19.9 cm having the highest frequency (355 stems ha^{-1}) constituting about 70 % of the total number of stem per hectare. This was followed by class 20-29.9 cm with a total of 73 stems ha^{-1}forming about 14 % of the total number of stem per hectare. Only 3 stems ha^{-1} was recorded for trees with dbh ≥ 90 cm. The height distribution graph (Figure 2) revealed that trees within height class of 10-15 m had the highest frequency of 312 stems ha^{-1}followed by trees in the class of 15.1-20 m with 211 stems ha^{-1}. Trees within this two height classes (10-20 m), which are usually the middle stratum trees, had the highest frequency distribution accounting for about 60 % of the total occurrence. The lower stratum trees (trees with height less than 10 m) accounted for about 14 % of total occurrence. For trees referred to as emergent trees, which are trees whose height is greater than 40 m, a total of 6 stems $ha^{-1}$was recorded.

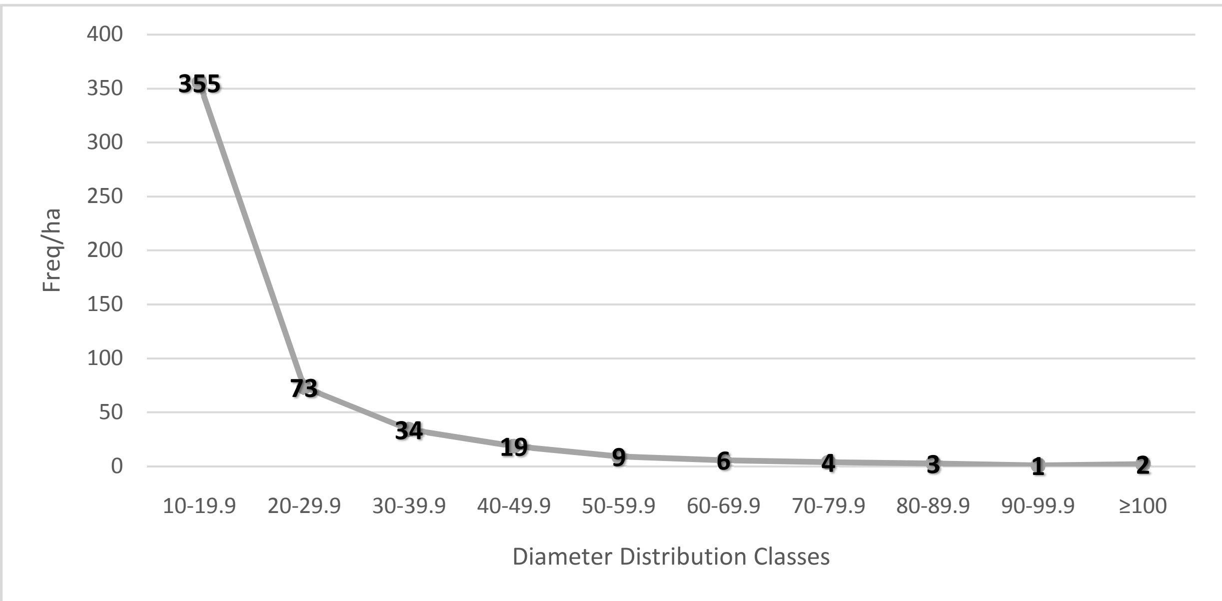

Figure 1: Diameter Class Distribution Frequency

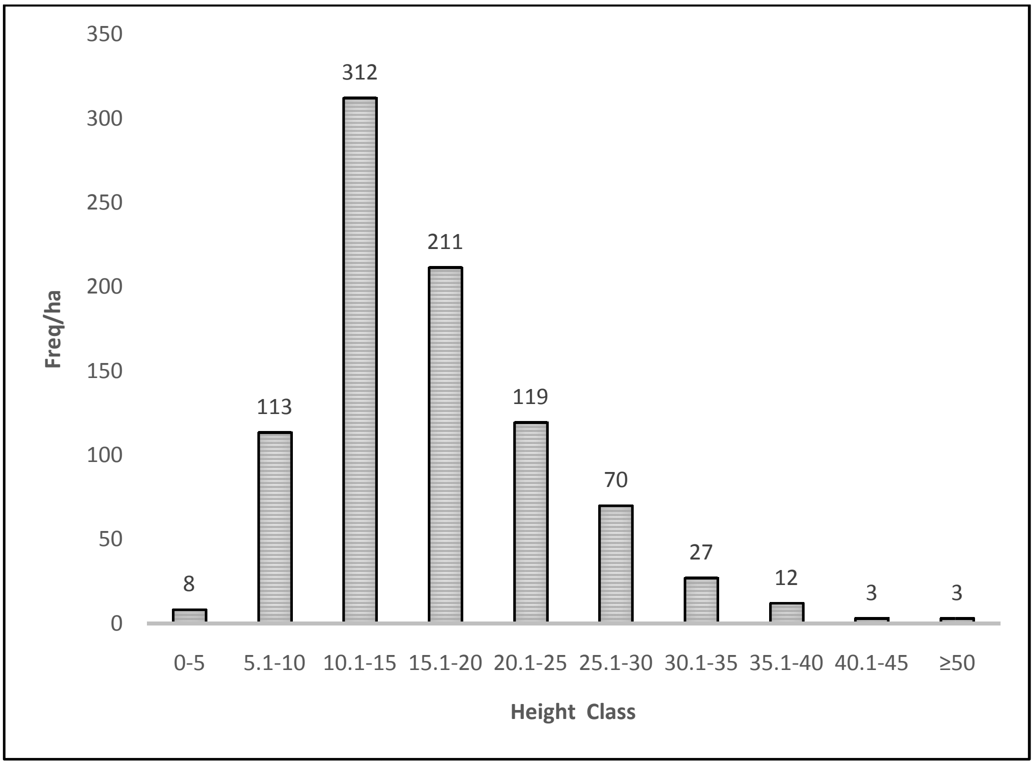

Figure 2: Height Frequency Distribution

Species and family distribution

There were 507 stems ha^{-1}, consisting of 97 species distributed among 75 generas and 36 families. Meliaceae has the highest frequency of 63 stems ha^{-1} with *Trichilia monadelph*a contributing about 32 stems ha^{-1}. This was followed closely by Ulmaceae having a total of 61 stemsha^{-1}while the least represented families were Irvingiaceae, Melastomataceae