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Differential vegetation status of Okomu National Park and Okomu Forest Reserve, Edo State, Nigeria

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Okomu National Park and Okomu Forest Reserve were established to protect the rich flora and fauna resources. Studies comparing the impact of these two approaches in conserving the rich flora and fauna resources have not been carried out on the study sites. This study is aimed at filling the knowledge gaps and assessed the differences in vegetation status of Okomu National Park and Okomu Forest Reserve. The purpose is to determine how these rich flora resources have been conserved and the conservation strategies that have met this goal, by assessing and comparing biodiversity status. In this study, a systematic sampling technique was used. Four transects (2 km) of 2 m width were utilised. One transect each was laid out per range (Arakhuan, Igwuowan, Babui Creek and Julius Creek range) in Okomu National Park. Four plots of 50 m × 50 m were alternately laid out along each transect. All living trees within each of the sample plots with diameter at breast height (Dbh) ≥ 10 cm were identified. The results indicated that the estimated mean number of trees per hectare for Okomu National Park and Forest Reserve were 386 (74 species) and 160 (55 species) ha^{-1}, respectively. The following tree species *Strombosia pustulata, Nauclea didirechii, Diospyros* species and *Barteria fistulosa* were more prominent in Okomu National Park while in Okomu Forest Reserve, *Diospyros* spp., *Allanblackia flouribunda, Terminali ivorensis,* and *Antanotha macrophylla* were the dominant species. The species richness were 12.76 and 10.84 for Okomu National Park and Forest Reserve, respectively. Shannon-Wiener diversity index (H^l) for Okomu National Park and Forest Reserve were 3.920 and 3.795, respectively. Despite the variation in the per hectare estimates of the two sites, the study revealed that floristic similarity between the two sites was significantly above the critical level judging from the value of the Sorenson's index (52%). The study proved that Okomu National Park showed better impact in conserving the rich flora resources than Okomu Forest Reserve.

Key words: Flora composition, species richness, species diversity, similarity index, vegetation status.

INTRODUCTION

Tropical rainforests contain trees of evergreen broadleaved species which do well between 10° north and 10° south of the equator under high humidity of low altitudes and temperature (Park, 1992). Wilson (1988), Osborne (2000) and MEA (2005), reported that tropical rainforests of the globe provide habitat for half or more of the world's known terrestrial plant and animal species and have abundant and diverse plant and animal

species. This makes it the world's most divers ecosystems. Biodiversity is significant for the protection of ecological systems (Haines-Young and Potschin, 2010) and every species have a basic role towards maintenance of this ecosystem (Jones and Lawton, 2012). Even though tropical rainforests occupy only about 7% of the total land area of the world (Whitmore, 1998), it holds 50% of the terrestrial carbon pool (Gorte and Sheikh, 2010). This is due to its status of having the highest tree diversity on earth (Clark et al., 1999).

According to Whitmore (1998), tropical rainforests in Africa contribute only 21.7% (1.8 million km^2) of world's total, making it less expansive than both the Southeast Asia and Latin America tropical rainforests. It stretches from the Congo basin westwards through Gabon and Cameroon and follows a narrow belt along the coast of the Gulf of Guinea, through Nigeria to Ghana and beyond, finally ending in Guinea at about 10°N (Richards, 1996). In Nigeria, approximately 35% of the country's total land mass of 997,936 km^2 is occupied by natural forest of total land area of 349,278 km^2 (Nweze, 2002). These forests have been under threat since 1979 (Aigbe and Oluku, 2012). On the average it decreased at the rate of 0.4 million ha per year (Nweze, 2002). Out of the land mass of 997,936 km^2, only 10% is under forest reserve (Aruofor, 2001) while seven National Parks have been established by the Federal Government with an intention to stem the dwindling forest resources in Nigeria. These 10% of forest reserves have deteriorated at an alarming rate and the National Park is under threat. There is therefore the need to ascertain the vegetation status of both forest reserve and national park. This aims at comparing the impact of the two approaches towards achieving the set goal of conserving the remaining tropical rainforests in Nigeria. Hence, this necessitates this research of differential status of Okomu Forest Reserve and Okomu National Park.

METHODOLOGY

Okomu Forest Reserve and National Park are both located about 45 km west of Benin City, the Edo State capital in the southern part of Nigeria. The Forest Reserve occupies an area of 1,238 km^2 while Okomu National Park, which is a forest block within Okomu Forest Reserve, has a size of 202 km^2. Both are situated between longitudes 5° and 5° 30'E and latitude 6° 10' N and 6° 30'N (Onojeghuo and Onojeghuo, 2015) (Figure 1).

