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FLORISTIC COMPOSITION, STRUCTURE AND DIVERSITY DISTRIBUTION IN OMO BIOSPHERE RESERVE, OGUN STATE, NIGERIA

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ABSTRACT

Tree species composition and diversity were assessed in Omo Biosphere Reserve, Ogun State, Nigeria. Systematic sampling design was used to lay two straight line transects, each of 1000 m long and separated by 500 m, in the reserve. Four Temporary Sample Plots (TSP) of size 50×50 m were laid along each transect at 250 m interval. Eight plots were enumerated for identification and frequency of occurrence (FO) of all woody plants with diameter at breast height (DBH) ≥ 10 cm. Identified tree species were categorised into different diameter classes. Data collected on DBH were used to compute Stem Volume (SV), Basal Area (BA) and Number of Trees per hectare (NT). Shannon Weiner and Simpson's indices were used to assess species diversity. Identified flora species in the reserve were from 30 families, 59 genera and 66 species. Family Ebenaceae had highest FO of 90±16.25/ha in the study area. The DBH of 146±0.72 cm; SV of 0.47±0.86 m^3/ha; BA, 86.45±0.34 m^2/ha; and NT, 405±1.95 were recorded. Shannon Weiner and Simpson's indices obtained were 4.01 and 0.09 respectively indicating a moderately diverse area. This study provides a baseline for the management of the forest reserve in southwestern Nigeria.

Keywords: Omo Biosphere Reserve, Species diversity, Species conservation, Tree density, Floristic composition.

INTRODUCTION

The tropical rainforest has been identified as the most biologically diverse terrestrial ecosystem on earth (Turner, 2001; Gillespie *et al*., 2004; Onyekwelu *et al.,* 2007; Schmitt *et al*., 2009; FAO, 2010 and IUCN, 2010). In terms of tree composition and species diversity, tropical rainforests are Earth's most complex ecosystems (Gebreselasse, 2011). Trees are often the most conspicuous plant life form in a typical tropical rainforest. The rainforest acts as a main repository of the genetic diversity of both flora and fauna. Omo Biosphere Reserve harbors a major percentage of Nigeria's remaining tropical rainforest. According to USAID (2006), the entire landscape is recognized internationally as a biodiversity hotspot.

The rainforest which accounts for only 2% of Nigeria's forest area is located in the southern part of the country and it is composed of humid lowland forest, fresh water and swamp forest. Each of these ecological zones has its own peculiarities and supports a wide range of plants and animals species (Odeh, 2009). The tropical rainforest has been the richest in abundance and diversity of plants and animals species. The high species diversity of tropical rainforests is partly responsible for the intense pressure under which they have been and are still subjected to by the populace (Alao and Shuaibu, 2011). The degradation, fragmentation and conversion of the forests to other forms of land uses in Nigeria, are currently progressing at alarming rates. Between 1990 and 2000, Nigeria lost about 2.7% of its natural forests to deforestation which increased to about 18.56% (about 2.06 million ha) between 2000 and 2010 (FRA, 2010; FAO, 2011). A cumulative 47.5% of Nigeria's natural forests were lost to deforestation between 1990 and 2010 (FRA, 2010). Recent global forest resources assessment revealed that Nigeria is one of the five countries in the world with the highest annual rate of deforestation for the period 2000 –2010 (FRA, 2010). These changes have caused the loss of some plant species and a decline in the biodiversity conservation status of the forest and environmental quality. The sustainable management and use of these resources are essential for the nation's economic and environmental security (Akinsanmi, 1999). Therefore, there is need to provide adequate quantitative and qualitative ecological data to guide forest owners and managers in fashioning

out realistic and effective management strategies which are imperative. This study therefore provides baseline and impact data on species composition and diversity in Omo Biosphere Reserve.

MATERIALS AND METHODS

The Study area

The forest reserve selected for this study is Omo Biosphere Reserve in Ogun State (Figure 1). The rainfall and temperature ranged between 10.30 mm to 1,029.70 mm and 25 °C to 31 °C respectively. The temperature obtained is an indication of tropical ecosystem. The soil is a mixture of Ferrallic and Ferruginous soils. It has been classified as a dry/deciduous lowland forest (Onyekwelu, *et al.*, 2007).

