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A SURVEY OF TREE SPECIES DIVERSITY IN AKURE FOREST RESERVE AND OKOMU NATIONAL PARK

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ABSTRACT

This research aimed to survey the tree species diversity in Akure Forest Reserve and Okomu National Park. The study was carried out in Akure Forest Reserve, Ondo State and Okomu National Park, Edo State. Sample plots of (100x100 m^2) were demarcated in the Forest Reserves and sub-divided into smaller units of (25 by 25m^2). Using 50% sampling intensity, data were collected from eight (8) plots in each Forest Reserves. Tree species were identified via their botanical names. Okomu National Park had 400 trees per hectare from 53 species and 26 families, whereas Akure Forest Reserve had 388 trees per hectare from 65 species and 30 families. A J-inverse diameter distribution was observed in the two Forest Reserves. A mean Diameter at Breast Height and basal area/ha of 32.90 cm and 48.76 m^2/ha, and 20.16 cm and 16.56 m^2/ha, were obtained for Akure Forest Reserve, and Okomu National Park respectively. Shannon-Wiener diversity index for, Okomu and Akure Forest Reserves were 3.52 and 3.83 respectively. It could therefore be concluded that the Forest Reserves are potential biodiversity places of interest if better conservation management efforts are employed. Therefore, conservation efforts should be stepped up in the Forest Reserves as they still contain important economic species.

Keywords: tropical forest, forest reserve, diversity index, biodiversity, deforestation.

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INTRODUCTION

Tropical regions forests account for about 52% of the total global forest, and they are known to be the most important areas in terms of biodiversity (Anbarashan and Parthasarathy, 2013). This diversity is a marker that allows the understanding of links between the richness and the abundance of individuals' trees which reflects the degree of heterogeneity or stability of vegetation (Ifo et al, 2016). Nigerian forest contains thousands of plant and animal species and is home to many culturally diverse indigenous people (Aigbe *et al.*, 2014). The natural forest reserves in Nigeria as reported by Nigeria Population Commission (NPC), (2006) occupy about 10 million hectares which accounts for about 10% of the land area.

However, the land area identified as forest lands has been declining progressively due to the industrial and social development which competes for the same pieces of land upon which the forest stands (Alamu and Agbeja, 2011). According to Wilkie, (2010), deforestation has been attributed to be the end result of various activities of man in the bid for economic development. The degradation, fragmentation and conversion of the forests to other forms of land uses in Nigeria are currently advancing at worrisome rates. Adedutan and Olusola, (2015) reported that in the last two decades, a significant portion of the undisturbed forest and Forest Reserves ecosystem in the 80s had been lost.

To preserve the biodiversity and productivity of tropical forest ecosystems sustainable management practices are required and this can only be possible through authentic information about the status and distribution of tree species, which form the framework for other life forms (Adeyemi *et al*, 2015). Subsequent to centuries of forest degradation, many rainforest ecosystems are severely threatened and persist as forest fragments. Thus, there is a growing interest in measuring habitat characteristics such as forest structure, floral composition, species diversity and species richness in forest areas (Gillespie *et al*. 2004). This study comparatively investigates the tree species diversity in Akure Forest Reserve and Okomu National Park.

MATERIALS AND METHODS

Study area

This study was carried out in Akure Forest Reserve in Ondo State and Okomu National Park, Edo State. Akure Forest lies within 4º 30' and 6º East and 5º 45' and 8º 15' North. The climate of the area is humid sub-tropical. It is dominated by broadleaved hardwood trees that form dense, layered stands. The mean annual temperature is about 26ºC (minimum 19ºC and maximum 34ºC) and the rainy season lasts for 9 months annually, between March and November (about 2500 mm with bimodal rainfall pattern) while the dry seasons usually last for 3 months, between December and February (Adekunle *et al*, 2013).

