

Plants in the Diet of African Forest Elephants in Okomu National Park, Nigeria

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Abstract

The study was carried out to assess the phytosociological and proximate properties of vegetation foraged by elephant in Okomu National Park, Edo State Nigeria. Five (5) of the compartments with foraged plants were randomly sampled with two quadrats each measuring 20m x 20m in dimension at breast height of the trees. A total number of forty-seven (47) species belonging to thirty (30) families were identified of which seventeen (17) plant species were fed upon by the elephants in the area studied. The most dominant species on the basis of Importance Value ranking were *Ceiba pentandra*, *Terminalia superba* and *Strombosia pustulata*. The life form pattern of the foraged plants consists of 71% tree, 18% herb, 6% shrub and 6% vine. The part fed upon by elephants consists of tree barks, leaves, roots, tubers, fresh young fronds and fruits. The proximate composition of selected plant species eaten by the elephants showed highest percentage of moisture in the root of *Thaumatococcus daniellii* and highest percentage of carbohydrate in the tuber of *Dioscorea praehensilis*. The high moisture content in these species suggests a daring need for the survival of the elephants in the forest. However, few plant species did not meet the elephants' nutrient requirements, hence their dependence on many species. The pattern of results obtained indicates reduction of tree densities which may lead to increase in herbaceous species because elephants feed on wide variety of plants which may alter the vertical structure of plants community. This kind of information will enhance management decision for sustainable management of the Okomu National Park.

Keywords: Phytosociological and Proximate properties, African elephants, Okomu Park.

Introduction

Plant-Animal Interaction (PAI) is the relationship between organisms in the kingdoms Animalia and Plantae. This relationship conceals an enormous number and diversity of ecological relationships and fundamental processes ranging from general to those that are highly specific which involve elaborate evolutionary adaptations (Herrera *et al.*, 2002). Plant-Animal Interaction has been categorized to be commensal, in which one partner benefits while the other is unaffected. Similarly, antagonistic is the interaction leading to the detriment of at least one partner whilst mutualistic is when both the plant and animal partners both benefit. Such, is the interaction between elephants and plants which is largely symbiotic. Elephants are classified as mega herbivores and consume up to 150kg of plant per day (Samansiri and Weerakoon, 2007). Being mega-herbivores, elephants need to take sufficient amount of forage and water per day (Jackson and Erasmus 2005; Stephenson 2007). Numerous studies on feeding habits of African and Asian elephants have shown that proportion of various plant categories in diet vary widely from one region to another (Sukumar, 1985). Grasses, shrubs, tree leaves, aquatic plants and occasionally fruits make up the component of their diet (Borah and Deka, 2008). Although elephants harvest food from a range of plant life forms, it is their conspicuous impact on woodlands that has the greatest potential to cause long-term vegetation change (Morrison *et al.*, 2016). Extensive conversion of woodlands to shrubland by elephants (Spinage, 1994) and the potential associated loss of biodiversity (Cumming *et al.*, 1997; Herremans, 1995; Kerley and Landman, 2006) may require management intervention (O'Connor *et al.*, 2007), but such action should be based on the understanding of why elephants choose to utilize woody plants in a destructive manner. Impact on woody vegetation is greatest when harvesting methods such as breaking branches, debarking stems, or toppling, pollarding or uprooting whole plants are used, and less when trunkloads of leaves are stripped without breaking branches (O'Connor *et al.*, 2007).

Elephants' utilization of trees entails switching to bark stripping as tree height increases (Smallie and O'Connor, 2000). Tree breaking is consistent with the elephant's diet (Ben-Shahar, 1993). Elephants consume considerable amounts of bark and roots of the felled trees to supplement their grass intake (Barnes, 1982). Large *Acacia* spp. trees are uprooted by 5 bull elephants for nutritional rather than social reasons as it is the younger low ranking bulls that are often involved (Croze, 1974). Elephant are constantly on the move looking for the necessary supply of food and sources of water (Davies, 2008). The survival of African as well as Asian elephants largely depends upon availability of extensive habitations for adequate protection and food for their healthiness and growth. The African forest elephant *Loxodonta cyclotis* (Matschie, 1900) is one of the world's largest terrestrial mammals.

Presently, very few forest areas in South Western Nigeria still contain elephants. One of such forest area is Okomu National Park. Amusa *et al.* (2017) carried out population status and distribution of forest elephants (*Loxodonta cyclotis*) in Okomu National Park and Omo Forest Reserve, South-western Nigeria. Okomu area has well marked rainy and dry seasons. The dry season which lasts from November to March is usually accompanied by northeast trade wind that causes harmattan (Azeez *et al.*, 2010). Okomu soil is acidic, nutrient-poor sandy loam. The soil pH ranged from very strongly acid (4.88) in the sub soil to neutral (6.75) in the top soil of Okomu forest (Agboola *et al.*, 2017). Vegetation is Guinea–Congolia lowland rain forest, which includes areas of Swamp-forest, high forest, secondary forest, and open scrub (Okomu National Park, 2010). In Nigeria, forest elephants have become extinct in many areas while the remnant fragile populations remain at high risk of total extirpation. As human populations increase rapidly, the elephant range is constantly being broken up into small fragments traversed by roads, human settlements and infrastructures thereby bringing elephants into conflict with humans. The aim of the present study is to describe the vegetation and forest structure of vegetation where the African elephants foraged using phytosociological and nutritional characteristics of the prominent plants fed upon by the elephants in Okomu National Park, Edo state Nigeria and to examine the impacts of continuous elephant activities on the structure and composition of the foraged vegetation.