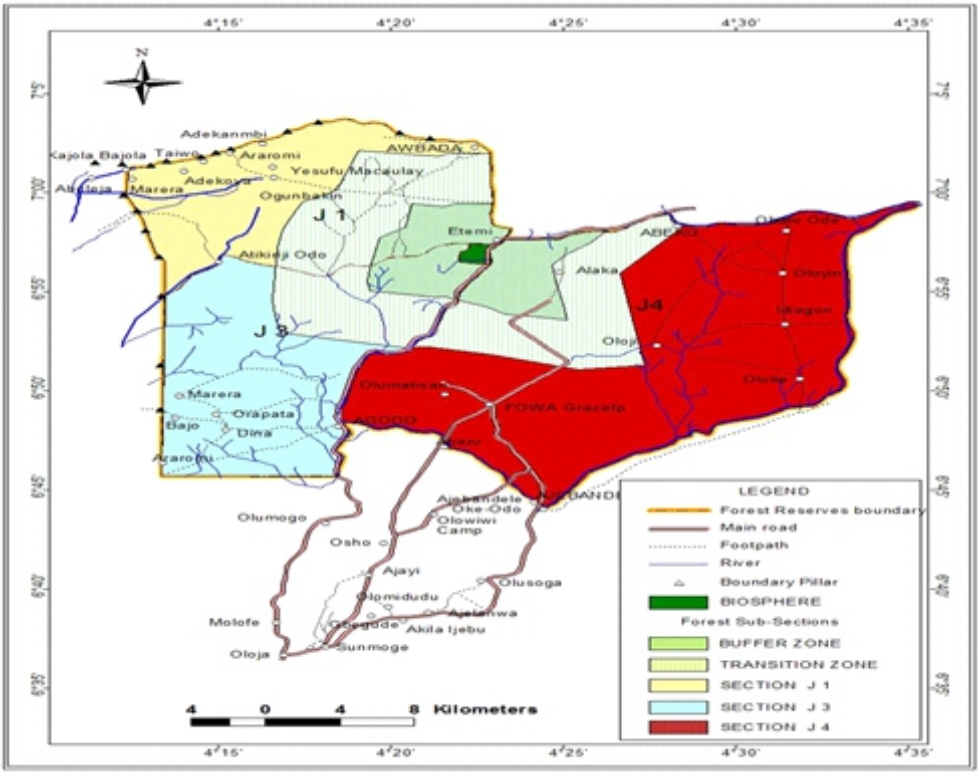

Figure 1: The Map of Omo Biosphere Reserve

Omo Biosphere Reserve is located within the Omo Forest Reserve, Area J4, in Ijebu East Local Government Area of Ogun State, Nigeria. It is located on latitude 6° 50' N and longitude 4° 22' E (Figure 1). It became a UNESCO Biosphere Reserve in 1949 (Were, 2001). IUCN (1991) identified eight Strict Nature Reserves (SNR) in Nigeria out of which only Omo was conferred with the status of a Biosphere Reserve under the UNESCO Man and Biosphere programme. It covers an area of 460 ha. Presently, MARK IV, an international NGO is undertaking an elephant programme in this reserve and this is assisting the reserve in maintaining its status. There are nine other forest reserves in Ogun State with total area of 275,362 ha.

Sampling and Plots Demarcation

Systematic sampling design (Systematic line transect) was employed for the laying of plots in the forest (Figure 2). One transects was laid at the well-stocked portion located at the center of the forest. Sample plots of equal size (50 × 50 m) were laid in alternate direction along transect at 250 m interval and thus summing up to eight (8) sample plots. Using this method ensured that the forest is relatively covered.

Species Identification and DBH Measurement

Measurement and identification of all woody plants with diameter at breast height of 10 cm and above was carried out. The tree growth variables were limited to diameter at breast height of all the standing trees in the forest.