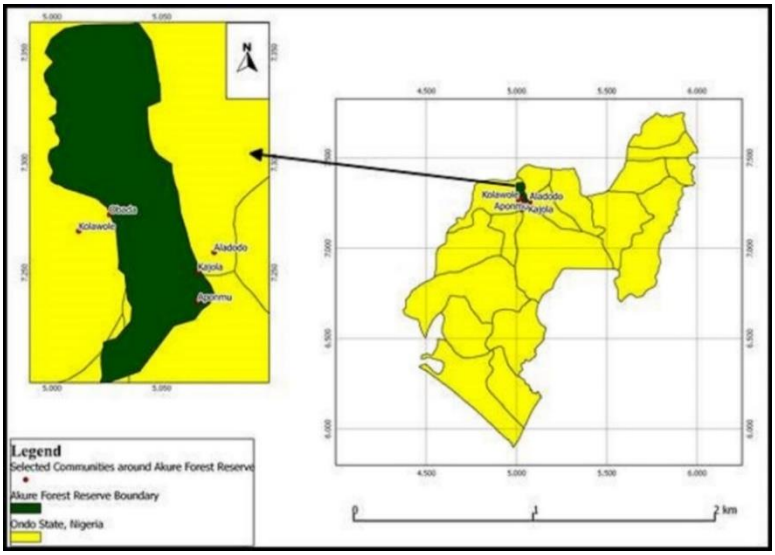

Figure 1: Map of Akure Forest Reserve (source: Olajuyigbe and Adaja, 2016)

The Okomu Forest Reserve is a forest block covering an area of 1081 km^2 in Ovia South-West Local Government Area of Edo State, Nigeria. Okomu National Park lies within the forest reserve. Okomu National Park is located between Latitude 6^0 15'N and 6^0 25' N and longitudes of 5^0 90'E and 5^0 23' N. The Park covers an area of 202.24 km² (Okomu National Park, 2010). The topography is gentle, ranging between 30 m and 60 m above sea level. Rainfall is between 1,524 and 2,540mm. The Park's dry season occurs from December to February and the wet season lasts from March to November (Soladoye and Oni, 2000). Vegetation is Guinea Congo lowland rain forest, including areas of swamp-forest, high forest, secondary forest and open shrub (Okomu National Park, 2010).

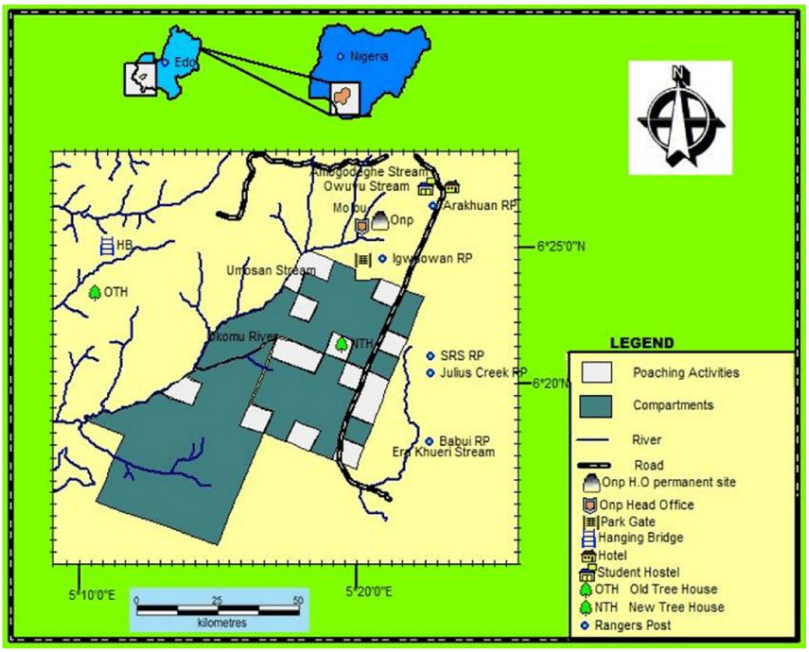

Figure 3: Map of Okomu National Park (source: Nwankwo, 2016)

Experimental Design Data Collection

Sample plots of (100x100 m^2) were demarcated in each of the selected forest reserves and sub-divided into smaller units of (25 m by 25 m^2). Using 50% sampling intensity, eight (8) plots were randomly selected in each forest reserve. Within each plot, trees species with diameter at breast height (DBH) ≥10 cm were identified, numbered and their DBH measured. The botanical names of trees encountered in the sample plots of each marked area were recorded. In cases where a tree's botanical name was not known, such trees were identified by their common name. Trees that could not be identified were referred as samples of such tree species and were taken to the herbarium for identification.