and Phyllanthaceae, details are as presented in Table 2. The ten most prominent species encountered is as shown in Table 3. Some of the least represented species were *Anthocleista vogelii, Canthium glabrifolium, Cylicodiscus gabunensis, Dichaetanthera calodendron, Discoglypremna caloneura, Enantia chlorantha, Guarea thompsonii,* and *Irvingia spp.*

Eighty-one percent(81 %) of all species encountered had a total volume of ≤ 5m^3, while only one species (*Terminalia ivorensis*) had a volume greater than 15m^3 (33.59 m^3). The total volume estimated per hectare was 264m^3 with 10 out of the 26 families contributing more than 70% of the total volume, highest among them were Combretaceae, Leguminosae: Caesalpinioideae and Meliaceae with total volume of 42m^3, 23m^3 and 21m^3 respectively. Sapindaceae, Melastomataceae and Phyllanthaceae contributed the least to the total volume. The total basal area estimated was 100m^2 with the family Combretaceae also having the largest value 3.43m^2. Meliceae ranked the highest in terms of relative density while Combretaceae had the highest rank in terms of relative dominance while the family Phyllanthaceae ranked the lowest in both in relative dominance and density.

Richness and Biodiversity Indices

The biodiversity indices revealed that Shannon-Weiner's index had a value of 3.94 while Simpson's diversity index was 96.97. Pielou's evenness index was 0.86, while Menhinick's index was 4.31, other indices are as highlighted in Table 4.