The botanical name of every living tree encountered in each sample plot was recorded. Where a tree's botanical name is not known immediately, such a tree was identified by its commercial or local name. Such commercial or local names were translated to correct botanical names using Gbile and Soladoye (2002). Trees that could not be identified were tagged 'unknown'. Specimens of such unknown trees were collected preserved and taken to Forestry Herbarium, Ibadan (FHI) of the Forestry Research Institute of Nigeria for identification. Each tree species was recorded individually in the field forms and possible effort was made not to omit any eligible stem in a sample plot. Failure to record any species indicated the absence of such species in the ecosystem

Data Analysis

Community Structure Analysis

The following community assessment variables were determined to analyse the orchard structure:

Basal Area Calculation

The basal area of all trees in the sample plots was calculated using the formula:

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

Where BA = Basal area (m^2), D = Diameter at breast height (cm) and pie = 3.142. The total basal area for each of the sample plots were obtained by adding the BA of all trees in the plot while mean BA for the plot (*BAp*) was obtained by dividing the total BA by the number of sample plots.

Basal area per hectare was obtained by multiplying mean basal per plot with the number of 50 × 50 m plots in a hectare (4).

BA/ha = BAP X 4 (2)

Where *ha BA* = Basal area per hectare

Volume Calculation

The volume of individual trees was estimated using the equation developed for tree volume estimation in lowland rainforest ecosystem of southwestern Nigeria FORMECU (1999). This equation is expressed as follows:

$$V = e^{-8.433+2.331Ln(D)} \quad (3)$$

Where V = Volume of tree (m^3) and D =dbh (cm). Total plot volume was obtained by adding the volume of individual trees encountered in the plots. Mean volume for sample plots was calculated by dividing the total plot by the number of sample plots.

Volume per hectare was obtained by multiplying mean volume per plot *VP* with the number of 50 m×50 m plots in a hectare (4).

Vha =VP x 4

Tree Species Classification and Diversity Indices

All the trees encountered were assigned to families and number of species in each family was obtained for tree species diversity classification. Frequency of occurrence was obtained for species abundance/ richness. This was repeated for all plants encountered in the sample plots for the site. The following biodiversity indices were used to obtain tree species richness and evenness within the forest. They were also used as indices for comparing biodiversity as indication of biodiversity loss. Species relative density (RD) number of individual per hectare was obtained using the formula below (Oduwaiye *et al.*, 2002):

$$RD = \left[\frac{n_i}{N}\right] \times 100 \quad (4)$$

Where RD = relative density, n_i = number of individuals of species i and N = total number of individuals in the entire population.

Species diversity is the number of different species in a particular area. This was obtained using a mathematical formula that takes into account the species richness and abundance of each species in the ecological community. The equation for the Shannon-Wiener diversity index given by Price (1997) was used:

$$H^1 = \sum_{i=1}^{S} p_i Lnp_i \quad (5)$$

H^1 is the Shannon diversity index, S is the total number of species in the community, p_i is the proportion of a species to the total number of plants in the community and Ln is the natural logarithm. Species evenness (E) measures the distribution of the number of individual in each species. It was determined using Shannon's equitability (E_H) as stated by Kent and Coker (1992)

$$E = \frac{H^1}{Ln(S)} \quad (6)$$

S is the total number of species in each community.

Simpson's Dominance Index

Simpson's dominance index is weighted towards the abundance of the commonest species.

$$\text{Simpson Index (C)} = \sum P_i^2 \quad (7)$$

Where Pi is the proportional abundance of the ith species

$$(P_i = \frac{n_i}{N})$$

Simpson's index varies from 0 to 1 and gives the probability that two individuals drawn at random from a population belong to the same species. If the probability is high, then the diversity of the community sample is low. The higher the dominance index the lower the Shannon diversity.