Data Analysis

According to Keay (1989), all the tree species encountered in each of the forest reserves were classified into families, and their frequencies of occurrences were also obtained. To ascertain diversity of the tree species the following bio-diversity indices were computed:

a) The Shannon-Wiener diversity index (H^1) given by Price (1997). This was used to calculate diversity index because it takes into account the richness and abundance of each species in the different Forest reserves. It is mathematically expressed as:

$$H' = \sum_{i=1}^{s} pi \ln(pi) \quad \text{.....(1)}$$

H' = Shannon diversity index,

S = the total number of species in the community,

Pi = proportion S (species in the family) made up of the i^{th} species

ln = natural logarithm.

b) Species Richness (SR): Species richness was computed using the procedure used by Oluwatosin and Jimoh (2016)

$$SR = \frac{S}{\sqrt{N}} \text{ ..... (2)}$$

Where:

SR = species richness index (Margalef index),

S =the total number of species and

N = the total number of individuals.

c) Species evenness (E): This was calculated by adopting Shannon's equitability (EH) as stated by Kent and Coker (1992).

$$E_H = \frac{\sum_{i=1}^{s} p_i \ln(p_i)}{\ln(S)} \text{ ..... (3)}$$

RESULT

Family and tree species richness in Akure Forest Reserve and Okomu National Park

Tables 1-2 showed the family distribution and species richness of trees in the Forest Reserves. From the tables, the total number of individual trees encountered in the Okomu National Park is 200 individual trees from 53 different species and 26 different families in, while 194 individual trees were encountered in the Akure Forest Reserve from 65 different species of 30

different families. *Fabaceae* (46) family accounts for the highest frequency of individual trees in Okomu National Park, while *Sterculiaceae* (43) in Akure Forest Reserve. As for species richness, *Pentaclethra macrophylla* (24) accounts for the species with highest number of individual trees in Okomu National Park while *Steculia rhinopetala* (16) recorded the highest number of individuals in Akure Forest Reserve. The table further reveals that *Terminalia ivorensis* (59.60 cm) accounts for the highest mean DBH (31.67 cm) in Okomu National Park while *Cordia mannii* and *Uapaca heudelotii* with mean DBH of 89 cm each in Akure Forest Reserve. while *Khaya africana* (10.00 cm) recorded the lowest mean DBH in Okomu National Park and *Monodora myristica* (12 cm) in Akure Forest Reserve.

Table 1: Family and tree species richness in Okomu Forest Reserve

Name	Family	N	N/ha	Mean DBH	RD	RDo	IVI
Allanblackia floribunda	Clusiaceae	7	14	23.36	3.50	3.85	3.67
Albizia stipulata	Fabaceae	1	2	15.10	0.50	0.03	0.27
Alstonia boonei	Apocynaceae	1	2	15.80	0.50	0.04	0.27
Annonidium mannii	Annonaceae	5	10	19.66	2.50	1.39	1.95
Anthocleista vogelii	Loganiaceae	1	2	21.20	0.50	0.06	0.28
Antiaris Africana	Moraceae	1	2	16.70	0.50	0.04	0.27
Baphia nitida	Fabaceae	11	22	16.81	5.50	4.92	5.21
Baphia pubescens	Fabaceae	2	4	51.30	1.00	1.51	1.26
Barteria fistulosa	Passifloraceae	4	8	12.60	2.00	0.37	1.18
Barteria negritiana	Passifloraceae	1	2	11.00	0.50	0.02	0.26
Blighia sapida	Sapindaceae	3	6	36.50	1.50	1.72	1.61
Bulchholzia coriacea	Caparaceae	2	4	14.30	1.00	0.12	0.56
Ceiba pentandra	Bombacaceae	1	2	12.80	0.50	0.02	0.26
Celtis zencheri	Ulmaceae	3	6	13.00	1.50	0.22	0.86
Cleistopholis patens	Annonaceae	2	4	37.50	1.00	0.81	0.90
Cola nitida	Malvaceae	1	2	18.60	0.50	0.05	0.27
Conbretum racemosum	Combretaceae	4	8	19.70	2.00	0.89	1.45
Daniellia oliveri	Fabaceae	2	4	23.80	1.00	0.33	0.66
Desplatsia subericarpa	Tiliceae	5	10	30.08	2.50	3.25	2.88
Detarium microcarpum	Fabaceae	1	2	19.70	0.50	0.06	0.28
Diospyros crassiflora	Ebenaceae	5	10	13.34	2.50	0.64	1.57
Diospyros dendo	Ebenaceae	1	2	24.80	0.50	0.09	0.29
Diospyros insculpta	Ebenaceae	3	6	12.83	1.50	0.21	0.86
Drypetese gossweileri	Euphorbiaceae	1	2	28.20	0.50	0.11	0.31
Elaeis guineensis	Arecaceae	1	2	30.20	0.50	0.13	0.32
Entandrophragma angolense	Meliaceae	9	18	15.35	4.50	2.75	3.62
Entandrophragma cylindrcum	Meliaceae	6	12	15.26	3.00	1.21	2.10
Funtumia elastic	Apocynaceae	3	6	15.70	1.50	0.32	0.91
Guarea cedrata	Meliaceae	5	10	16.78	2.50	1.01	1.76
Guarea thompsonii	Meliaceae	1	2	13.60	0.50	0.03	0.26
Gubourtea ehie	Fabaceae	6	12	17.65	3.00	1.61	2.31
Jacaranda mimosifolia	Bignoniaceae	1	2	12.40	0.50	0.02	0.26
Khaya Africana	Meliaceae	1	2	10.00	0.50	0.01	0.26
Khaya ivorensis	Meliaceae	1	2	31.50	0.50	0.14	0.32
Klainedoxa gabonensis	Irvingiaceae	2	4	10.80	1.00	0.07	0.53
Lovoa trichilioides	Meliaceae	2	4	14.35	1.00	0.12	0.56
Monodora myristica	Annonaceae	4	8	14.80	2.00	0.50	1.25
Myrianthus arboreas	Urticaceae	8	16	29.99	4.00	8.28	6.14

