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Structure and Floristic Compositions of Ehor Forest Reserve, Edo State, Nigeria

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ABSTRACT

In this study, the variability of structure and floristic composition of Ehor Forest Reserve (which consist of areas BC (Benin Council) 12/1, 15/1 and 16/1) was investigated. Systemic line transect was employed for laying of sample plots for data collection. The 20m x 20m (0.04 ha) sample plots were laid in alternate directions along two transects at 250m interval and thus summing up to 4 sample plots per transect and a total of 8 sample plots per BC area. A total of 541 trees were measured in 24 sample plots from the three BC areas. Tree identification and detailed growing stock measurements of diameter at breast height (Dbh) and total height were made on all trees with Dbh ≥ 5 cm within the sample plots. Individual tree basal area was computed and extrapolated to per-hectare basis. The biodiversity indices computed were species relative density, species relative dominance, Importance Value Index (IVI) and Family Importance Index (FIV). The results show that an average number of trees per hectare were 206 (30 species), 809 (49 species) and 675 (44 species) encountered in areas BC 12/1, 15/1 and 16/1 respectively. The mean basal area/ha estimated was highest in the BC 16/1 (28.24 m2) followed by BC 15/1 (26.66 m2) and lowest in BC 12/1 (1.82m2). In BC 12/1, Ceiba pentandra had the highest IVI of 12.62 %. Brachystegia kennedyi had the highest IVI of 7.83 % in BC 15/1 while Trichilia welwitschii had the highest species share of area BC 16/1 with an IVI of 8.904 %. The forest had two vertical structure layers in 12/1, three vertical structure layers in 15/1 and two vertical structure layers in 16/1. The findings of this study revealed that the three BC areas of Ehor Forest Reserve had more trees in the lower Dbh class than in upper Dbh class, however, only area BC 15/1 and 16/1 is well-stocked.

Key words: Forest structure, tropical forest, floristic composition, Ehor forest reserve, importance value index

INTRODUCTION

Ehor Forest Reserve is a typical tropical rainforest, with diverse and high economic floras like some other tropical rainforests (Meyer *et al.,* 2000 and Oates *et al.,* 2004). The tropical rainforests are the most biodiverse terrestrial ecosystems in the world (Turner, 2001; Onyekwelu *et al*., 2008; Schmitt *et al.,* 2009; FAO, 2010; IUCN, 2010). It contains about 70% of plant and animal species in the world ecosystem unlike what is obtainable in the temperate region (Lovejoy, 1997). Thus, the tropical rainforest is a main storehouse of the genetic diversity of both flora and fauna (Aigbe and Omokhua, 2015). Understanding forest structure and composition is important for forest managers to evaluate the complexity and resources of tropical forest. Trees form the major structural and functional basis of tropical forest ecosystems and can serve as robust indicators of changes and stressors at the landscape scale (Mistra, 1968).

Throughout the world, there is increasing awareness and recognition that the forest is fundamental in maintaining ecological processes/services, are source of livelihood to rural populace and are important in enhancing economic growth (UNEP, 2007; FAO, 2009). Forests play important role in regulating local and global climate (Yeshitela, 2008). They are crucial in reducing soil erosion, maintaining soil moisture and regulating stream flow as well as in providing habitat to varieties of plants and animals (FRIN, 2000; Lalfakawma, 2010).

It has been pointed out that the rate of anthropogenic activities within the forests in Nigeria is overwhelmingly high (FRA, 2010). In Edo State, Ehor Forest Reserve is under intense unregulated timber and various forest produce extraction (Ihenyen *et al.,* 2010). According to Aigbe *et al*. (2014), anthropogenic activities could lead to changes in the diversity of plant populations which in turn

could result in changes in the diversity of other organisms in the ecosystem. The sustainable management and use of forest resources is essential for the nation's economic and environmental security (Akinsanmi, 1999). To ensure the sustained management of these forest resources, accurate information about status of the forest and the types of species present is necessary. This will provide baseline data for sustainable management of Ehor Forest Reserve.

METHODOLOGY

Study Location

Ehor Forest Reserve (Figure 1), which is made up of areas BC (Benin Council) 16/1, BC 15/1 and BC 12/1, occupies an area of 7,680 hectares of land in Uhunmwode Local Government Area of Edo State, Nigeria. It is located between latitudes 6^0 34' N and 6^0 38' N and longitudes 5^0 54' E and 5^0 58' E (Ihenyen *et al.,* 2010). The different BC areas of Ehor Forest Reserve have different topography. The BC 16/1 has sloppy, undulating and flat topography. BC 15/1 has flat topography while BC 12/1 is highly undulated. The soil of Ehor Forest Reserve belongs to the class of rainforest soils that are moderately to very deep and, well drained and composed of sands, sandy loam and loamy sands (Aigbe and Odulami, 2016).

The average annual temperature in Ehor is 25.5^0C. Annual precipitation averages 1755 mm. Precipitation is lowest in January with an average of 10mm (en Climate-data, 2015) while of the rains fall in September with an average of 311mm. March is the hottest month of the year (en Climate-data, 2015). In August, the average temperature is 23.7 ^{0}C, which is the lowest average monthly temperature.

Method of Data Collection

Systemic line transect was employed in laying temporary sample plots. Two transects, with a distance of 500m between them, were laid at the centre of each of the three BC areas. Temporary sample plots of 20m x 20m (0.04 ha) in size were laid at every 250m interval in alternate direction along each transect and thus summing up to 4 sample plots per transect and 8 plots per BC area. This was repeated in the other two BC areas of Ehor Forest Reserve, bringing the total of 24 sample plots for this study. Within each sample plot, woody plant species with diameter at breast height (dbh) ≥ 5 cm were identified and their dbh and total height measured. Trees were identified by their botanical names and family names by an experienced forest taxonomist. Some trees that their botanical names were not immediately known on the field were identified by their common name. Trees that could not be identified by botanical and common names in the field were designated "unknown", and samples of their part(s) (such as leaves, bark, fruits) were collected and used for identification in the laboratory.