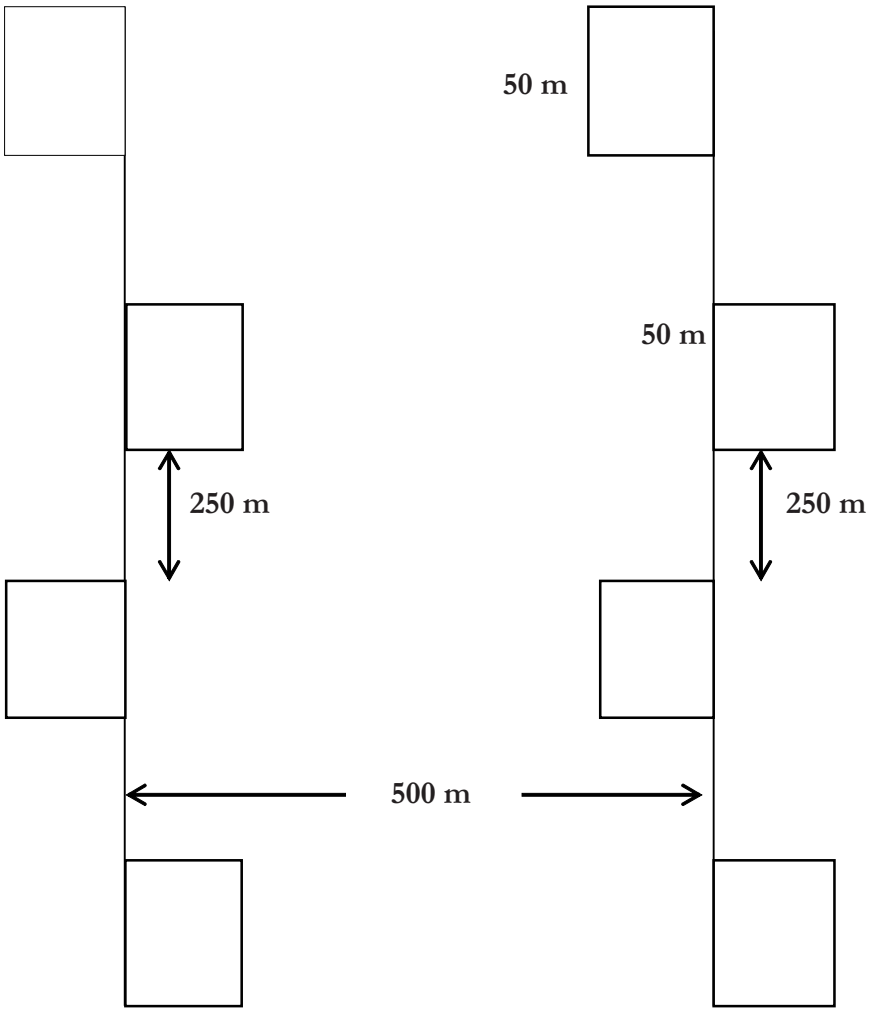

Figure 2: Plot Layout with Systematic Line Transects Sampling Technique

RESULTS AND DISCUSSION

Floristic Composition and Tree Growth Parameters

Table 1 showed that *Diospyrus dendo* had highest frequency and relative density of 20.35 followed by *Funtumia elastica* with relative density of (12.80), *Sterculia rhinopetala* (5.28), followed by *Nesogordonia papaverifera* (4.52), *Baphia nitida* (4.52), *Phyllanthus discoideus* (3.51), *Bosqueia angolense* (3.51), *Pterygota macrocarpa* (2.76), *Baphia nitida* (2.51), *Ricinodendron heudelotii* (2.26) while species with relatively low densities were *Spathodea companulata* (0.25) *Bombax buonopozense* (0.25) *Blighia sapida* (0.25), *Allanblackia floribunda* (0.25) *Celtis mildbraedii* (0.25), *Drypetes gilgiana* (0.25), *Macaranga barteri* (0.25), *Ceiba pentandra* (0.25).

The Shannon-Wiener diversity index (H') and

Simpson's index (D) was calculated to be 4.05 and 0.09 in Omo Biosphere Reserve. This result showed that trees were found to be more diverse in study site which is an indication of a great diverse ecosystem in terms of species distribution and abundance. The Simpson's index (D) of 0.09 indicated that the diversity of the reserve is very high and it is an indication of a healthy reserve (Table 2). The growth variables obtained at the study area are presented in table 3. Total volume obtained was 306.62 m^3ha^{-1} in Omo Biosphere Reserve. The basal area was 86.45 m^2ha^{-1}, total number of stems ha^{-1} was 405 stems $ha.^{-1}$