***Key: N**- frequency of trees, **N/ha** - abundance of tree per hectare, **Mean DBH** - the average diameter at breast height, **RD**- relative density of species, **RDo**- relative dominance of species, **IV** - importance values of species.*

Table 2: Family and tree species richness in Akure Forest Reserve

Species Name	Family	N	N/ha	Mean	RD	RDo	IV
Albizia adianthifolia	*Caesalpiniodeae*	2	4	74.50	1.03	1.78	1.40
Albizia zygia	*Caesalpiniodeae*	2	4	32.25	1.03	0.33	0.68
Alstonia boonei	*Apocynaceae*	6	12	32.25	3.09	3.00	3.04
Anonidium mannii	*Annonaceae*	5	10	27.56	2.58	1.52	2.05
Anthocleista vogelii	*Loganaceae*	1	2	25.00	0.52	0.05	0.28
Anthonotha macrophylla	*Leguminosae-*	1	2	34.80	0.52	0.10	0.31
Anthonotha obanensis	*Fabaceae*	2	4	20.45	1.03	0.13	0.58
Baphia nitida	*Fabaceae*	1	2	27.30	0.52	0.06	0.29
Blighia sapida	*Sapindaceae*	1	2	15.00	0.52	0.02	0.27
Brachystegia eurycoma	*Leguminosae-*	5	10	35.68	2.58	2.55	2.56
Buchholzia coriacea	*Capparidaceae*	2	4	14.90	1.03	0.07	0.55
Ceiba pentandra	*Bombacaceae*	3	6	57.57	1.55	2.39	1.97
Celtis mildbraedii	*Ulmaceae*	6	12	40.60	3.09	4.75	3.92
Celtis philippensis	*Ulmaceae*	4	8	26.13	2.06	0.87	1.47
Celtis zenkeri	*Ulmaceae*	12	24	22.70	6.19	5.94	6.06
Chrysophyllum albidum	*Sapotaceae*	1	2	23.00	0.52	0.04	0.28
Chrysophyllum	*Sapotaceae*	4	8	44.50	2.06	2.54	2.30
Chytranthus macrobotrys	*Sapotaceae*	2	4	21.30	1.03	0.15	0.59
Cleistopholis patens	*Annonaceae*	5	10	46.14	2.58	4.26	3.42
Cola gigantea	*Sterculiaceae*	10	20	36.99	5.15	10.95	8.05
Cola hispida	*Sterculiaceae*	1	2	18.30	0.52	0.03	0.27
Cordia mannii	*Boraginaceae*	1	2	89.00	0.52	0.63	0.57
Cordia millenii	*Boraginaceae*	1	2	84.00	0.52	0.56	0.54
Croton penduliflorus	*Euphorbiaceae*	1	2	54.70	0.52	0.24	0.38
Desplatsia dewevrei	*Tiliaceae*	1	2	23.70	0.52	0.04	0.28
Diaspyros dendo	*Ebenaceae*	3	6	20.27	1.55	0.30	0.92
Enantia chlorantha	*Annonaceae*	2	4	13.55	1.03	0.06	0.54
Entandrophragma	*Meliaceae*	1	2	24.60	0.52	0.05	0.28
Entandrophragma utile	*Meliaceae*	2	4	56.00	1.03	1.00	1.02
Erythrina senegalensis	*Papilionoideae*	2	4	26.25	1.03	0.22	0.63