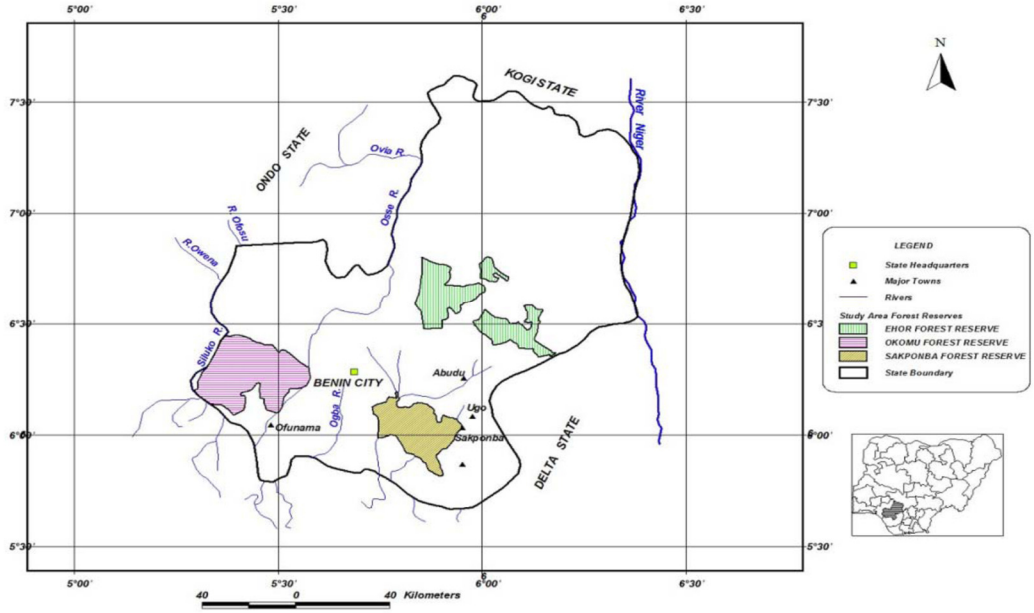

Figure 1: Map of Edo State showing the three BC areas of Ehor Forest Reserve
Source: Azeez *et al.,* 2010.

Data Computation and Analyses

(i) ***Basal Area***

The basal area of all trees in the sample plots were calculated using equation (1):

$$BA = \pi D^2 / 4 \quad \text{-------Equation 1}$$

Where BA = basal area (m^2)

π = 3.142

D = Dbh (m)

Total basal area per plot was obtained by adding the basal area of all individual trees within the plot. Mean plot basal area per BC area was computed by summing the total plot basal areas of all the sample plots for the respective BC area and dividing by the number of sample plots from that BC area. Basal area per hectare was then obtained by multiplying the mean plot basal area by the number of sample plots per hectare.

(ii) ***Species Relative Density (%)***

The relative density (RD) of each species was computed using the equation of Brashears *et al*. (2004) (equation 2):

$$RD = \left(\frac{n_i}{N}\right) \times 100 \quad --- Equation \ \ 2$$

Where, RD is the relative density of the species; n_i is the number of individuals of species i and N is the total number of all individual trees.

(iii) ***Species Relative Dominance (%)***

Relative dominance (RD_0) of each species were estimated using equation (3):

$$RD_0 = \frac{\left(\sum B_{a_i} \times 100\right)}{\sum B_{a_n}} \quad --- Equation \ \ 3$$

Where, RD_0 is the relative dominance of the species; B_{a_i} is the basal area of all individual trees belonging to a particular species; B_{a_n} is the basal area of the stand.

(iv) ***Importance Value Index (IVI)***:

The sum of the RD and RDo divided by 2 (RD + RDo)/2 gives the importance value index for each species (Brashears *et al*. 2004; Yang *et al*. 2008). This was used to express the share of each species in the tree community (Rajkumar and Parthasarathy, 2008).

(v) ***Family Importance Value (FIV)***:

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

Based on the forest structural analysis of Proctor *et al.* (1983) and Newbery (1991), the size class distributions of individual trees were classified under four distinct dbh categories, namely, smaller (10 – 20cm); medium (21 - 50 cm); large (51- 100cm) and largest (> 100 cm). The stems were further classified into 11 diameter classes to show the graphical pattern of tree population distribution. And tree height classification was based on Hopkins (1974) height vertical classification for forest structure strata. Hopkins (1974) method was adopted in grouping tree heights into height frequency classes. This was used to assess the structure of the ecosystem. The height classes and their strata are as follow: 1.5 – 9 m shrub stratum, 9-15 m lower stratum, 15-36 m middle stratum, 36-45 m upper stratum and trees with height greater than 45 m are in the topmost storey called emergent.

RESULTS

Summary of tree growth attributes

A total of 541 individual trees were encountered within the 24 sample plots from the three BC areas of Ehor Forest Reserve. 30 tree species distributed into 18 families and 29 genera were encountered in BC area 12/1, 49 tree species distributed into 24 families and 43 genera were encountered in BC area 15/1 while a total of 44 species distributed into 25 families and 37 genera were encountered in BC area 16/1. The results indicated that the average number of trees per hectare in areas BC 12/1, 15/1 and 16/1 were 206, 809 and 675, respectively (Table 1).