Four hundred and five (405) Nigerian tropical timber species were reported in Omo Biosphere Reserve (Table 3) which exceeded the values 296/ha and 323/ha observed by Adekunle (2007) and Aigbe *et al.,* (2014) in Obanla Natural Forest and Afi Forest Reserve respectively. However, lower tree density was recorded compared to Illoje Kaoje Forest Reserve, Oban Forest Reserve with the density of 568/ha, 808/ha and 1420/ha respectively (Aigbe *et al.,* 2014) and Ehor Forest Reserve with the value of 2062 (Jane Ihenyer *et al.,* 2009). Table 1 showed that Ebenaceae and Apocynaceae had highest frequency of individual tree species to be 81 and 51 in the species of the family- *Diospyrus dendo* (Welw.Ex.hien) and *Funtumia elastica* (Preuss). The Nigerian rainforest is dominated by members of Sterculiaceae (*Cola* spp, *Sterculia spp*), Moraceae (*Antiaris africana, Ficus spp*), Meliaceae (e.g *Entandrophragma spp, Khaya ivorensis*) and species like *Nauclea diderrichii, Erythrophleum ivorensis, Brachystegia eurycoma* and *Terminalia superba* (Isichei, 1995; Richards, 1996; Were, 2001) which is consistent with the findings of this study. In addition, the results indicated that members of Ebenaceae (*Diospyrus dendo*), Apocynaceae (*Funtumia elastica*), Sterculiaceae (*Sterculia rhinopetala*), Papilionaceae (*Baphia nitida*), Moraceae *(Morus mesozegia*) are important parts of the floristic composition of the study sites. This result is in accordance with the findings of Onyekwelu *et al.,* (2007) who reported Apocynaceae (*Funtumia elastica*), Euphorbiaceae (*Bridelia species, Drypetes spp*) and species like *Diospyrus* species and *Strombosia species* are important part of floristic composition of Queens Forest and Elephant Forest in Ogun state, also Oluwa Forest in Ondo state. Omo Biosphere Reserve was found to be richer in species composition; this may be due to the proper monitoring of the Biosphere Reserve.

Table 1: **Family, Density and Tree Species Identified in Omo Biosphere Reserve**

Family Names	Species Names	Density	Relative density	Pi	(pi ln pi)
Amaryllidaceae	*Newbouldia laevis*	2	0.50	0.01	-0.05
Anacardiaceae	*Spondias mombin*	3	0.75	0.01	-0.05
Annonaceae	*Cleistopholis patens*	1	0.25	0.00	-0.08
Annonaceae	*Xylopia aethiopica*	4	1.01	0.01	-0.15
Annonaceae	*Cleistopholis patens*	6	1.51	0.02	-0.17
Annonaceae	*Hexalobus monopetalus*	2	0.50	0.01	-0.05
Annonaceae	*Enantia chlorantha*	4	1.01	0.01	-0.15
Apocynaceae	*Funtumia africana*	2	0.50	0.01	-0.05
Apocynaceae	*Funtumia elastica*	51	12.8	0.13	-0.27
Apocynaceae	*Alstonia booneii*	5	1.26	0.01	-0.05
Arecaceae	*Elaeis guineensis*	4	1.01	0.01	-0.05
Bignoniaceae	*Spathodea companulata*	1	0.25	0.01	-0.05
Bombacaceae	*Ceiba pentandra*	2	0.50	0.01	-0.05
Bombacaceae	*Bombax buonopozense*	1	0.25	0.01	-0.05
Caesalpinaceae	*Blighia sapida*	1	0.25	0.01	-0.05
Caesalpinaceae	*Afzelia africana*	2	0.50	0.01	-0.05
Caesalpinioideae	*Daniellia spp*	1	0.25	0.01	-0.05
Cannabaceae	*Celtis zenkeri*	8	2.01	0.02	-0.15