Table 2: Family Distribution

Family	NS/ha	TV/ha	TBA/ha	RD	RDo	FIV
Meliaceae	63	21.04	2.10	12.37	8.33	10.35
Ulmaceae	61	19.53	1.93	12.07	7.64	9.86
Sterculiaceae	41	16.65	1.57	8.06	6.22	7.14
Ebenaceae	37	5.02	0.61	7.26	2.42	4.84
Leguminosae:Caesalpinioideae	34	23.27	2.02	6.66	7.98	7.32
Leguminosae:Mimosoideae	32	12.11	1.10	6.35	4.35	5.35
Apocynaceae	31	15.03	1.57	6.03	6.23	6.13
Olacaceae	26	11.14	1.29	5.17	5.10	5.13
Guttiferae	23	6.18	0.63	4.44	2.50	3.47
Combretaceae	17	41.52	3.43	3.41	13.58	8.49
Rubiaceae	16	4.45	0.48	3.07	1.89	2.48
Moraceae	15	8.60	0.93	3.04	3.67	3.36
Annonaceae	15	19.86	1.64	2.92	6.50	4.71
Sapotaceae	13	1.83	0.28	2.63	1.11	1.87
Verbanaceae	9	2.11	0.25	1.86	0.98	1.42
Myristicaceae	9	3.49	0.39	1.80	1.54	1.67
Passifloraceae	9	0.89	0.12	1.76	0.48	1.12
Tiliaceae	8	4.17	0.44	1.62	1.75	1.68
Ochnaceae	7	5.75	0.41	1.39	1.64	1.52
Euphorbiaceae	6	17.66	1.60	1.18	6.33	3.76
Rutaceae	5	3.76	0.39	1.07	1.54	1.31
Capparaceae	4	0.89	0.11	0.87	0.44	0.66
Bombacaceae	4	3.19	0.27	0.80	1.06	0.93
Lecythidaceae	4	0.62	0.08	0.70	0.31	0.51
Bignoniaceae	3	1.26	0.12	0.52	0.49	0.50
Leguminosae:Papilionoideae	3	1.30	0.12	0.52	0.49	0.50
Simaroubaceae	3	0.83	0.13	0.52	0.50	0.51
Unknown	2	1.05	0.09	0.46	0.37	0.42
Sapindaceae	2	0.29	0.03	0.35	0.12	0.24
Loganiaceae	1	1.91	0.24	0.28	0.94	0.61
Rhamnaceae	1	3.27	0.15	0.28	0.60	0.44
Burseraceae	1	0.91	0.09	0.17	0.37	0.27
Violaceae	1	1.30	0.28	0.17	1.12	0.64
Irvingiaceae	0	2.78	0.30	0.06	1.20	0.63
Melastomataceae	0	0.21	0.03	0.06	0.12	0.09
Phyllanthaceae	0	0.19	0.02	0.06	0.07	0.06
Grand Total	507	264.07	25.26	100.01	99.99	100.00

**NS/ha=Number of stems per hectare, TBA/ha=Total Basal Area per hectare, TV/ha= Total Volume per hectare, RD= Relative Density, RDo=Relative Dominance, FIV=Family Importance Value*

Table 3: Ten Most Prominent Species

Tree Species	Family	Freq/ha
Trichiliamonadelpha	Meliaceae	32
Celtismildbraedii	Ulmaceae	28
Celtisbiondii	Ulmaceae	27
Diospyrospp	Ebenaceae	24
Allanblackia floribunda	Guttiferae	23
Albizialebbeck	Leguminosae:Mimosoideae	20
Strombosiapustulata	Olacaceae	19
Anthonothamacrophylla	Leguminosae:Caesalpinioideae	18
Sterculiaoblonga	Sterculiaceae	15
Entandrophragmacylindricum	Meliaceae	15

Table 4: Richness and Biodiversity

Indices	Value
Menhinick's index (D)	4.31
Shannon-Weiner Index (H')	3.94
Pielou's Evenness Index (E)	0.86
Margalef's Index of Species Richness (M)	15.41
Simpson Index (λ)	0.03
Simpson Diversity Index (1- λ)	96.97
Number 1 of Hill Diversity Indices (N1)	51.58
Number 2 of Hill Diversity Indices (N2)	39.24