Table 1: Summary of tree growth attributes of the study area

Number of tree/ha	BC 12.1			BC 15.1			BC 16.1		
	206			809			675		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Dbh (cm)	6.68	10.27	18.14	4.5	18.17	76.38	5.73	21.48	47.74
Ht (m)	3.9	8.4	15.3	2.4	12.61	25.2	2.7	14.7	25.5
Basal area/ha (m2)	0.36	1.82	2.61	16.91	26.66	36.72	18.16	28.24	49.2

Dbh-Diameter at breast height; Ht-Height

Source: Field Work, 2015

Table 2: Tree species abundance, basal area, relative density, relative dominance and Importance Value Index of area BC 12/1 in Ehor Forest Reserve

Tree species	Family	No Stem/ha	BA/ha	RD%	RDo%	IVI
Albizia ferruginea	Mimosoidae	6	0.041	3.03	2.25	2.64
Anthonotha macrophylla	Caesalpinioideae	3	0.019	1.52	1.07	1.29
Berlinia coriaceae	Caesalpiniodeae	6	0.054	3.03	2.95	2.99
Blighia sapinda	Sapindeae	3	0.014	1.52	0.79	1.15
Brachystegia eurycoma	Caesalpiniodeae	10	0.061	4.55	3.36	3.95
Brachystegia kennedyi	Caesalpiniodeae	13	0.152	6.06	8.35	7.2
Bridelia micrantha	Euphorbiaceae	9	0.046	4.55	2.51	3.53
Canarium schweinfurthii	Burseraceae	3	0.029	1.52	1.58	1.55
Ceiba pentandra	Bombacaceae	19	0.294	9.09	16.14	12.62
Celtis zenkeri	Ulmaceae	13	0.081	6.06	4.45	5.26
Cleistopholis patens	Annonaceae	13	0.117	6.06	6.4	6.23
Combredendron marcrocarpum	Lecythidaceae	3	0.046	1.52	2.52	2.02
Drypetes chevalieri	Euphorbiaceae	10	0.056	4.55	3.05	3.8
Funtumia elastic	Apocynaceae	3	0.012	1.52	0.66	1.09
Hypodaphnis zenkeri	Lauraceae	9	0.095	4.55	5.23	4.89
Irvingia grandifololia	Irvingaceae	3	0.048	1.52	2.64	2.08
Lophira alata	Ochnaceae	3	0.05	1.52	2.76	2.14
Mansonia altissima	Sterculiaceae	19	0.114	9.09	6.24	7.67
Marcaranga barteri	Euphorbiaceae	6	0.038	3.03	2.09	2.56
Monodora brevipes	Annonaceae	6	0.051	3.03	2.8	2.92
Pausinystalia johimbe	Rubiaceae	3	0.042	1.52	2.29	1.9
Pentaclethra marcrophylla	Mimosoides	3	0.019	1.52	1.07	1.29
Petersianthus macrocarpus	Lecythidaceae	3	0.046	1.52	2.52	2.02
Ricinodendron heudelotii	Rubiaceae	3	0.014	1.52	0.79	1.15
Scottellia coriaceae	Flacourtiaceae	3	0.019	1.52	1.07	1.29
Staudtia stipitata	Myristicaceae	9	0.09	4.55	4.95	4.75
Sterculia tragacantha	Sterculiaceae	3	0.012	1.515	0.66	1.09
Trema guineensis	Ulmaceae	13	0.105	6.061	5.77	5.92
Trichilia welwitschii	Meliaceae	3	0.029	1.515	1.58	1.55
Trilepisium madagascariense	Moraceae	3	0.027	1.515	1.48	1.5

BA – Basal area; RD – Species relative density; RD_0 –Species relative dominance; IVI –Importance Value Index

Source: Field Work, 2015

The mean dbh were 10.27 cm, 18.17 cm and 21.48 cm for BC areas 12/1, 15/1 and 16/1, respectively, while the mean total height of trees in the respective BC areas were 8.40 m, 12.61 m and 14.70 m. The mean basal area per hectare were 1.82 m^2ha^{-1} for BC 12/1 area, 26.66 $m^2ha^{-1}$for BC 15/1 area and 28.24 m^2ha^{-1} for BC 16/1 area (Table 1).

Forest structure and Floristic composition

Importance Value Index of Study Sites

Importance Value Index (IVI) shows share of species importance in forest community. In area BC 12/1, both *Ceiba pentandra* (Bombacaceae) and *Mansonia altissima* (Sterculiaceae) had the common highest species occurrence of 19 stems/ha and relative density of 9.09% (Table 2). This was closely followed by *Brachystegia kennedyi* (Caesalpiniodeae), *Celtis zenkeri* (Ulmaceae), *Cleistopholis patens* (Annonaceae) and *Trema guineensis* (Ulmaceae) with all having 13 stems/ha and relative density of 6.06%. *Ceiba pentandra* (Bombacaceae) had the highest basal area/ha (0.294 m^2) while the least basal area/ha (0.012 m^2) was recorded for *Funtumia elastica* and *Sterculia tragacantha*. However, *Ceiba pentandra* had the highest species IVI of 12.62 %. This was closely followed by *Mansonia altissima* with IVI of 7.67 % (Table 2). In area BC 15/1, the tree species with the highest occurrence of 75 stems/ha and relative density of 9.27% is *Berlina coriacea* (Caesalpinoideae) (Table 3). This was closely followed by *Celtis zenkeri* (Ulmaceae) with 63 stems/ha and relative density of 7.72%. The third most abundant species is *Brachystegia kennedyi* (Caesalpinoideae) with 50 stems/ha and a relative density of 6.18%. The highest basal area per hectare (2.53 m^2) was contributed by *Brachystegia kennedyi*. This was followed by *Celtis zenkeri* with basal area 1.84 m^2 while the least basal area/ha (0.030 m^2) was recorded for *Daniellia oliveri* (Caesalpinoideae) and *Diospyros crassiflora* (Ebenaceae).