Family Names	Species Names	Density	Relative density	Pi	(pi ln pi)
Capparaceae	*Buchholzia coriacea*	2	0.50	0.01	-0.05
Cecropiaceae	*Musanga cecropioides*	2	0.50	0.01	-0.05
Clusiaceae	*Allanblackia floribunda*	1	0.25	0.01	-0.05
Combretaceae	*Terminalia superba*	2	0.50	0.01	-0.05
Ebenaceae	*Diospyros dendo*	81	20.35	0.20	-0.32
Ebenaceae	*Diospyros mespiliformis*	5	1.26	0.01	-0.05
Ebenaceae	*Diospyros canaliculata*	4	1.01	0.01	-0.05
Cannabaceae	*Celtis mildbraedii*	1	0.25	0.01	-0.05
Euphorbiaceae	*Ricinodendron heudelotii*	9	2.26	0.02	-0.15
Euphorbiaceae	*Phyllanthus discoideus*	14	3.52	0.04	-0.13
Euphorbiaceae	*Uapaca togoensis*	2	0.50	0.01	-0.05
Eurphobiaceae	*Bridelia micrantha*	2	0.50	0.01	-0.05
Eurphobiaceae	*Drypetes gilgiana*	1	0.25	0.00	-0.05
Eurphobiaceae	*Macaranga barteri*	1	0.25	0.00	-0.05
Fabaceae	*Erythrina spp*	1	0.25	0.00	-0.05
Irvingiaceae	*Irvingia gabonensis*	2	0.50	0.01	-0.05
Leguminosae	*Dialium guineense*	2	0.50	0.01	-0.05
Malvaceae	*Ceiba pentandra*	1	0.25	0.00	-0.05
Meliaceae	*Trichilia hendolotii*	4	1.01	0.01	-0.05
Meliaceae	*Carapa procera*	1	0.25	0.01	-0.05
Meliaceae	*Entandrophragma spp*	1	0.25	0.01	-0.05
Moraceae	*Bosqueia angolense*	14	3.52	0.04	-0.13
Moraceae	*Morus mesozygia*	4	1.01	0.01	-0.05
Moraceae	*Buchholzia coriacea*	1	0.25	0.00	-0.05
Moraceae	*Ficus spp*	2	0.50	0.01	-0.05
Moraceae	*Antiaris africana*	2	0.50	0.01	-0.05
Myaesristiceae	*Pycnanthus angolensis*	7	1.76	0.02	-0.08
Mysristicaceae	*Phyllanthus discoideus*	1	0.25	0.00	-0.05
Olacaceae	*Strombosia pustulata*	6	1.51	0.02	-0.08
Papilionaceae	*Baphia nitida*	18	4.52	0.05	-0.15
Rubiaceae	*Mitragyna stipulosa*	4	1.01	0.01	-0.05
Rubiaceae	*Corynanthe pachys*	1	0.25	0.00	-0.05
Rubiaceae	*Canthium inspida*	4	1.01	0.01	-0.05
Rutaceae	*Zantoxyllum zantoxynoides*	5	1.26	0.01	-0.05
Rutaceae	*Fagara zantoxyllum*	1	0.25	0.01	-0.05
Sapotaceae	*Aninqueria robusta*	1	0.25	0.01	-0.05
Sapindaceae	*Lecaniodiscus cupanioides*	1	0.25	0.01	-0.05
Sapindaceae	*Blighia sapida*	10	2.51	0.03	-0.11
Sterculiaceae	*Sterculia tragacantha*	7	1.76	0.02	-0.08
Sterculiaceae	*Nesogordonia papaverifera*	18	4.52	0.05	-0.15
Sterculiaceae	*Sterculia rhinopetala*	21	5.28	0.05	-0.15
Sterculiaceae	*Mansonia altissima*	5	1.26	0.01	-0.05
Sterculiaceae	*Cola gigantea*	6	1.51	0.02	-0.05
Sterculiaceae	*Morus mesozygia*	3	0.75	0.01	-0.05
Sterculiaceae	*Cola millenii*	3	0.75	0.01	-0.05
Sterculiaceae	*Cola nigerica*	1	0.25	0.01	-0.05
Sterculiaceae	*Pterygota macrocarpa*	11	2.76	0.03	-0.11
Sterculiaceae	*Sterculia tragacantha*	1	0.25	0.01	-0.05

Source: Field Survey, 2015

Diversity indices

Overall Shannon-Wiener diversity index for Omo Biosphere Reserve was found to be 4.05. This is in conformity with the value obtained for temperate forest which ranges from 1.16 and 3.40 (Pande *et al.*, 1996) and tropical forest where it can reach up to 5.40 (Parthasaranthy *et al.,* 1992). The Shannon-Wiener diversity index obtained is higher than the tree species diversity values in tropical forests of Kalakad Forest Reserve in Western Ghats which was reported to be between 3.31 and 3.69 (Parthasaranthy *et al.,* 1992). In a related study (Knight, 1975) the Shannon-Wiener seems to be high with the value of 4.8. The reason for the high value in Omo Biosphere Reserve may be due to the proper monitoring and laws that guided the use of the Biosphere.