Materials and Methods

Study area description

Okomu National Park is located in Ovia South-West Local Government Area of Edo State. It occupies an area of 202.24 km² within the lowland forest of Nigeria. It lies between Longitude 5°00'E – 5°30'E and latitude 6°00'N - 6°30'N (Figure 1) between the River Osse and Siluko to the East and West respectively and about 40km from Benin city, the Edo State Capital. Okomu National Park has seventy-nine compartments out of which five compartments (45, 52, 53, 61, 64) have been observed by Park rangers to be foraged by elephants. The Park holds a remnant of the Nigerian lowland forests that once formed a continuous 50 - 100 km wide belt from the Niger River west to the Dahomey Gap in Benin. To the South and Southeast the forest was separated from the coast by mangrove and swamp forests, while to the north it merged into the Guinean Forest-Savanna Mosaic eco-region (Okomu National Park, 2010).

Data Collection

Five out of the seventy-nine compartments foraged by the elephants were randomly sampled. These compartments are compartments 45, 52, 53, 61, 64. In each compartment, two quadrats measuring 20m x 20m in dimension were established and the diameter at breast height of tree within the quadrats was recorded. The

Global Position System location of each quadrat was recorded during plot sampling in Table 1

Table 1: GPS Location of the Sampled Compartments

SITE	COMPARTMENT	QUADRATS	LATITUDE	LONGITUDE
			(N)	(E)
A	45	Plot 1	06° 22.307	005° 20.897
		Plot 2	06° 22.315	005° 20.848
B	52	Plot 1	06° 22.615	005° 21.609
		Plot 2	06° 21.165	005° 19.567
C	53	Plot 1	06° 21.408	005° 19.822
		Plot 2	06° 21.199	005° 20.347
D	61	Plot 1	06° 20.179	005° 18.943
		Plot 2	06° 20.164	005° 18.990
E	64	Plot 1	06° 20.495	005° 18.107
		Plot 2	06° 20.522	005° 18.110

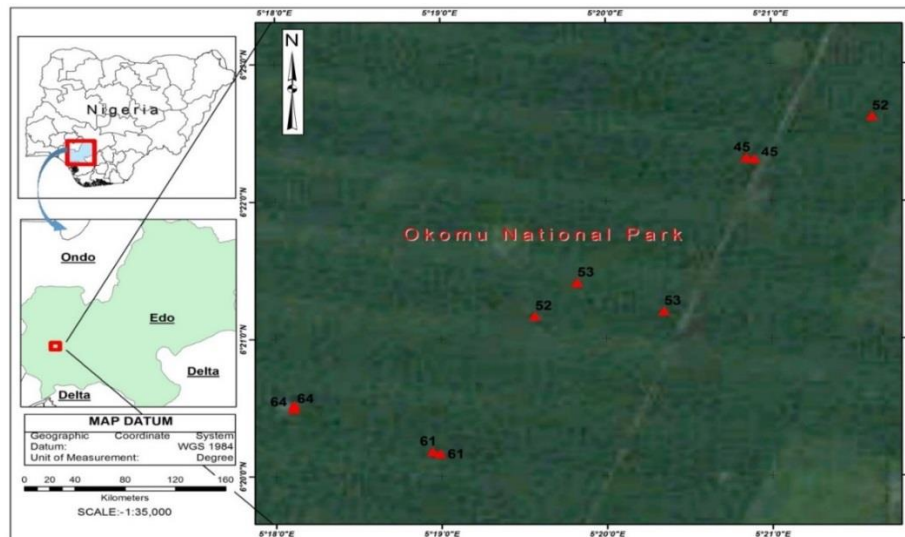


Figure 1: Map showing sample points in the study area in the Okomu National Park

Data Analysis

Data of the trees species in all quadrats were analyzed to determine the values of density, dominance and frequency (Sevda and Emire, 2018). The relative values of density, dominance and frequency values were determined for each species (Akinsoji, 2013). They were used to calculate the Importance Values of each species.

$$\text{Density} = \frac{\text{Number of individuals}}{\text{Area sampled}}$$

$$\text{Relative Density} = \frac{\text{Density for a species}}{\text{Total density for all species}} \times 100$$

$$\text{Dominance} = \frac{\text{Total of basal area or areal coverage values}}{\text{Area sampled}}$$

$$\text{Relative Dominance} = \frac{\text{Dominance for a species}}{\text{Total dominance for all species}} \times 100$$

$$\text{Frequency} = \frac{\text{Number of plots in which species occurs}}{\text{Total number of plots sampled}} \times 100$$

$$\text{Relative Frequency} = \frac{\text{Frequency value for a species}}{\text{Total of frequency values for all species}} \times 100$$

$$\text{Importance Value} = \text{Relative density} + \text{Relative dominance} + \text{Relative Frequency}$$

Collections of Plant Materials

The plant parts of *Desplatsia subericarpa* (fruit), *Dioscorea praehensilis* (tuber), *Thaumatococcus daniellii* (root), *Anthonotha macrophylla* and *Trichilia monadelphpha* (bark) were collected from study area. These plants were collected from their natural habitat identified by rangers in the Park.

Proximate Analysis

Proximate analysis of fruits, herbs and tree barks played a crucial role in assessing their nutritional significance. Proximate analyses of five selected species of plant parts fed upon by elephants and collected from the study site were carried out. They were subjected to a series of relatively simple chemical tests so as to determine the percentage content of moisture, crude protein, crude fiber, ash, fat and digestible carbohydrate.