The study sites have the same climatic condition and are relatively low lying with an average elevation of 25 m above sea level. It is drained to the east by River Osse and to the west by River Siluko. The sands are made up of red earth and form a relatively thick series of deposits which are conformable with and partly inter-stratified with lignites and clays (FRIN, 2000). The soil in these sites is ferrallitic, composed of quartzite and kaolin from tertiary secondary sedimentary rocks (Ikhuoria, 1993). The geological formation of the soils of the study sites is the coastal plains sands and Lignite group, which is of late Tertiary age. According to FRIN (2000), the coastal plains sand sub-formation is what was formerly referred to as the "Benin Sands" group. The soil texture varied from loamy sand to sandy loam (FRIN, 2000). The soil has a mean pH of 5.0 which is highly weathered, poor in nutrient and is formed from sandstones. The soil acidity decreases down the profile (FRIN, 2000). The climate of Okomu is tropical, with well-marked rainy and dry seasons. The mean annual rainfall is 2 100 mm, which falls mainly between March and October, with the highest rainfall occurring in July and/or September. The dry season begins in November and ends in February. The relative humidity is high, not less than 65% during the afternoons in any month of the year. The mean monthly temperature is 30.2°C. The highest rainfalls occur in June, July and September (FRIN, 2000). The vegetation of Okomu Forest Reserve and National Park consists of lowland rainforest, semi-deciduous, humid and freshwater swamp forests found along the rivers within the study sites.

Method of data collection and analysis

Systematic sampling technique was employed for the study. Four transects (2 km) of 2 m width were cut at 1 km interval in the reserve while one transect each was laid per range (Arakhuan, Iguowan, Babui Creek and Julius Creek range) in Okomu National Park. Four plots of 50 m × 50 m were alternately laid out along each transect. All living trees within each of the sample plot with Dbh ≥ 10 cm were identified. The enumeration of the tree species found in the reserve was done with the help of a forest taxonomist. Data analyses were carried out using simple statistics (frequency), t- test and various biodiversity indices like Shannon-Wiener, species richness and evenness indices. Tree enumeration was done on per hectare basis.

RESULTS AND DISCUSSION

Floristic composition

Over the entire sample plots size of 50 m × 50 m a total of 1552 and 618 trees were found in Okomu National Park and Forest Reserve, respectively. A total of 74 species were distributed among 30 families and 65 genera in Okomu National Park while a total of 55 species distributed among 31 families and 49 genera were recorded in Okomu Forest Reserve (Table 1). This distributions of tree species indicate that the study sites are repository of timber species when compared with 49 tree species distributed among 24 families and 43 genera recorded for Ehor Forest Reserve, Nigeria (Aigbe et al., 2017) and 46 tree species distributed among 30 families and 44 genera in Billy Barquedier National Park, District

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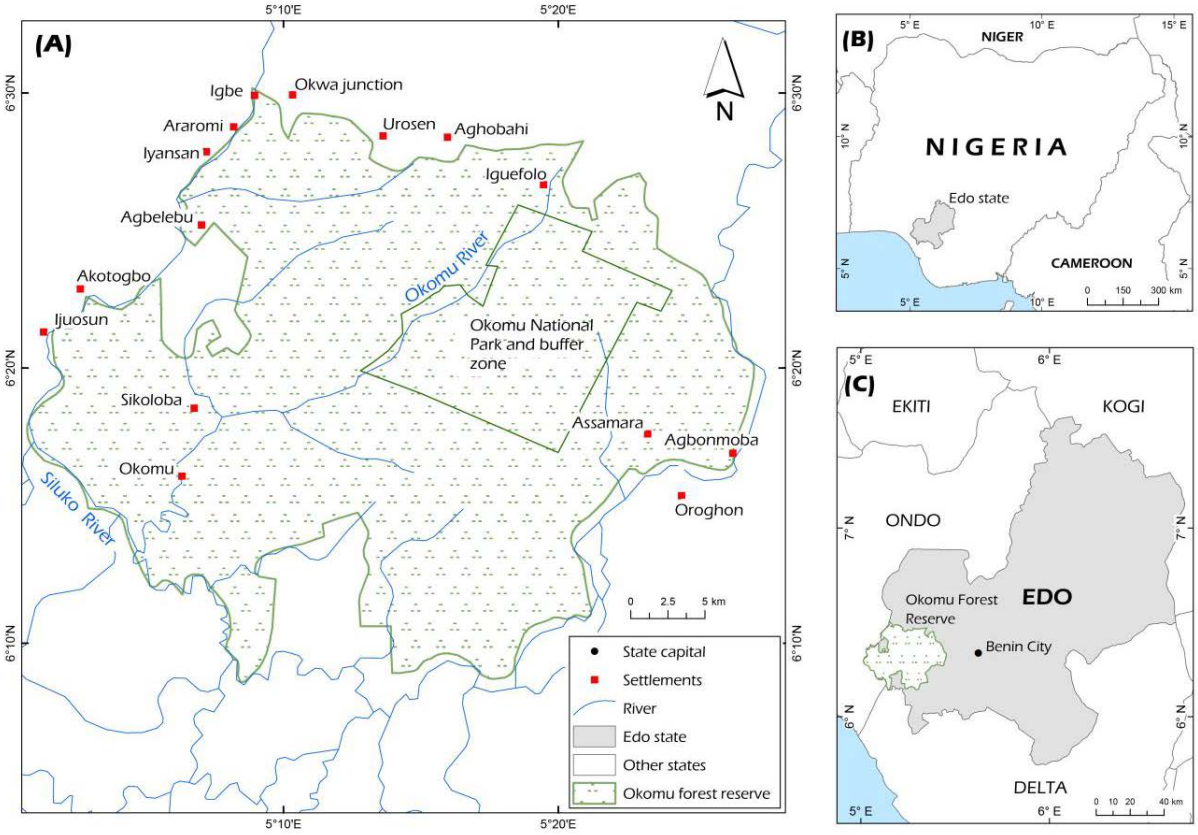