Discussion

According to McLennan and Plumptre (2012), information on forest structure is very important in forest management especially for National Park. The density and size distribution of the trees are the major contributor to the structure of tropical rainforest and despite the wide range of tree density, for trees whose dbh is greater than 1.3cm, a density of 300-700 is usually recorded (Huang *et al.,* 2003). For the study area, the estimated density of trees was 507 stems ha^{-1} which is higher in comparison to the 387 recorded by Adekunle *et al.* (2013) for a tropical rainforest in South-Western Nigeria. It is also higher than that reported by Jimoh *et al.* (2012) for closed canopy forest (159 stems ha^{-1}) and a secondary forest (132 stems ha^{-1}) in Cross-river National Park. In addition, Aigbe and Omokhua (2015) reported 306 stems ha^{-1} for Oban forest reserve which is lower compared to that obtained in the study area.

Boakye *et al.* (2015), McLennan and Plumptre (2012) and Kupsch *et al.* (2014) also reported a lower values of 355stems ha^{-1}, 467 stemsha^{-1} and 490 stemsha^{-1} for forests in Ghana, Uganda and Cameroon respectively. Brewer and Webb (2002) reported 358 stems$ha^{-1}$for a forest in North Central America. It however compared closely with those reported by Onyekwelu *et al.* (2007) for Oluwa, Queen's and Elephant Forest (513,671 and 508 stems ha^{-1} respectively). Sidiyasa (2001) also reported a closely comparable value of 535stems $ha^{-1}$for a forest in Indonesia while Pitman *et al.* (2002) reported higher values of 598 and 654 stems $ha^{-1}$for Manu (Peru) and Yasuni (Ecuador) National Parks respectively. These results imply that estimated density for trees in Okomu National Park, which is a rain forest is in the range obtainable in most rich tropical and closed canopy forest indicating that the National Park is a relatively dense forest when compared to other similar tropical forest.

The basal area obtained for the study area (25.26 m^2/ha) isgreater than the values (10.39 m^2/ha, 7.47 m^2/ha, 2.86 m^2/ha) estimated by Kponstu (2011) for a forest reserve in Ghana. The value is also close to 22.54 m^2/ha recorded by Adekunle *et al.* (2013) for a strict nature reserve, 27.38 m^2/ha reported by Jimoh *et al.* (2012) for a secondary forest in Cross-River National Park and 28.97 m^2/ha estimated by Ola-Adams (2014) for Omo Biosphere Reserve. It also comparesclosely with the 24.7 m^2/ha reported for a forest in Costa Rica by Brewer and Webb (2002) and the 25.5 m^2/ha and 27.9 m^2/ha recorded for two forest types in Uganda by McLennan and Plumptre (2012). Naidu and Kumar (2016) and Brewer and Webb (2002) also reported values of 25.82 m^2/ha and 28.5 m^2/ha for forests in India and Panama respectively which are close to the values obtained from the study area.

However, Onyelwelu *et al.* (2007) reported higher values (29.4 m^2/ha, 35.9 m^2/ha, 85.4 m^2/ha) for Elephant, Oluwa and Queens forests respectively. Aigbe and Omokhua (2015) also estimated a higher value of 36.47m^2/ha for Oban Forest reserve while Jimoh *et al.* (2012) reported 41.59 m^2/ha for a close canopy forest in Cross-River National Park. Pitman *et al.* (2002) also reported higher values of 29.2 m^2/ha and 30.2 m^2/ha for Manu and Yasuni National Parks while Brewer and Webb (2002) estimated 30.3 m^2/ha and 34.9 m^2/ha for forests in Belize and Mexico. More so, Rutishauser, *et al.*, (2013) also reported a higher value of 39.8 m^2/ha for an old secondary forest in Indonesia, and Kupsch *et al.* (2014) 40.7 m^2/ha for a National Park in Cameroon. Adeyemi *et al.* (2015) reported a much higher value of 111.32 m^2/ha for Okwangwo Forest in Cross-River State. According to McElhinny (2001), basal area is indicative of stand volume and biomass which has implication for carbon stock.