Sample treatment

The leaves were ground into fine powder using pestle and mortar, and sieved through 20mm-mesh sieve. The dried powdered sample was used for the analysis while for the moisture content however, fresh leaves were used.

Ash content was determined by incineration of 10g sample in a furnace at 600°C for 8hours and was ashed to constant weight. Each ash sample was dissolved in 10cm³ 6M nitric acid in 100cm³ volumetric flask and made up to mark with water. The sample solution was kept in plastic labeled containers for analysis. The recommended methods of the Association of Official Analytical Chemist (AOAC, 1990) were used for the determination of moisture, ash, crude lipid, crude fiber and nitrogen contents.

For **moisture content**, fresh leaves of the sample in triplicate were weighed in Petri dishes and dried in an oven at 105°C for 24 hours. The percentage loss in weight was expressed as percentage moisture content. A similar determination was carried out on dried sample so as to evaluate the residual moisture content. The nitrogen content of the powdered leaves was used as an index of the protein termed ‘crude protein’ as distinct from true protein. The crude protein (CP) content was calculated from the nitrogen determined by Kjeldahl method (Pearson, 1999).

To extract **crude protein**, all the nitrogen present in the sample was converted to ammonia by digesting the sample with sulphuric acid, (H₂SO₄). Sodium hydroxide, (NaOH) was then added to the digest to liberate the ammonia, which was distilled off, and collected in standard acid. The quantity so collected was determined by titration. It was assumed that the nitrogen was derived from protein containing the percent nitrogen, and multiplying the nitrogen figure by 6.25; an approximate crude protein value was obtained.

Fat content is followed by continuous extraction of known weight of the powdered sample with petroleum ether (40 – 60°C) in a soxhlet extractor. The residue after evaporation of the solvent was then weighed and the lipid content determined.

Digestible carbohydrate content was determined by what is known as ‘estimation by difference’, where the sum of the moisture, ash, protein and lipid contents were subtracted from one hundred (100).

The **crude fiber** was determined by subjecting the residual powdered sample from ether extraction to successive treatment with boiling using 0.25M H₂SO₄ acid and 0.312M NaOH, alkaline. The insoluble residue was washed with hot water until it is base free. It was then dried to constant weight in an oven at 105°C, cooled in desiccators and weighed. The weighed samples were incinerated in a furnace at 550°C for 2hrs until constant weight was obtained. The crude fiber was calculated as the loss in weight on ashing. The organic residue was the crude fiber.

Results

A total of forty-seven (47) plant species belonging to 30 families were encountered in the study compartments (Table 2). The Family Meliaceae is represented by 5 species (Figure 3); Annonaceae and Apocynaceae with 4 species each; Fabaceae and Rubiaceae have 3 species each; Cannabaceae, Myristicaceae and Sterculiaceae are represented by 2 species each while Bombacaceae, Burseraceae, Caesalpiniaceae, Capparaceae, Combretaceae, Ebenaceae, Euphorbiaceae, Irvingiaceae, Lecythidaceae, Loganiaceae, Malvaceae, Moraceae, Ochnaceae, Olacaceae, Passifloraceae, Putranjivaceae, Rhizophoraceae, Rutaceae, Sapotaceae, Tiliaceae, Urticaceae and Violaceae have 1 species. The species with highest number of trees occurrence are *Strombosia pustulata* represented by twenty-four (24) tree plants while trees species, *Monodora myristica*, *Canarium schweinfurthii*, *Hylodendron gabunense*, *Cylicodiscus gabunensis*, *Irvingia wombolu*, *Petersianthus macrocarpus*, *Strychnos innocua*, *Khaya ivorensis*, *Milicia excelsa*, *Pycnanthus angolensis*, *Massularia acuminata* and *Chrysophyllum albidum* were represented by one species each (Table 2).

Table 2: List of Okomu National Park elephant-foraged Species and their individual number with respect to Family