Ficus exasperata	*Moraceae*	1	2	44.50	0.52	0.16	0.34
Ficus sur	*Moraceae*	1	2	61.40	0.52	0.30	0.41
Funtumia elastica	*Apocynaceae*	7	14	18.36	3.61	1.32	2.46
Garcinia kola	*Guttiferea*	1	2	16.80	0.52	0.02	0.27
Glyphaea brevis	*Tiliaceae*	2	4	13.50	1.03	0.06	0.54
Gmelina arborea	*Labiatae*	1	2	29.60	0.52	0.07	0.29
Khaya grandifoliola	*Meliaceae*	2	4	16.25	1.03	0.08	0.56
Lecaniodiscus cupanioides	*Sapindaceae*	1	2	20.10	0.52	0.03	0.27
Malacantha alnifolia	*Sapotaceae*	2	4	15.00	1.03	0.07	0.55
Mansonia altissima	*Sterculiaceae*	9	18	35.61	4.64	8.22	6.43
Margaritaria discoidea	*Euphorbiaceae*	2	4	38.70	1.03	0.48	0.76
Microdesmis puberula	*Pandaceae*	1	2	22.60	0.52	0.04	0.28
Milicia excelsa	*Moraceae*	1	2	12.90	0.52	0.01	0.26
Mitragyna ciliata	*Rubiaceae*	1	2	28.00	0.52	0.06	0.29
Monodora myristica	*Annonaceae*	1	2	12.00	0.52	0.01	0.26
Musanga cecropioides	*Moraceae*	1	2	39.00	0.52	0.12	0.32
Newbouldia laevis	*Bignonaceae*	2	4	21.60	1.03	0.15	0.59
Pachystela brevipes	*Sapotaceae*	3	6	18.17	1.55	0.24	0.89
Picralima nitida	*Apocynaceae*	4	8	13.50	2.06	0.23	1.15
Pterocarpus osun	*Leguminosae*	5	10	29.02	2.58	1.69	2.13
Pterygota macrocarpa	*Sterculiaceae*	3	6	27.90	1.55	0.56	1.05
Pycnanthus angolensis	*Myristicaceae*	1	2	56.00	0.52	0.25	0.38
Rhicinodedron heudelotti	*Euphobeaceae*	4	8	61.30	2.06	4.81	3.44
Steculia rhinopetala	*Sterculiaceae*	16	32	30.99	8.25	19.67	13.96
Sterculia tragacantha	*Sterculiaceae*	1	2	27.00	0.52	0.06	0.29
Strombosia pustulata	*Olacaceae*	4	8	15.38	2.06	0.30	1.18
Symphonia globulifera	*Clusiaceae*	1	2	38.20	0.52	0.12	0.32
Terminalia ivorensis	*Combretaceae*	1	2	67.00	0.52	0.36	0.44
Terminalia superba	*Combretaceae*	4	8	51.93	2.06	3.45	2.76

Species Name	Family	N	N/ha	Mean	RD	RDo	IV
Trichilia heudelotii	*Meliaceae*	6	12	25.48	3.09	1.87	2.48
Trilepisium	*Moraceae*	7	14	42.84	3.61	7.20	5.40
Triplochiton scleroxylon	*Sterculiaceae*	3	6	55.20	1.55	2.19	1.87
Uapaca heudelotii	*Euphorbiaceae*	1	2	89.00	0.52	0.63	0.57
Zanthoxylum leprieurii	*Rutaceae*	2	4	27.70	1.03	0.25	0.64
Zanthoxylum rubescens	*Rutaceae*	2	4	28.80	1.03	0.27	0.65