Diameter and Height Distribution

The diameter distribution followed a J-inverse distribution which is typical of tropical forests as noted by Husch, *et al.* (2003).It is also in agreement with studies by Jimoh, *et al.* (2012), Adekunle, *et al.* (2013), Etigale, *et al.* (2014), Aigbe and Omokhua (2015), Boakye *et al.* (2015), and McLennan and Plumptre (2012). The J-inverse diameter distribution indicates that there are more individual trees in the small dbh class and fewer trees in the larger dbh classes. This as explained by some authors (Hartshorn, 1980; Hadi *et al.*, 2009), is due to the fact that few tropical trees grows naturally to large dbh classes, and past selective extraction of trees species with large dbh. The distribution pattern could also signifythat there is a successful regeneration of tree species within the park as observed Boakye, *et al.,* (2015). According to Boakye, *et al.,* (2015), a population needs an abundant of juvenile to recruit into adult size classes in order to maintain its population. This has implications for carbon stock management because a regenerating forest has a high potential for carbon sequestration.

The height classification shows that most of the trees (60 %) fall within the middle stratum, while a few emergent trees were also recorded. The presence of emergent trees is an indication of good conservation effort. This result is in agreement with studies by Adekunle *et al.* (2013) and Jimoh *et al.* (2012). According to Jimoh *et al.* (2012), height and diameter distributions give a good indication of the ratio of young to old trees which has implications for management and conservation. Variation in tree height is considered an important attribute of structure because stands containing a variety of tree heights are also likely to contain a variety of tree ages and species thereby providing a diversity of micro-habitats for wildlife (Zenner, 2000). Middle canopy trees which are prominent in this study harbors most rainforest wildlife species because of the availability of food at this level according to Michael (2001).

Species and Family Distribution

Species richness which is the most basic and natural measure of diversity is the number of species present in an area (COLBY, n.d.). The result on species richness shows Okomu National Park is relatively rich in flora species distributed into several families as indicated in the values obtained (97 species distributed into 36 families) when compared with values from similar sites in Nigeria. The diversity is closely comparable to that obtained by Adekunle *et al.* (2013) which estimated 94 species belonging to 34 families in a strict nature reserve in south-west Nigeria and higher than that reported by Aigbe and Omokhua (2015) for Oban forest reserve (72 species and30 families).

Onyekwelu *et al.* (2007) reported a much lower value for Queen's, Oluwa and Elephant forests with 51, 45, and 31 species distributed in 31 families respectively while Adeyemi *et al.* (2015) reported a higher value for Okwangwo forest (125 species belonging to 36 families). The value obtained was also lower than the 118 species reported by Adeyemi *et al.* (2013) for Oban Division of Cross River National Park. One hundred and forty two (142) species was reported for a forest reserve in Ghana and 512 reported by Haung *et al.* (2013) for a forest Tanzania. Naidu and Kumar (2016) recorded 129 species for a tropical forest in India.

The relatively high flora species richness indicated by the result is typical of tropical forests and the fact that the forest is under strict conservation might be one of the factors responsible for such values. However, the higher values recorded for Okwangwo and Cross River National Park might be due to fact that the forests were primary forest whereas Okomu Park had been exploited before going by the extensive pottery and charcoal found below the forest as reported by Omene *et al.* (2015).

However, in a study by Pitman, *et al.*, (2002) 1017 species distributed into 72 families was reported for Yasuni National Park in Eucaudor, while Hadi *et al.* (2009) reported 139 species belonging to 36 families in Indonesia. In other studies conducted in South America, the number of species reported for Guatemala, Mexico, Costa Rica, Panama and Belize were within the range of 53 and 91 as reported by Brewer and Webb (2002) for trees whose dbh were greater than 10 cm. Comparing these results with those obtained from the study area and similar study area negates the assertion made by Cazzolla *et al.* (2017) that African's tropical forest can be considered species poor when compared to tropical forest in South America and Asia. However, Nwoboshi (1982) noted that the number of tree species per hectare could be as high as 400 in very rich rainforests and specifically those in South America and Southeast Asia can harbour up to 200 to 300 species per hectare (Richards 1996).