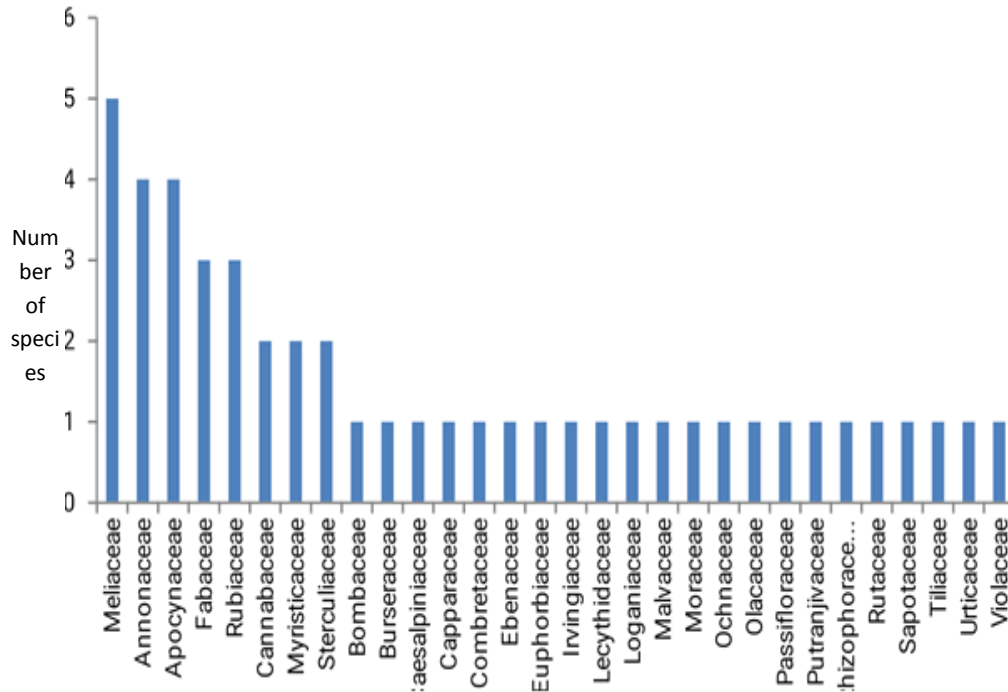
S/N	Families	Tree species	Number of trees	IUCN Red List status
1	Annonaceae	<i>Enantia chlorantha</i> (Oliver) van Setten & Maas.	4	NE
		<i>Annonidium mannii</i> Engl. & Diels	4	NE
		<i>Cleistopholis patens</i> (Benth.) Engl. & Diels	8	NE
		<i>Monodora myristica</i> (Gaertn.) Dunal	1	NE
2	Apocynaceae	<i>Alstonia boonei</i> De Wild.	3	NE
		<i>Funtumia elastica</i> (Preuss) Stapf	12	NE
		<i>Rauvolfia vomitoria</i> Afzel.	2	NE
		<i>Voacanga africana</i> Stapf	5	NE
3	Bombacaceae	<i>Ceiba pentandra</i> (Linn.) Gaertn.	12	LC
4	Burseraceae	<i>Canarium schweinfurthii</i> Engl.	1	NE
5	Caesalpiniaceae	<i>Hylodendron gabunense</i> Taub.	1	NE
6	Cannabaceae	<i>Celtis biondii</i> Pamp.	17	NE
		<i>Celtis zenkeri</i> Engl.	4	LC
7	Capparaceae	<i>Buchholzia coriacea</i> Engler	14	NE
8	Combretaceae	<i>Terminalia superba</i> Engl. & Diels	3	NE

9	Ebenaceae	<i>Diospyros gabunensis</i> L.	11	NE
10	Euphorbiaceae	<i>Ricinodendron heudelotii</i> (Baill.) Pierre ex Pax	2	VU
11	Fabaceae	<i>Anthonotha macrophylla</i> P. Beauv. Fl. Oware1	23	NE
		<i>Cylicodiscus gabunensis</i> Harms	1	NE
		<i>Piptadeniastrum africanum</i> (Hook. f.) Brenan	3	NE
12	Irvingiaceae	<i>Irvingia wombolu</i> Vermoesen	1	NE
13	Lecythidaceae	<i>Petersianthus macrocarpus</i> (P Beauv.) Liben	1	LC
14	Loganiaceae	<i>Strychnos innocua</i> subsp. <i>innocua</i> var. <i>innocua</i>	1	NE
15	Malvaceae	<i>Cola smithii</i> Schott & Endl.	11	NE
16	Meliaceae	<i>Lovoa trichilioides</i> Harms	12	LC
		<i>Entandrophragma cylindricum</i> (Sprague)	3	VU
		<i>Guarea cedrata</i> De Wild. C.A Chev.) pellegr.	5	VU
		<i>Khaya ivorensis</i> A. Chev.	1	VU
		<i>Trichilia monadelpha</i> (Thonning) de Wildeman	5	LC
17	Moraceae	<i>Milicia excelsa</i> (Welw.) C.C. Berg	1	NT
18	Myristicaceae	<i>Pycnanthus angolensis</i> (Welw.) Warb.	1	NE
		<i>Staudtia stipitata</i> Warburg	3	NE
19	Ochnaceae	<i>Lophira alata</i> Banks ex Gaertn. F	4	VU
20	Olacaceae	<i>Strombosia pustulata</i> Oliv. var. <i>lucida</i>	24	LC
21	Passifloraceae	<i>Barteria fistulosa</i> (Mast.) Sleumer	3	NE
22	Putranjivaceae	<i>Drypetes gossweileri</i> S.Moore.	2	NE
23	Rhizophoraceae	<i>Anopyxis klaineana</i> (Pierre) Engl.	2	VU
24	Rubiaceae	<i>Canthium glabriflorum</i> Lam	2	VU
		<i>Massularia acuminata</i> (G.Don) Bullock ex Hoyle	1	LC
		<i>Rothmannia hispida</i> (K.Schum.) Fagerl.	23	NE
25	Rutaceae	<i>Zanthoxylum zanthoxyloides</i> (Lam.) Zepern. & Timler	3	NE
26	Sapotaceae	<i>Chrysophyllum albidum</i> G. Don.	1	NE

27	Sterculiaceae	<i>Sterculia oblonga</i> MAST. and S.	10	VU
		<i>Sterculia tragacantha</i> Lindl.	5	LC
28	Tiliaceae	<i>Desplatsia subericarpa</i> Bocq.	3	NE
29	Urticaceae	<i>Myrianthus arboreus</i> P. Beauv	6	NE
30	Violaceae	<i>Rinorea dentata</i> (P. Beauv.) O. Ktze.	10	NE

KEY: NE: Not Evaluated, NT: Near Threatened, LC: Least Concern, VU: Vulnerable.