Table 3: Tree species abundance, basal area, relative density, relative dominance and Importance Value Index of area BC 15/1 in Ehor Forest Reserve

Tree species	Family	No Stem/ha	BA/ha	RD%	RDo%	IVI
Albizia ferruginea	Mimosoideae	9	0.35	1.16	1.31	1.23
Albizia lebbeck	Mimosoideae	19	0.58	2.32	2.17	2.25
Albizia zygia	Mimosoideae	6	0.35	0.77	1.32	1.05
Anthonotha macrophylla	Caesalpiniodeae	31	0.4	3.86	1.5	2.68
Baphia nitida	Papilionoideae	19	0.17	2.32	0.62	1.47
Berlinia coriacea	Caesalpinoideae	75	1.41	9.27	5.29	7.28
Berlinia grandiflora	Caesalpinoideae	3	0.05	0.39	0.2	0.29
Blighia sapida	Sapindaceae	38	0.65	4.63	2.45	3.54
Brachystegia kennedyi	Caesalpinoides	50	2.53	6.18	9.48	7.83
Canarium schweinfurthii	Burseraceae	19	0.26	2.32	0.96	1.64
Carappae procera	Meliaceae	6	0.1	0.77	0.38	0.58
Ceiba pentandra	Bombacaceae	10	0.55	1.16	2.06	1.61
Celtis zenkeri	Ulmaceae	63	1.84	7.72	6.91	7.32
Cleistopholis patens	Annonaceae	16	0.77	1.93	2.88	2.4
Cola hispida	Sterculiaceae	9	0.31	1.16	1.16	1.16
Daniellia oliveri	Caesalpinoideae	3	0.03	0.39	0.13	0.26
Diospyros crassiflora	Ebenaceae	3	0.03	0.39	0.11	0.25
Diospyros dendo	Ebenaceae	31	0.79	3.86	2.97	3.41
Diospyrositurensis	Ebenaceae	28	1.15	3.48	4.33	3.9
Drypetes chevalieri	Euphorbiaceae	47	1.61	5.79	6.03	5.91
Fagara zanthoxyloides	Rubiaceae	6	0.23	0.77	0.85	0.81
Funtumia elastic	Apocynaceae	6	0.14	0.77	0.54	0.66
Guarea cedrata	Meliaceae	16	0.87	1.93	3.27	2.6
Hannoa klaineana	Simaroubaceae	10	0.57	1.16	2.13	1.64
Hylodendron gabunense	Caesalpinoideae	6	0.32	0.77	1.22	1
Irvingia grandifolia	Irvingaceae	16	0.31	1.93	1.17	1.55
Lannea welwitschii	Anarcadaceae	3	0.19	0.39	0.72	0.55
Lecaniodiscus cupanioides	Sapindaceae	34	1.75	4.25	6.56	5.4
Lovoa trichiloides	Meliaceae	3	0.49	0.39	1.83	1.11
Maesopsis eminii	Rhamnaceae	9	0.49	1.16	1.85	1.51
Marcaranga barteri	Euphorbiaceae	9	0.09	1.16	0.33	0.74
Musanga cecropioides	Aquifoliaceae	19	1.02	2.32	3.83	3.07
Nesogordonia papaverifera	Sterculiaceae	13	0.26	1.54	0.98	1.26
Pausinystalia johimbe	Rubiaceae	25	0.69	3.09	2.6	2.85
Pentaclethra macrophylla	Papilionoideae	6	0.24	0.77	0.89	0.83
Petersianthus macrocarpus	Lecythidaceae	6	0.19	0.77	0.73	0.75
Porterandia cladanthera	Rubiaceae	6	0.12	0.77	0.46	0.62
Pterocarpus osun	Papilionoideae	3	0.06	0.39	0.24	0.31
Pycnanthus angolensis	Lauraceae	6	0.18	0.77	0.69	0.73
Ricinodendron heudelotii	Rubiaceae	16	1.52	1.93	5.7	3.82
Scottellia coriacea	Flacourtiaceae	9	0.62	1.16	2.32	1.74
Sterculia oblonga	Sterculiaceae	9	0.5	1.16	1.89	1.52
Sterculia tragacantha	Sterculiaceae	19	0.57	2.32	2.14	2.23
Strombosia pustulata	Olacaceae	3	0.08	0.39	0.31	0.35
Tetrorchidium didymostemon	Euphorbiaceae	9	0.11	1.16	0.43	0.79
Treculia africana	Moraceae	6	0.23	0.77	0.85	0.81
Trichilia welwitschii	Miliaceae	22	0.32	2.7	1.12	1.95
Trilepisium madagascariense	Moraceae	16	0.31	1.93	1.15	1.54
Xylopia aethiopica	Annonaceae	13	0.23	1.54	0.86	1.2

BA – Basal area; RD – Species relative density; RD_0 – Species relative dominance; IVI – Importance Value Index

Source: Field Work, 2015

Table 4: Tree species abundance, basal area, relative density, relative dominance and Importance Value Index of area BC 16/1 in Ehor Forest Reserve