Key: ***N****- frequency of trees,* ***N/ha*** *- abundance of tree per hectare,* ***Mean DBH*** *- average diameter at breast height,* ***RD****- relative density of species,* ***RDo****- relative dominance of species,* ***IV*** *- importance values of species.*

Tree distribution based on DBH class

Figure 1 below shows the DBH class distribution of the two in the studied forest reserves. the figure shows the J-inverse diameter distribution where most trees in the forests occupies the lower DBH class i.e. DBH class 10 – 19 cm. It however showed that Okomu National Park accounts for the highest frequency of trees occupying the lower DBH class. The figure further showed that the frequency of the trees progressively reduces in the both forest reserves as we go higher the frequency class and only Akure Forest Reserve have trees with DBH over 100 cm.

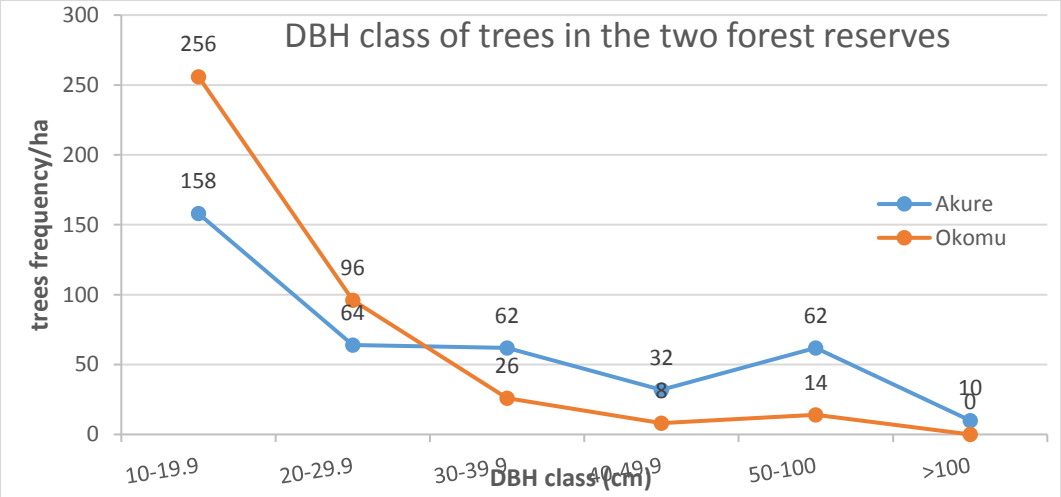

Figure 3: Tree distribution based on DBH class

Table 3 showed the summary of various analysis conducted for the two Forest Reserves under study. The table revealed that Akure Forest Reserve had 388 individual trees per hectare, with sixty-five (65) species form thirty (30), Okomu forest reserve had 400 trees per hectare, spreading across fifty-two (52) species from about 26 families. The table also revealed that Akure Forest Reserve recorded a higher mean DBH value (32.90 cm) and basal area per hectare (48.76 m^2/ha) than Okomu forest reserve with 20.16 cm and 16.56 m^2/ha respectively. For the species diversity indices, the Shannon-Wiener diversity index for Okomu and Akure Forest Reserves are 3.52 and 3.83 respectively, species richness is 3.68 and 4.67 for Okomu and Akure Forest Reserves respectively while species evenness for the two Forest Reserves are 0.66 and 0.73 for Okomu and Akure Forest Reserve respectively.

Table 9: Summary of the results of various analyses conducted for the two study sites

Study site	Density (tree/ha)	No of families	No of species	Mean dbh (cm)	Mean BA (m2/ha)	Dominant DBH (cm)	H'	E_H	SR	D
Okomu	400	26	52	20.41	16.56	67.00	3.52	0.66	3.68	1.78
Aponmu	388	30	65	32.90	48.76	123.10	3.83	0.73	4.67	1.44

Key: *H' = Shannon-Wiener diversity index E_H = Shannon's equitability (species evenness); SR = species richness, D = difference between the diversity index (H') and its maximum value (H_{max}).*