Figure 2: Family Distribution of Species encountered in Sampled Compartments



Plants fed upon by elephants are listed in Table 3. It consists of tree barks, leaves, roots, tubers, fresh young fronds and fruits. Most of the plants and part eaten were commonly the leaves and stems which formed the bulks of the elephant diet. In the area studied, Elephants fed on thirty- six percent (36%) of the 47 plants species which consist of various life forms. Elephant fed on the tree species like *Anthonotha macrophylla*, *Rothmannia hispida*, *Myrianthus arboreus*, *Ceiba pentandra*, *Trichilia monadelpha*, *Canarium schweinfurthii*, *Elaeis guineensis* and *Macaranga barteri*. Besides the elephants also fed on various shrubs, herbs and vine of *Laccosperma secundiflora*, *Aframomum melegueta*, *Thaumatococcus daniellii*, and *Dioscorea praehensilis* as their food resources. Fruits of *Desplatsia subericarpa*, *Anonidium*

mannii, *Irvingia wombolu*, *Myrianthus arboreus*, *Strychnos innocua* and *Sarcocephalus diderrichi* were consumed by the elephants. They often uprooted the plant with the help of their trunk and sometimes forefoot. The seed of *Myrianthus arboreus* was observed in the dung piles of elephants collected in the study area. The composition of different plant growth forms, family and species name eaten by elephant in study area was revealed and recorded (Table 3). This was obvious both from the examination of elephant dung which consist of 100% woody plants debris and from the collection of plants utilized by elephants. The percentage frequencies of the five plant parts consumed is as follow fruit eating (40%), bark peeling (27%), leaf eating (14%), root uprooting (14%) and tuber uprooting (5%) (Figure 3). The elephants preferred to feed on soft part of plant mostly the fruits and leaves of the plant. The bark of woody plant is often ripped off, since it is rich in calcium, which is essential for the favorable growth of their bone and for the tusks in males.

Table 3: List of foraged plants their family, life form and plant parts eaten by the elephants of Okomu National Park

S/N	Species	Family	Local name (Benin)	Life form	Parts eaten	IUCN Red List Status
1	<i>Aframomum melegueta</i>	Zingiberaceae	Oseghe	H	r, f	NE
2	<i>Annonidium mannii</i>	Annonaceae	Oghede-egbo	T	f	NE
3	<i>Anthonotha macrophylla</i>	Fabaceae	Oghaba	T	b, f	NE
4	<i>Canarium schweinfurthii</i>	Burseraceae	Ekpakpogho	T	b, f	NE
5	<i>Ceiba pentandra</i>	Bombacaceae	kapok	T	b	LC
6	<i>Desplatsia subericarpa</i>	Tiliaceae	Ighiwogha	T	f	NE
7	<i>Dioscorea praehensilis</i>	Dioscoreaceae	Ogigba	H	t	NE
8	<i>Elaeis guineensis</i>	Arecaceae	Ivi-oromila	T	f y f	LC
9	<i>Irvingia wombolu</i>	Irvingiaceae	Ogwi/Ogui.	T	f	NE
10	<i>Laccosperma secundiflora</i>	Arecaceae	Ikan, okakan	V	l	LC
11	<i>Macaranga barteri</i>	Euphorbiaceae	Ohaha	T	r	NE
12	<i>Myrianthus arboreus</i>	Urticaceae	ayon udin	T	f	NE
13	<i>Sarcocephalus</i>	Euphorbiaceae	Obhiakhe	T	b, f	VU

	<i>diderrichii</i>					
14	<i>Rothmannia</i>	Rubiaceae	Asun-	T	b	NE
	<i>hispida</i>		leghere			
15	<i>Strychnos</i>	Loganiaceae	UN	S	f	NE
	<i>innocua</i>					
16	<i>Thaumatococcus</i>	Marantaceae	Ebe-eba	H	l, r	NE
	<i>daniellii</i>					
17	<i>Trichilia</i>	Meliaceae	Ovallo	T	b	LC
	<i>monadelpha</i>					

KEY (T – tree, S – shrub, H – herb, V – vine, l – leaves, b – bark, r – root, f – fruits, fyf –fresh young frond, t- tuber, UN- Unknown., NE: Not evaluated, LC: Least concern, VU: Vulnerable.)

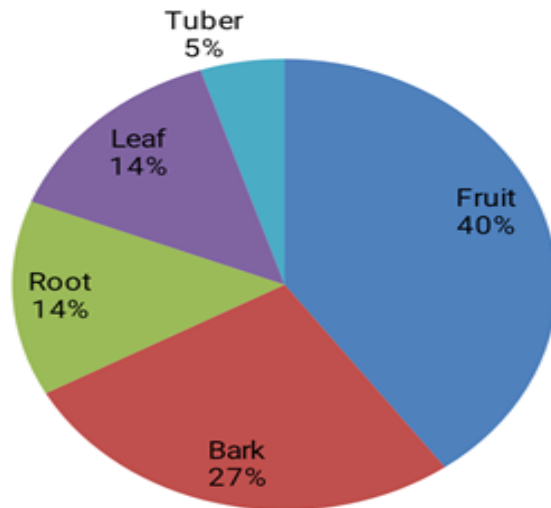


Figure 3: Relative frequencies of plant parts foraged by elephants in Okomu National Park.