Tree species	Family	No Stem/ha	BA/ha	RD%	RDo%	IVI
Albizia ferruginea	Mimosoideae	13	0.6	1.85	2.14	1.2
Albizia lebbeck	Mimosoideae	9	0.27	1.39	0.97	1.18
Anthonatha macrophylla	Caesalpiniodeae	6	0.22	0.93	0.78	0.85
Antiaris toxicaria	Moraceae	6	0.17	0.93	0.59	0.76
Berlinia coriacea	Caesalpiniodeae	9	0.26	1.39	0.93	1.16
Berlinia grandifolia	Caesalpinoideae	9	0.26	1.39	0.93	1.16
Blighia sapida	Sapindeae	47	1.84	6.94	6.51	6.73
Brachystegia eurycoma	Caesalpinoideae	3	0.49	0.46	1.73	1.09
Brachystegia kennedyi	Caesalpinoideae	41	1.63	6.02	5.77	5.89
Canarium schweinfurthii	Burseraceae	19	0.59	2.78	2.1	2.44
Carappae procera	Meliaceae	3	0.07	0.46	0.23	0.35
Ceiba petandra	Bombacaceae	19	1.51	2.78	5.34	4.06
Celtis zenkeri	Ulmacaceae	63	1.3	9.26	4.62	6.94
Cleistopholis patens	Annonaceae	9	0.97	1.39	3.43	2.41
Daniella oliveri	Caesalpinoideae	6	0.32	0.93	1.14	1.03
Diospyros iturensis	Ebenaceae	6	0.3	0.93	1.05	0.99
Drypetes chevalieri	Euphorbiaceae	9	0.26	1.39	0.91	1.15
Fagara zanthoxyloides	Rubiaceae	9	0.35	1.39	1.24	1.31
Funtumia elastica	Apocynaceae	6	0.23	0.93	0.8	0.86
Guarea cedrata	Meliaceae	41	1.83	6.02	6.47	6.24
Guarea thompsonii	Meliaceae	3	0.15	0.46	0.52	0.49
Hannoa klaineana	Simaroubaceae	6	0.14	0.93	0.5	0.71
Hylodendron gabunense	Caesalpiniodeae	31	1.15	4.63	4.07	4.35
Irvingia grandifolia	Irvingaceae	3	0.12	0.46	0.43	0.45
Lannea nigritana	Anarcardiaceae	13	0.26	1.85	0.92	1.39
Lannea welwitschii	Anarcardiaceae	3	0.14	0.46	0.48	0.47
Lecaniodiscus cupanioides	Sapindaceae	38	1.23	5.56	4.36	4.96
Lophira alata	Dipterocarpaceae	3	0.09	0.46	0.33	0.4
Lovoa trichilioides	Meliaceae	16	1.16	2.32	4.11	3.21
Marcaranga barteri	Euphorbiaceae	6	0.02	0.93	0.08	0.5
Monodora myristica	Annonaceae	3	0.02	0.46	0.06	0.26
Musanga cecropioides	Aquifoliaceae	22	1.04	3.24	3.67	3.45
Pausinystalia johimbe	Rubiaceae	13	0.71	1.85	2.51	2.18
Petersianthus macrocarpus	Lecythidiaceae	13	1.11	1.85	3.93	2.89
Piptadeniastrum africanum	Mimosoideae	6	0.32	0.93	1.15	1.04
Pterocarpus osun	Papilioniodeae	3	0.05	0.46	0.18	0.32
Pycnanthus angolensis	Lauraceae	19	0.74	2.78	2.6	2.69
Ricinodendron heudelotii	Rubiaceae	16	1.36	2.32	4.81	3.57
Scottellia coriaceae	Flacourtiaceae	16	1.28	2.32	4.52	3.42
Sterculia oblonga	Sterculiaceae	9	0.25	1.39	0.9	1.14
Sterculia tragacantha	Sterculiaceae	19	0.86	2.78	3.04	2.9
Strombosia grandifolia	Olacaceae	6	0.09	0.93	0.32	0.62
Strombosia pustulata	Olacaceae	3	0.24	0.46	0.85	0.65
Tetrorchidium didymostemon	Euphorbiaceae	3	0.12	0.46	0.41	0.44
Trichilia welwitschii	Meliaceae	69	2.15	10.19	7.62	8.9

BA – Basal area; RD – Species relative density; RD_0 – Species relative dominance; IVI – Importance Value Index

Source: Field Work, 2015

However, *Brachystegia kennedyi* had the highest species IVI of 7.83 %, which was closely followed by *Berlina coriacea* with IVI of 7.28 % (Table 3). Table 4 shows tree species abundance, density, relative dominance and IVI of BC 16/1 area of Ehor Forest Reserve. The tree species with the highest occurrence (69 stems/ha) and relative density of 10.19% was *Trichilia welwitschii* (Meliaceae) (Table 4). This was closely followed by *Celtis zenkeri* (Ulmaceae)

with 63 stems/ha and relative density of 9.26%. The third most abundant species was *Blighia sapida* (Sapindeae) with 47 stems/ha and a relative density of 6.94%. *Trichilia welwitschii* had the highest basal area/ha of 2.15 m^2 followed by *Blighia sapida* (1.84 m^2) while the least basal area/ha of (0.02 m^2 was recorded for *Marcaranga barteri*. However, *Trichilia welwitschii* had the highest species IVI of 8.904 %, which was closely followed by *Celtis zenkeri* with IVI of 6.937 % (Table 4).

Table 5: Families abundance, basal area, relative density, relative dominance and Family Importance Index of BC 12/1, 15/1 and 16/1 in Ehor Forest Reserve