The Simpson's index (D^i) reciprocal form obtained 11.11 (Table 2), which is an indication of a high diversity value is in agreement with Young and Swiacki (2006) who stated that diversity was made up of species present and the relative abundance of those species. The higher the value of index the higher the diversity index (Ojo, 2004).

The high Evenness indices data obtained 0.96 for Omo Biosphere Reserve is an indication of high species distribution. This result is similar to the findings of Onyekwelu *et al.,* (2007) who reported that the higher the species distribution, the more the evenness of species. Evidence has shown that the tropical rainforest ecosystem is among the most complex and species rich single ecosystem of the world (Bhat *et al.*, 2000; Gillespie *et al.*, 2004) and there is a wide variation in the composition and abundance of species between various tropical forests (Parthasarathy *et al.*, 1992).

Table 2: Diversity Indices, Species Evenness Obtained in the Study Area

Diversity indices (Variables)	Omo Biosphere Reserve
Shannon-Wiener (H-index)	4.01
Simpson's index (D^1)	11.11
Evenness (E)	0.96

Table 3: Tree Growth Variables Obtained at the Study Area

Variables	Values
Basal area (m^2)/ha	86.45
Volume (m^3)/ha	306.62
Average Dbh (m)	1.46
Confidence limit of Volume estimate /ha (lower limit)	298.55
Confidence limit of Volume estimate /ha (upper limit)	342.8
No of stems per hectare	405

Source: Field survey, 2015

Diameter class distribution pattern of Omo Biosphere Reserve

There were higher numbers of stems per hectare in the smaller diameter classes of 10-19.99 cm with population sizes of 105 trees in Omo Biosphere Reserve. Diameter ranges of 20- 29.9 cm had 73 trees/ha, while the diameter class of 30-39.9 cm had 51 trees/ha in Omo Biosphere Reserve. Lesser number of stems per hectare was recorded in diameter classes of 70-89.9 cm in study area (Table 4). It implies that higher number of the trees was wildlings and they were not merchantable. Oduwaiye *et al.,* (2002) revealed that all the plots accessed had the largest class of diameter below 10 cm at the Okomu Permanent Sample Plot. Conversely, Salami and Akinyele (2017) discovered highest number of trees for diameter class 10-19.9 cm (27.93%) at Gambari Forest. Also, Oduwaiye and Ajibode (2005) reported the highest number of trees for diameter class of 11-30 cm followed by those of between 0-10 cm at Onigambari Forest Reserve.

Table 4: Percentage Diameter Distribution into Diameter Classes in the Study Areas

Diameter classes (cm)	Freq/ha	% Distribution
10 – 19.9	105	25.9
20 – 29.9	73	18.02
30 – 39.9	51	12.59
40 – 49.9	41	10.12
50 – 59.9	36	8.88
60 – 69.9	22	5.43
70 – 79.9	20	4.93
80 – 89.9	11	2.72
90 – 99.9	14	3.46
>100	32	7.90
Total	**405**	**100**

Source: Field Survey, 2015

CONCLUSIONS AND RECOMMENDATIONS

Omo Biosphere Reserve which has an estimated number of four hundred and five (405) individual tree species per hectare is meaningfully rich in tree species when compared to the tree densities of other tropical rainforest reserves. The species diversity indices and abundance obtained in this research compared favourably with similar forest ecosystems. The Shanon –Weiner diversity index (4.05) obtained from this research falls within the general limit of diversity index in tropical rainforest. Some tree species encountered *Diospyrous dendo* and *Funtumia elastica* were the most abundant with a total of 81 and 51 stands/hectare. The prominent tree sizes in the reserve were dbh sized class of 10-20 cm, which tend to dominate. To prevent the extinction of some families and species, urgent measures need to be taken to the increase the dwindling low density of some species and restock the forest reserve, particularly with the seedlings of species that were represented by only one stem per hectare.

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