The plant density of species in area studied within Okomu National Park ranged from 0.00025m² - 0.006m² with the species of *Strombosia pustulata* having the highest density while species of *Canarium schweinfurthii*, *Chrysophyllum albidum*, *Cylicodiscus gabunensis*, *Hylodendron gabunense*, *Irvingia wombolu*, *Khaya ivorensis*, *Massularia acuminata*, *Milicia excelsa*, *Monodora myristica*, *Petersianthus macrocarpus*, *Pycnanthus angolensis* and *Strychnos innoca* were recorded with the lowest density using the quadrat method. *Strombosia pustulata* has the highest Frequency (90%) followed by *Celtis biondii* (80%) and *Cola smithii* (60%). 50% Frequency was recorded for five species namely *Anthonotha macrophylla*, *Diospyros gabunensis*, *Funtumia elastica*, *Lovoa trichilioides*, *Rothmannia hispida* species. However, the species with the lowest Frequency were

Drypetes gossweileri, *Canarium schweinfurthii*, *Chrysophyllum albidum*, *Cylicodiscus gabunensis*, *Hylocodendron gabunense*, *Irvingia wombolu*, *Khaya ivorensis*, *Massularia acuminata*, *Milicia excelsa*, *Monodora myristica*, *Petersianthus macrocarpus*, *Pycnanthus angolensis* and *Strychnos innoca*. The plant dominance in the area varied from 1.32cm² - 8886.03cm² with *Ceiba pentandra* having the highest dominance species however, the lowest dominance species was recorded for *Chrysophyllum albidum*. The maximum Relative Frequency (RF= 7.14%) and the highest Relative Density (RD= 8.73%) were documented for *Strombosia pustulata*. The species with highest Importance Value rank is *Ceiba pentandra* (SIV=50.4608) while the species with the lowest Importance Value rank is *Chrysophyllum albidum* (SIV=1.1639) (Table 4).

Proximate analysis of five different selected plant part fed upon by elephant collected from the area studied are subjected to a series of relatively simple chemical tests known as nutritional analysis. These species with their part mostly consume by elephants include *Anthonotha macrophylla* (bark), *Trichilia monadelphpha* (bark), *Thaumatococcus daniellii* (root), *Dioscorea praehensilis* (tuber) and *Desplatsia subericarpa* (fruit). All the samples were analyzed for moisture, crude protein, crude fiber, crude fat and total ash content. Highest amount of moisture (89.42%) was observed in *Thaumatococcus daniellii* whereas *Dioscorea prehensilis* (38.11%) showed lowest amount. In case of crude protein high amount (11.42%) was in *Anthonotha macrophylla*, low amount (0.98%) in *Thaumatococcus daniellii*. High amount (10.09%) of crude fibre was observed in *Dioscorea praehensilis* whereas *Anthonotha macrophylla* showed low (4.28%) fiber content. *Desplatsia subericarpa* showed high amount (3.98%) of crude fat and *Dioscorea praehensilis* showed low amount (0.98%). The total ash content of *Dioscorea* was high (8.47%), while *Anthonotha macrophylla* showed low amount (3.76%). The crude carbohydrate was high (41.28%) in *Dioscorea praehensilis*, however, *Thaumatococcus daniellii* showed low amount (1.92%) (Table 5).

Discussion

International Union for Conservation Nature (2007) presented the result in the study of conservation of Asian elephant in Bangladesh where the elephants foraged about 12% of the total local plant species. Although there were about 143 plant species recorded in the Chunati Wild Life Sanctuary in the report but about 17 species being utilized by the Asian elephants. This is in agreement with 17 species eaten by the African elephant in Okomu National Park. The nutrition of the elephant in the West African forest zone consists almost entirely of woody plant part and fruit (Short, 1981) which is similar to plant sampled in the five compartments in Okomu National Park where the larger percentage of plants that elephants feed on were woody species which is about 71 percent and the rest plant parts shared the remaining percentage. Joshi and Singh (2008) specifically stated that the elephants fed on 74% tree, 14% grass, 8% shrub and 4% of climber out of two hundred and sixty two

(262) flora plant species and this resonate with observations from this study. Elephants have evolved to be generally herbivores consuming a wide variety of plants of over a hundred species (Sukumar, 1989, Samansiri and Weerakoon, 2007). The compartments where the elephant foraged in Okomu National Park has lower number of plants compared to the 57 plant species reported by Raj *et al.* (2016), but the families are diverse in Okomu National Park. In a similar report Sukumar (1985) listed 33 plants species fed upon by the elephant, belonging to Malvaceae, Leguminosae, Palmae and Bamboo. There were 17 families foraged by African elephant in this study, this is far diverse than the 4 families reported by Sukumar (1985). The proximate analysis of fruits, herbs and tree barks plays a crucial role in assessing their nutritional significance. The study revealed that plant parts fed upon by elephants consists of tree barks, shrubs, fruits and vines. These observations are in agreement with the findings on food and feeding behaviour of Asiatic elephant (*Elephas Maximus* Linn.) in Kuldiha Wild Life Sanctuary, Odisha, in India by Mohapatra *et al.* (2013). The nutritional analysis result showed that most plants fed upon by elephants contained high amount of moisture and carbohydrate respectively. Borah and Deka, (2008) pointed out that highest percentage of carbohydrate found in *Anthrocephalus* sp. (62.33%) and high content of moisture and digestible carbohydrate could be supplementary sources of moisture to the elephant's diet. In like manner, supplementary moisture content resulted to highest percentage moisture content in the root of *Thaumatococcus daniellii* while the highest percentage of carbohydrate was observed in the tuber of *Dioscorea praehensilis*. The location of Okomu national park might be a consequence of high moisture content in the root which is between River Osse and Siluko. In addition, the study was carried out during raining season. The availability of these plant species in the compartments provides a suitable habitat for elephants in Okomu National Park. The distribution of preferred plants close to the lake shore influences the elephant's preference to use most of their time utilizing the habitats. While elephant signs such as elephant trails, damaged trees, and areas in forest are conspicuous, elephant themselves are at low density and their overall impact on the forest is little. Among the seventeen identified plant species seed of *Myrianthus arboreus*