Sites	Family/Sub Family	Abundance/ha	BA/ha	RD%	RDo%	FIV
BC 12/1						
	Annonaceae	22	0.181	10.61	9.92	10.26
	Apocynaceae	3	0.012	1.52	0.66	1.09
	Bombacaceae	19	0.294	9.09	16.13	12.61
	Burseraceae	6	0.077	3.03	4.21	3.62
	Caesalpinioideae	31	0.287	15.15	15.71	15.43
	Euphorbiaceae	25	0.14	12.12	7.65	9.89
	Flacourtiaceae	3	0.019	1.52	1.07	1.29
	Lauraceae	10	0.095	4.55	5.22	4.88
	Lecythidaceae	6	0.092	3.03	5.04	4.03
	Meliacea	3	0.029	1.52	1.58	1.55
	Mimosoideae	10	0.06	4.55	3.31	3.93
	Moraceae	3	0.027	1.52	1.48	1.49
	Myristicaceae	9	0.09	4.55	4.94	4.74
	Ochnaceae	3	0.05	1.52	2.76	2.14
	Rubiaceae	6	0.056	3.03	3.08	3.05
	Sapindaceae	3	0.014	1.52	0.79	1.15
	Sterculiaceae	19	0.113	9.09	6.17	7.63
	Ulmaceae	25	0.188	12.12	10.28	11.2
BC 15/1						
	Anacardiaceae	3	0.193	0.39	0.72	0.55
	Annonaceae	28	0.995	3.48	3.73	3.6
	Apocynaceae	6	0.145	0.78	0.54	0.66
	Aquifoliaceae	19	1.021	2.32	3.83	3.07
	Bombacaceae	10	0.548	1.16	2.05	1.61
	Burseraceae	34	0.569	4.25	2.13	3.19
	Caesalpinioideae	178	5.163	22.01	19.37	20.69
	Ebenaceae	59	1.943	7.34	7.29	7.31
	Euphorbiacea	66	1.806	8.11	6.78	7.44
	Flacourtiaceae	10	0.619	1.16	2.32	1.74
	Lauraceae	6	0.183	0.77	0.69	0.73
	Lecythidaceae	6	0.195	0.77	0.73	0.75
	Meliaceae	47	1.779	5.79	6.67	6.23
	Mimosoideae	34	1.281	4.25	4.8	4.53
	Moraceae	22	0.533	2.7	2	2.35
	Olacaceae	3	0.084	0.39	0.31	0.35
	Papilionoidae	28	0.468	3.48	1.75	2.61
	Rhamnaceae	9	0.494	1.16	1.85	1.51
	Rubiaceae	50	2.446	6.18	9.18	7.68
	Rutaceae	3	0.115	0.39	0.43	0.41
	Sapindaceae	72	2.399	8.88	9	8.94
	Simaroubaceae	3	0.197	0.39	0.74	0.56
	Sterculiaceae	50	1.642	6.18	6.16	6.17
	Ulmaceae	63	1.842	7.72	6.91	7.32
BC 16/1						
	Anacardiaceae	13	0.396	1.85	1.39	1.62

Annonaceae	13	0.988	1.85	3.48	2.67
Apocynaceae	6	0.225	0.93	0.79	0.86
Aquifoliaceae	22	1.035	3.24	3.65	3.44
Bombacaceae	19	1.509	2.78	5.31	4.05
Burseraceae	19	0.594	2.78	2.09	2.44
Ceasalpiniodeae	109	4.332	16.2	15.25	15.73
Dipterocarpaceae	3	0.093	0.46	0.33	0.39
Ebenaceae	6	0.296	0.93	1.04	0.98
Euphorbiacea	19	0.392	2.78	1.38	2.08
Flacourtiaceae	16	1.277	2.32	4.49	3.41
Irvingiaceae	3	0.122	0.46	0.43	0.45
Lauraceae	19	0.891	2.78	3.14	2.96
Lecythidaceae	13	1.109	1.85	3.9	2.88
Meliaceae	131	5.352	19.44	18.84	19.14
Mimosoideae	28	1.201	4.17	4.23	4.19
Moraceae	6	0.168	0.93	0.59	0.76
Olacaceae	9	0.329	1.39	1.16	1.27
Papilionoideae	3	0.05	0.46	0.18	0.32
Rubiaceae	34	2.258	5.09	7.95	6.52
Rutaceae	3	0.159	0.46	0.56	0.51
Sapindaceae	84	3.07	12.5	10.81	11.65
Simaroubaceae	6	0.14	0.92	0.49	0.71
Sterculiaceae	28	1.111	4.17	3.91	4.04
Ulmaceae	63	1.303	9.26	4.59	6.92

Source: Field Work, 2015

Family Importance Index Value (FIV) of Study Sites

Table 5 shows the results of family diversity indices (abundance/ha, BA/ha, RD%, RDo% and FIV) of the three BC areas of Ehor Forest Reserve. In BC 12/1, the familes with highest number of species per hectare (31 stems/ha) is Caesalpiniodeae while the highest basal area per hectare (0.294 m^2/ha) was recorded by Bombacaceae family. Caesalpiniodeae was the most important family in BC 12/1 area with FIV of 15.43%. Meliaceae, Sapindacea, Apocynaceae, Flacourtiaceae, Moraceae and Ochnaceae had the lowest number of species /ha of 3 stems/ha while the lowest FIV of 1.15% was recorded by the Sapindacea family (Table 5). In BC 15/1, Caesalpiniodeae had the highest number of species and basal area of 176 sttems /ha and 5.16m^2/ha respectively, followed by 72 number of species/ha recorded for Sapindaceae and basal area of 2.45 m^2/ha recorded for Rubiaceae. The families of Anarcardiaceae, Olacaceae, Rutaceae and Simaroubaceae were the least abundant with of 3 number of species/ha each (Table 5). In area BC 16/1, the family Meliaceae had the highest number of species with 131 stems/ha and also the highest basal area of 5.35 m^2/ha, which was followed by Caesalpiniodeae with number of species and basal area of 109 stems/ha and 4.33 m^2/ha respectively. The families Irvingaceae, Papilionoidaea, Rutaceae and Dipterocarpaceae had the lowest number of speciesvalue of 3 stems/ha each (Table 5).

Diameter distribution Pattern

Tables 6, 7 and 8 showed the diameter distribution patterns of trees and number of species/families per Dbh classof BC areas 12/1, 15/1 and 16/1 respectively in Ehor Forest Reserve while figures 2, 3 and 4 depict the graphical pattern of the diameter distribution.