The findings on family distribution which indicated Meliaceae, Ulmaceae and Sterculiaceae having the highest distribution is in agreement with similar study by Isichei (1995) for Nigeria rainforest. This is also in agreement with studies in similar forests by Adekunle (2007), Adekunle, *et al.* (2013) and Onyekwelu *et al.* (2007) . Aigbe and Omokhua (2015) and Deb *et al.* (2015) also had Meliaceae as one of the highest ranking families.

Species Richness and Biodiversity

Species diversity index is a measure of diversity that incorporates both the number of species in an assemblage and some measure of their relative abundances (Gottelli and Chao, 2013). The species diversity indices considered in this study revealed that the Park is diverse in terms of flora species as indicated in the results obtained. Magurran (1988) asserted that the values of Shannon-Wiener diversity index is usually found to fall between 1.5 and 3.5 and only rarely surpasses 4.5, the value obtained for the study area was 3.94. The value is higher than the 3.74 reported by Adekunle *et al.* (2013) for a strict nature reserve, 3.795 reported by Aigbe and

Omokhua (2015) and 2.82, 3.12 and 3.31 reported for threeprotected areas by Onyekwelu *et al.* (2007). It was also higher than that reported by Cazolla *et al.* (2017) for a protected forest reserve in Ghana (4.35) and closely comparable to the value (3.76 - 3.96) reported by Naidu and Kumar (2016) for a forest in India.

Pielou's species evenness index (E) is a value between zero and one with one indicating that all species are equally abundant. The value of E obtained was 0.86, the value compared closely with the 0.82 reported by Adekunle *et al.* (2013) and 0.89 reported by Aigbe and Omokhua (2015). It was higher than the value (0.78) reported by Naidu and Kumar (2016). Simpson diversity index was also high for the study area indicating that dominance is shared by large number of species rather than a few as affirmed by Whittaker (1965). The Margalef's index was higher than the 2.28 reported by Adeyemi *et al.* (2013).

The results obtained for species richness and biodiversity is highly significant for the two major management purposes. They are wildlife management and carbon stock management. The mixed composition of species and families helps to provide an important ecological niche for the flora and fauna species in the study area thereby contributing significantly to biodiversity conservation in the Park. According to Fran (2015), all wildlife requires a habitat which is usually diverse depending on the species, therefore great diversity for wildlife will support the greatest number of species. Aremu*et al.* (2012) in a study conducted in Okomu National Park noted that a healthy and improved habitat for the Park is necessary for higher population of arboreal species as it serves as source of food, cover and breeding space for the wildlife species.

Species diversity is also significant for carbon sequestration because the value of carbon stored within the forest is dependent on the trees photosynthesizing and storing it, as stated by Hindsley (2010). The efficiency and rate of carbon sequestration of different tree species differ as such the cumulative carbon stock will be greater in a more diverse forest. A study carried out by Poorter, *et al.* (2015) revealed that biodiversity has an independent, positive effect on Above Ground Biomass (AGB) and ecosystem functioning, not only in relatively simple temperate systems but also in structurally complex hyper-diverse tropical forests. This indicates that diversity is a requirement for enhancing carbon storage (Wageningen University, 2015). Hindsley (2010) therefore recommended that biodiversity conservation should be an important factor to be considered under United Nation Reducing Emissions from Deforestation and Degradation strategy. Terry-Cobo (2010) further stressed the importance of attaching a value to biodiversity. This is so that the "financial instruments would include the vital services a healthy ecosystem provides, rather than simply paying for sucking carbon out of the atmosphere" (Terry-Cobo, 2010).

Conclusion and Recommendations

The study has shown that Okomu National Park though small in size, is a rich forest with abundance of species diversity which compares favourably with similar forests, therefore conscious effort should be made in managing the forest actively. Greater attention should be given to the Parks forest as the wild animals within the Park are dependent on the forest for food and shelter. The study has also demonstrated the need to put more effort in the conservation of the nation's forests as a species diversity can be achieved even on a relatively small sized forest with proper management. In addition, since the forest is rich with lots of biodiversity which is highly significant for carbon sequestration, the possibility of actively managing the park for carbon stock should be explored. This is very important especially in accessing carbon funds for the purpose of providing the much needed incentives for forest dependent community around the Park.

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