Table 4: Phytosociological features of the sampled quadrats in Okomu National Park

S/N	Tree species	No of individual species	No of plots in which species occurred	Total number of plots sampled	Frequency %	Density m ²	Dominance Cm ²	Relative frequency %	Relative density %	Relative dominance %	Importance Value %
1	<i>Ceiba pentandra</i>	12	2	10	0.2	0.003	8886.029	1.587302	4.363636	44.5098	50.4608
2	<i>Terminalia superba</i>	3	2	10	0.2	0.00075	4216.714	1.587302	1.090909	21.1214	23.7996
3	<i>Strombosia pustulata</i>	24	9	10	0.9	0.006	46.156	7.142857	8.727273	0.2312	16.1013
4	<i>Celtis biondii</i>	17	8	10	0.8	0.00425	25.978	6.349206	6.181818	0.1301	12.6611
5	<i>Anthanathia macrophylla</i>	23	5	10	0.5	0.00575	58.855	3.968254	8.363636	0.2948	12.6267
6	<i>Rothmannia hispida</i>	23	5	10	0.5	0.00575	23.853	3.968254	8.363636	0.1195	12.4514
7	<i>Cola smithii</i>	11	6	10	0.6	0.00275	516.348	4.761905	4	2.5864	11.3483
8	<i>Eumunia elastic</i>	12	5	10	0.5	0.003	102.266	3.968254	4.363636	0.5122	8.8441
9	<i>Lecyda trichilioides</i>	12	5	10	0.5	0.003	77.677	3.968254	4.363636	0.3891	8.7210
10	<i>Diospyros gahumensis</i>	11	5	10	0.5	0.00275	33.066	3.968254	4	0.1656	8.1339
11	<i>Cleistopholis patens</i>	8	3	10	0.3	0.002	429.443	2.380952	2.909091	2.1511	7.4411
12	<i>Rinorea dentata</i>	10	4	10	0.4	0.0025	33.123	3.174603	3.636364	0.1659	6.9769
13	<i>Buchholzia coriacea</i>	14	2	10	0.2	0.0035	15.239	1.587302	5.090909	0.0763	6.7545
14	<i>Khaya ivorensis</i>	1	1	10	0.1	0.00025	1109.327	0.793651	0.363636	5.5566	6.7139
15	<i>Pistadeniastrum africanum</i>	3	3	10	0.3	0.00075	445.861	2.380952	1.090909	2.2333	5.7052
16	<i>Alstonia boonei</i>	3	3	10	0.3	0.00075	443.143	2.380952	1.090909	2.2197	5.6915
17	<i>Celtis zenkeri</i>	4	2	10	0.2	0.001	499.363	1.587302	1.454545	2.5013	5.5431
18	<i>Sterculia tragacantha</i>	5	4	10	0.4	0.00125	46.27	3.174603	1.818182	0.2318	5.2245
19	<i>Myrianthus arboreus</i>	6	3	10	0.3	0.0015	100.354	2.380952	2.181818	0.5027	5.0654
20	<i>Sterculia oblonga</i>	10	1	10	0.1	0.0025	104.414	0.793651	3.636364	0.5230	4.9530
21	<i>Bicnodendron heudelotii</i>	2	2	10	0.2	0.0005	475.006	1.587302	0.727273	2.3793	4.6939
22	<i>Trichilia monadelphica</i>	5	3	10	0.3	0.00125	62.572	2.380952	1.818182	0.3134	4.5126
23	<i>Lophira alata</i>	4	2	10	0.2	0.001	273.839	1.587302	1.454545	1.3717	4.4135
24	<i>Guarea cedrata</i>	5	3	10	0.3	0.00125	20.015	2.380952	1.818182	0.1003	4.2994
25	<i>Voacanga Africana</i>	5	3	10	0.3	0.00125	16.17	2.380952	1.818182	0.0810	4.2801
26	<i>Desplatia subericarpa</i>	3	3	10	0.3	0.00075	137.028	2.380952	1.090909	0.6864	4.1582
27	<i>Ammonidium mannii</i>	4	3	10	0.3	0.001	25.783	2.380952	1.454545	0.1291	3.9646
28	<i>Staudtia stipitata</i>	3	2	10	0.2	0.00075	177.054	1.587302	1.090909	0.8869	3.5651
29	<i>Barteria fistulosa</i>	3	3	10	0.3	0.00075	10.462	2.380952	1.090909	0.0524	3.5243
30	<i>Enantia chlorantha</i>	4	2	10	0.2	0.001	30.605	1.587302	1.454545	0.1533	3.1951
31	<i>Zanthoxylum zanthoxylodes</i>	3	2	10	0.2	0.00075	82.069	1.587302	1.090909	0.4111	3.0893
32	<i>Casuarium schweinfurthii</i>	1	1	10	0.1	0.00025	379.145	0.793651	0.363636	1.8991	3.0564
33	<i>Canthium glaberriflorum</i>	2	2	10	0.2	0.0005	117.959	1.587302	0.727273	0.5909	2.9054
34	<i>Anopyxis klaineana</i>	2	2	10	0.2	0.0005	117.714	1.587302	0.727273	0.5896	2.9042
35	<i>Entandrophragma cylindricum</i>	3	2	10	0.2	0.00075	21.816	1.587302	1.090909	0.1093	2.7875