Table 6: Diameter at breast height distribution of trees in BC 12/1 in Ehor Forest Reserve

Dbh(cm)	Abundance/ha	No of Species	No of family
5-10.99	150	25	16
11-20.99	56	14	11
21-30.99	0	0	0
31-40.99	0	0	0
41-50.99	0	0	0
51-60.99	0	0	0
61-70.99	0	0	0
71-80.99	0	0	0
81-90.99	0	0	0
91-100	0	0	0
>100	0	0	0

Table 6 indicates that in BC 12/1 trees within the Dbh class of 5-10.99 cm had the highest frequency of 150 stems/ha, which was followed by trees within the Dbh class of 11-20.99 cm with 18 stems/ha. In 15/1, trees within Dbh class of 11-20.99 cm had the highest frequency of 316 stems/ha, followed by trees within the

Table 7: Diameter at breast height distribution of trees in BC 15/1 in Ehor Forest Reserve

Dbh (cm)	Abundance/ha	No of Species	No of family
5-10.99	234	27	15
11-20.99	316	38	19
21-30.99	212	31	20
31-40.99	44	12	10
41-50.99	0	0	0
51-60.99	0	0	0
61-70.99	0	0	0
71-80.99	3	1	1
81-90.99	0	0	0
91-100	0	0	0
>100	0	0	0

Table 8: Diameter at breast height distribution of trees in BC 16/1 in Ehor Forest Reserve

Dbh (cm)	Abundance/ha	No of Species	No of family
5-10.99	75	11	10
11-20.99	253	24	17
21-30.99	269	31	17
31-40.99	56	11	10
41-50.99	22	7	6
51-60.99	0	0	0
61-70.99	0	0	0
71-80.99	0	0	0
81-90.99	0	0	0
91-100	0	0	0
>100	0	0	0

Dbh class of 5-10.99 cm which had 234 stems/ha (Table 7). With 269 stems/ha, the Dbh class of 21-30.99 cm had the highest frequency of trees in BC 16/1, which was followed by trees within Dbh class of 11-20.99 with 253 stems/ha (Table 8).

Height Vertical Stratification

Tables 9, 10 and 11 showed tree height class distribution in BC areas 12/1, 15/1 and 16/1 respectively.

Table 9: Tree height distribution in BC 12/1 in Ehor Forest Reserve

Height(m)	Abundance/ha	No of Species	No of family
0-1.2	0	0	0
1.5-9	134	24	15
15-Sep	69	16	12
15-36	3	1	1
36-45	0	0	0
>45	0	0	0

Table 10: Tree height distribution in BC 15/1 in Ehor Forest Reserve

Height(m)	Abundance/ha	No of Species	No of family
0-1.2	0	0	0
1.5-9	247	24	15
15-Sep	178	28	18
15-36	306	40	21
36-45	22	6	6
>45	56	12	10

Table 9 indicates that in BC area 12/1, trees in shrub layer had the highest frequency of occurrence with 134 stems/ha, followed by trees in lower stratum which had 69 stems/ha and by trees in middle stratum with 3 stems/ha. BC 15/1 area had more trees in the middle stratum (306 stems/ha) followed by trees in the shrub layer which had 247 stems/ha (Table 10). Table 11 shows that in BC 16/1, trees in the middle stratum had the highest frequency of stems/ha (341 stems/ha), followed by tree species in the lower stratum which had 184 stems/ha. Trees in shrub layer had 150 stems/ha. The height distribution status of BC areas 12/1, 15/1 and 16/1 is depicted graphically in Figures 5, 6 and 7 respectively.

Table 11: Tree height distribution in BC 16/1 in Ehor Forest Reserve

Height(m)	Abundance/ha	No of Species	No of family
0-1.2	0	0	0
1.5-9	150	18	15
15-Sep	184	25	14
15-36	341	35	20
36-45	0	0	0
>45	0	0	0

DISCUSSION

Forest structure and floristic composition

Studies on forest structure and floristic compositions are instrumental in the sustainability of forests since they play a major role in the conservation of plant species, and the management of forest ecosystems (Tilman, 1988, Ssegawa and Nkuutu, 2006). The result of this study revealed that Ehor forest is a repository of many indigenous tropical hardwood tree species in different families. A total of 541 individual trees of different diameter classes were measured in the BC areas 12/1, 15/1 and 16/1 of the forest reserve. The forests reserve had an average frequency of 206, 809 and 675 trees per hectare in BC areas 12/1, 15/1 and 16/1, respectively (Table 1). The number of trees per hectare is higher in BC areas 15/1 and 16/1 than BC area 12/1. This is an indication of of better tree stocking in both

BC areas 15/1 and 16/1 than BC area 12/1. The lower frequency of trees in BC 12/1 area could be attributed to higher anthropogenic activity in this area as evidenced by farming activities in it. When compared to some rainforests around the world, the sites investigated could be considered to be fully stocked, except BC area 12/1 that has 206 stems per hectare. Number of tree species ha^{-1} could be as high as 400 in very rich rainforests (Nwoboshi, 1982).

Although the density of trees per hectare was lower in area BC 12/1, the number of trees per hectare obtained is higher than the 152 and 171 trees per hectare reported for tropical Barro Island in Panama by Hubbell and Foster (1983) and Thorington *et al.* (1982), respectively as well as the 104 trees per hectare for tropical Jengka Reserve, Malaysia (Ho *et al.* 1987) but lower than the 323 and 306 trees per hectare reported for Afi River and Oban Forest Reserves in Nigeria (Aigbe *et al.,* 2014; Aigbe and Omokhua, 2015). The tree densities of BC areas 15/1 and 16/1 compares favourably with the 508 – 671 trees per hectare reported for three natural tropical forests ecosystems in southwestern, Nigeria (Onyekwelu *et al*., 2008) as well as the 620 - 709 trees per hectare reported by Singh *et al*. (1984) for evergreen Silent Valley, Kerala, India. Other densities reported for various tropical ecosystems include: 1420 trees per hectare for Amazonia tropical rainforest (Campbell *et al.,* 1986); 391 to 617 trees per hectare for tropical rainforest in Costa Rica (Heaney and Proctor, 1990); 1533 and 1183 trees per hectare for slope and alluvium forests, respectively in Caledonia (Jaffre and Veillon, 1990). It has been reported that tree density can be affected by natural calamities, anthropogenic activities and soil properties (Adenkule *et al*., 2013b).