DISCUSSION

The study took place in the tropical rain forests of Akure and the Okomu Forest Reserve in Southern Nigeria. Majority of the tree species found in the two studied forests are tropical species common to the tropical rainforest and are of economic value. Akure Forest Reserve recorded a higher number of species (65 species) spreading over 30 families than Okomu National Park of 52 species from 26 families. This result is similar to that of Adekunle *et al*, (2013) who recorded 94 tropical wood species and 30 families in the Akure strict natural reserve (queen's plot) and Onyekwelu *et al*, (2008) who recorded 54 species and 27 families in the same queen's forest. The 388 stems/ha and 400 stems/ha recorded in the Forest Reserves is similar to what was obtained by Adekunle *et al*, (2013). These results imply that estimated density for trees in the studied Forest Reserves, which is a rain forest is in the range obtainable in richest tropical and closed canopy forest signifying that the forests are relatively dense forest.

The findings on family distribution which indicated *Fabaceae* and *Sterculiaceae* are having the highest distribution in this research. The Nigerian rainforest ecosystem is dominated by members of *Sterculiaceae* (e.g. *Cola spp*., *Sterculia spp*.), *Moraceae* (*Antiaris africana, Ficus spp*.), *Ulmaceae* (*Celtis spp., Holoptelea grandis*), *Meliaceae* (e.g. *Entandrophragma spp., Khaya ivorensis*) and species like *Nauclea diderrichii, Erythrophleum ivorense, Brachystegia eurycoma* and *Terminalia superba* (Richards, 1939; Onyekwelu *et al*, 2008; Oke *et al*, 2017) which is consistent with the result of this study.

The basal area obtained for the study are 48.76 m^2/ha and 16.56 m^2/ha for Akure Forest Reserve and Okomu National Park respectively is within the range (22.54 m^2/ha – 85.4 m^2/ha) that was observed by other researcher in different forest reserves (Oyekwelu *et al*, 2008; Jimoh *et al*., 2012; Adekunle *et al*, 2013; Oke *et al*, 2017). McElhinny (2005), had opined that basal area is indicative of stand volume and biomass which has implication for carbon stock.

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), Aigbe and Omokhua (2015), Boakye *et al*. (2015), and Oke *et al*, (2017). 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 may be due to the fact that few tropical trees grow naturally to large DBH classes, and the past selective extraction of trees species with large DBH (Hartshorn, 1980; Hadi *et al*., 2009).

The diversity indices used in this research includes Shannon-Wiener diversity index (H') Shannon's equitability (species evenness) (EH), and species richness (SR). Several researchers have adopted the use of Shannon-Weiner diversity index to investigate ecosystem diversity as it takes into consideration both the species richness and evenness in a community (Onyekwelu *et al*., 2005; Adekunle *et al*, 2013; Adeduntan and Olusola, 2015, Oke *et al*, 2017; Amonum et al, 2019). The Shannon-Weiner diversity index of 3.52 for Okomu National Park and 3.83 for Akure Forest Reserves is very close to the range of values (3.04-3.94) reported for some tropical rainforest sites in southern Nigeria by Oyekwelu *et al*, (2008), Adekunle *et al*, (2013) and Oke *et al*, (2017). This result is an indication that biological diversity is adequately conserved in these Forest Reserves because of the strictness in protection of the reserves especially for native species, major species and species with narrow range. The trend of Shannon-Wiener diversity indices (H') showed that Akure forest was more diverse than Okomu. The species diversity of these forests decreases as the level of forest degradation increases this is in line with the findings of Oyekwelu *et al*, (2008) and Adekunle *et al*, (2013). The E_H values obtained in this study showed that trees species are more evenly distributed in Akure forest than Okomu National Park. This is a suggestion that species distribution is also affected by level of forest degradation. The low E_H in Okomu National Park though a strictly conserved forest may suggest previous exploitation of the park going by the extensive pottery and charcoal found below the forest as reported by Omene *et al*. (2015).

CONCLUSION AND RECOMMENDATIONS

The results of this study revealed the biodiversity and species abundance in Akure Forest Reserve and Okomu National Park. The species diversity and abundance of the forests

studied compared favorably with other similar forest ecosystems. These forests, therefore, are potential biodiversity places of interest if better conservation management efforts and thorough research of all the biodiversity indicators are employed. This result will serve as reference data that could be helpful in the appraisal of plant resources of the tropical rainforest ecosystem for its effective management. Conservation efforts should be stepped up in forest reserves especially the ones with species considered to be endangered to prevent them from going into extinction.

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