36	<i>Irvingia wombolu</i>	1	1	10	0.1	0.00025	277.331	0.793651	0.363636	1.3891	2.5464
37	<i>Rauvolfia vomitoria</i>	2	2	10	0.2	0.0005	7.207	1.587302	0.727273	0.0361	2.3507
38	<i>Pycnanthus angolensis</i>	1	1	10	0.1	0.00025	183.637	0.793651	0.363636	0.9198	2.0771
39	<i>Pterisanthus macrocarpus</i>	1	1	10	0.1	0.00025	111.983	0.793651	0.363636	0.5609	1.7182
40	<i>Drypetes gossweileri</i>	2	1	10	0.1	0.0005	6.119	0.793651	0.727273	0.0306	1.5516
41	<i>Strychnos imoca</i>	1	1	10	0.1	0.00025	76.52	0.793651	0.363636	0.3833	1.5406
42	<i>Millettia excels</i>	1	1	10	0.1	0.00025	60.277	0.793651	0.363636	0.3019	1.4592
43	<i>Cylicodiscus gabunensis</i>	1	1	10	0.1	0.00025	28.751	0.793651	0.363636	0.1440	1.3013
44	<i>Monodora myristica</i>	1	1	10	0.1	0.00025	27.251	0.793651	0.363636	0.1365	1.2938
45	<i>Massularia acuminata</i>	1	1	10	0.1	0.00025	13.463	0.793651	0.363636	0.0674	1.2247
46	<i>Hylocladon gabunense</i>	1	1	10	0.1	0.00025	9.622	0.793651	0.363636	0.0482	1.2055
47	<i>Chrysophyllum albidum</i>	1	1	10	0.1	0.00025	1.32	0.793651	0.363636	0.0066	1.1639

Table 5: Proximate composition of parts of selected plant species foraged by elephant in Okomu National Park

S/N	Name of Species	Plant Part	Carbohydrate %	Protein %	Fibre %	Lipid %	Moisture %	Ash %
1	<i>Anthonotha macrophylla</i>	Bark	31.43	11.42	4.28	1.79	47.26	3.76
2	<i>Trichilia monadelpha</i>	Bark	30.57	1.08	9.42	1.34	49.16	8.41
3	<i>Thaumatococcus daniellii</i>	Root	1.92	0.98	7.44	1.39	89.42	7.85
4	<i>Dioscorea praehensilis</i>	Tuber	41.28	1.04	10.09	0.98	38.11	8.47
5	<i>Desplatsia subericarpa</i>	Fruit	11.85	2.98	7.04	3.98	67.81	6.32

was observed in the dung piles of elephants which was also listed by Short (1981) in addition to two other seeds types namely: *Strychnos aculeatu* and *Klainedoxa gabonensis*. Elephant's droppings contain high percentage of woody material and seeds hence transport considerable dropping material from one place to another serving as an agent of seed dispersal thus contributing to the complexity and diversity of the Park. Elephant feeding behaviour is very important in its effects on the maintenance and functioning of the Okomu National Park. **Elephant browsing and movement opens dense vegetation, creating suitable establishment sites for dispersed seeds (Yumoto et al., 1995). As a result, seed dispersal by elephants favors seedling survival and growth (Nchanji and Plumptre, 2003; Jothish 2013; Spanbauer and Adler, 2015) and promotes forest species diversity (Campos-Arceiz and Blake, 2011).** The study revealed that the total amount of plant matter mouthed by the elephants was not fully consumed (this may be regarded as a wasteful mode of feeding). A relatively large part usually dropped to the ground sometimes utilized by other herbivores thus representing associational behavior between animal inhabitants of the park. Perhaps, the non-eaten vegetation could form a secondary food source to other herbivores in such cases thus; it is not a waste after all. An abundance of alternative food items such as regenerating trees is

perhaps the reason for the low incidence of pushing over. Elephant consumption can alter the vertical structure of the woody plant community, commonly manifested as reduced tree density and increased shrub density (Guy, 1989) and continuous browsing may result in more accessibility in the classes plants size (Jachmann and Bell, 1985; Mapaire and Mhlanga, 2000). The consequences of elephants' presence in the ecosystem such as Okomu National Park may therefore have implications, both positive and negative, for biodiversity. For example, Anderson and Coe's (1974) report on elephant dung demonstrates its use as food for baboons and birds but mainly for both adult and larval beetles (and thus also as an oviposition site), with an estimated 16000 beetle individuals removing 1.5kg of dung in two hour, elephant dominance has conservation implication because of their impact on other species, especially when occurring at relatively high densities (Cumming *et al.*, 1997; Western and Maitumo, 2004; Wiseman, *et al.*, 2004). Under such conditions, their foraging and feeding habits may reduce tree densities and transform forests and intact woodlands into mixed woodlands and even grassland (Dublin *et al.*, 1990; Ben-Shahar, 1993; Barnes *et al.*, 1994; Leuthold, 1996; Trollope *et al.*, 1998; Van De Vijver *et al.*, 1999; Eckhardt *et al.*, 2000; Mosugelo *et al.*, 2002). Elephants have thus been implicated in increased impacts on herbaceous and woody vegetation (Van Wyk and Fairall, 1969; Ben-Shahar, 1993), and declines in plant species composition, density and diversity (Conybeare, 1991) in areas close to water such as lake area. However few species may not be able to satisfy the nutrient requirement hence dependence of the many species. The study will enhance management decision that will ensure sustainable management of the Okomu National Park.

In conclusion, this study revealed the browsing activities of Africa elephant at Okomu National Park and how it's altered the structure and species composition of the foraged vegetation. It is therefore, pertinent to collect and conserve at the gene bank for posterity to prevent the imminent loss of biodiversity at the park.

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