The mean basal area for both BC areas 15/1 (26.66 m^2) and 16/1 (28.24 m^2) was higher than the value of BC area 12/1 (1.82 m^2). This could be attributed to the higher number of trees/ha in BC areas 15/1 and 16/1. Alder and Abayomi (1994), stated that a well-stocked tropical rainforest in Nigeria has average basal area of 15 m^2, which implies that BC areas 15/1 and 16/1 are well stocked The basal area values obtained for BC areas 15/1 and 16/1 were higher than 11 m^2/ha reported by Visalakshi (1995) for tropical dry evergreen forests in southern India and 17 m^2/ha for Equatorial Insular forest in eastern Caroline, Island, Panama (Itow, 1986).

The first four dominant families in BC area 12/1 are Caesalpinioideae, Ulmaceae, Euphorbiaceae and Annonaceae; In BC 15/1 Caesalpinioideae, Sapindaceae, Euphorbiaceae and Ulmaceae dominated while in BC area 16/1, Meliaceae, Caesalpinioideae, Sapindaceae, and Ulmaceae were the dominant families. Dominant families in the study area were slightly different from those reported for tropical rainforest ecosystems in southwestern Nigeria (Adekunle, 2006; Onyekwelu *et al.,* 2008, Aigbe *et al*., 2014; Aigbe and Omokhua, 2015). For example, Onyekwelu *et al*. (2008) noted that members of the Euphorbiaceae, Sterculiaceae, Meliaceae, Mimosoideae and Apocynaceae families are dominant in three rainforest ecosystems in southwestern Nigeria, which are different from the dominating families in BC areas 12/1, 15/1 and 16/1. Adekunle *et al.* (2013b) also reported that Caesalpinioideae, Sterculiaceae, Meliaceae and Moraceae families are dominant in Strict Nature Reserve, within Akure Forest Reserve in Ondo State, Southwest, Nigeria. The dorminant families also have the highest FIV accordingly. This finding agrees with the opinion of Adekunle *et al*. (2013a) that the dominant family in have the highest FIV.

The IVI is a good indication of tree species that are important in the floristic composition of a forest. Dominant species in the three BC areas were different from those reported for some tropical rainforest ecosystems in Nigeria. For example, Adekunle *et al.* (2013b), reported *Mansonia altissima* and *Triplochiton scleroxylon* as the dominant species in Akure Forest Reserve while Aigbe *et al.* (2014), reported *Pycnathus angolensis and Staudtia stipitata* as the dominant species in Afi River Forest Reserve. Some few species have three trees per hectare, indicating that these species might be under threat of extinction due probably to anthropogenic factor. FORMECU (1999) reported that tropical tree species with frequency of less than 10 individuals per hectare is endangered. Ihenyen *et al.* (2010) and Alamu and Agbeja (2011) also reported that one tree species per hectare is endangered.

The patterns of Dbh distribution in BC areas 12/1, 15/1 and 16/1, as shown in Figures 2, 3 and 4 respectively, indicate positive skewness. This distribution revealed that there are more trees in lower dbh class that are sufficient enough to replace trees in the upper dbh class in the future (i.e. when the big trees are harvested or when they die). This is consistent with the views of some researchers (Boubli *et al.,* 2004; Bobo *et al.,* 2006). Aigbe and Omokhua (2015) also reported positive skewness in dbh distribution pattern of trees in for Oban Forest Reserve in Nigeria. The implication of this is that the forests are still undergoing regeneration and recruitment.

The height distribution of tree in the three BC areas (Figures 5, 6 and 7) indicates that only BC area 15/1 have three strata and the emergent layer. BC areas 12/1 and 16/1 have two strata. BC area 12/1 has more trees in the shrub layer and lower stratum. BC areas 15/1 and 16/1 had more trees occupying the middle stratum (height class of 15 - 36 m). The findings here are corroborated by the work of Adekunle *et al.* (2013b) that horizontal and vertical structures of the forest (e.g. diameter and height distributions) show a forest whose population structure is expanding, ensuring its stability. Mature forests, composed

of mature trees in various layers are ecosystems with a recognized ability to maintain both structure and floristic diversity that is stable over time through the dynamic balance of mortality, recruitment and growth of plants (Stephenson and Van Mantgem, 2005; Saiter *et al*., 2011).

CONCLUSION

The findings in this research revealed that Ehor Forest Reserve is a repository of many indigenous tropical tree species. Apart from area BC 12/1, which exhibited noticeable pocket of farming activities that makes it relatively degraded, other BC areas investigated are well stocked going by the tree densities and mean basal area per hectare. The positive skewness of the diameter distribution pattern for the three BC areas indicated that the forest is vigour if it is well managed. The tree species prominent in area BC 12/1 are *Ceiba pentandra* and *Mansonia altissima* while in area BC 15/1 had *Berlinia coriacea, Celtis zenkeri* and *Brachystegia kennedyi*. The commonest tree species in area BC 16/1 are *Trichilia welwitschii, Celtis zenkeri* and *Blighia sapida*. The prominent families common to the three BC area are Caesalpinioideae and Ulmaceae. The result of the forest structure shows that only BC 15/1 contained three strata and emergent layer. BC areas 12/1 and 16/1 have two strata (lower and middle strata). BC area 12/1 has more trees in the shrub layer and lower stratum. BC area 15/1 and 16/1 have more trees occupying the middle stratum (height class of 15 - 36 m) with the highest number of species and families. In order to conserve the rich indigenous tropical tree species of this forest reserve, continuous forest inventory is required and restocking is necessary in BC area 12/1 to prevent extinction of some indigenous species.

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