Figure 1. Map of the study sites showing (A) Okomu Forest Reserve and within Okomu National Park, (B) Nigeria showing Edo State and (C) Edo State showing Okomu Forest Reserve.
Source: Onojeghuo and Onojeghuo (2015).

of Stann Creek Valley in southeast Belize (Luna-Kamyshev et al., 2020). However, the tree species distribution was more abundant in Okomu National Park than in Okomu Forest Reserve. The estimated mean number of tree per hectare for Okomu National Park and Forest Reserve were 386 and 160 ha^{-1}, respectively. The number of trees per hectare was higher in Okomu National Park than Okomu Forest Reserve because there were evidence of intense logging and farming activities in Okomu Forest Reserve. This may have contributed to the lower tree density in the reserve. The results of the study with reference to average trees per hectare prove better for the management objective in Okomu National Park than the Forest Reserve. Also, it should be noted that tree stocking is better in Okomu National Park when compared with other tropical rainforest around the globe. For example, Ho et al. (1987), reported 104 trees/ha for tropical Jengka Reserve, Malaysia; Hubbell and Foster (1983) and Thorington et al. (1982), reported 152 and 171 trees/ha for tropical Barro Island in Panama, respectively. By contrast, Aigbe (2014), reported average trees per hectare for both Afi River and Oban Forest Reserves to be 323 and 306, respectively and 405 trees/ha reported by Salami and Akinyele (2018), in Omo Biosphere Reserve, Ogun State, Nigeria. The studied sites could be considered to be species rich in terms of number of stem density per hectare since according to Onyekwelu et al. (2008), between 100 and 300 tree species ha^{-1} are found in rainforests while Nwoboshi (1982), reported that the number of tree species ha^{-1} could be as high as 400 in very rich rainforests. Tree density can be influenced by natural calamities, soil properties and anthropogenic activities (Adekunle et al., 2013a).

The order of family dominance varied in each site. The first four dominant families in Okomu National Park were Meliaceae (8), Rubiaceae (8), Annonaceae (6) and Moraceae and Sterculiaceae (5) while in Okomu Forest Reserve, Apocynaceae (6), Annonaceae (5) and Meliaceae (4) were the dominant families (Table 1). Dominant families in the two sites were different from those reported for tropical rainforest ecosystems in other part of the globe. For example, Aigbe et al. (2014), reported members of the Caesalpinioideae,

Table 1. Tree Species Abundance in Okomu National Park and Okomu Forest Reserve.

Family	Species	Ab_p	Ab_R	R Ab_p	R Ab_R
Annonaceae	*Annomdium manii*	5	0	0.0032	0
Annonaceae	*Cleistopholis patens*	45	18	0.0290	0.0285
Annonaceae	*Enantia chlorantha*	5	9	0.0032	0.0142
Annonaceae	*Monodora myristica*	25	6	0.0161	0.0095
Annonaceae	*Monodora tenuefolia*	10	0	0.0064	0
Annonaceae	*Polyalthia suaveolens*	0	4	0	0.0063
Annonaceae	*Polyceratocarpus parviflorus*	0	4	0	0.0063
Annonaceae	*Xylopia aethiopica*	5	8	0.0032	0.0127
Apocynaceae	*Alstonia boonei*	20	14	0.0129	0.0221
Apocynaceae	*Antiaris africana*	5	0	0.0032	0
Apocynaceae	*Funtumia elastic*	15	0	0.0097	0
Apocynaceae	*Hunteria umbellate*	0	5	0	0.0079
Apocynaceae	*Pleioceras barterii*	0	7	0	0.0111
Apocynaceae	*Rauwolfia vomitoria*	0	11	0	0.0174
Apocynaceae	*Tabernaemontana pachysiphen*	5	0	0.0032	0
Apocynaceae	*Voacanga africana*	0	3	0	0.0048
Apocynaceae	*Voacanga amydalina*	0	2	0	0.0032
Arecaceae	*Elaeis guineensis*	0	1	0	0.0016
Asteraceae	*Vernonia amydalina*	0	4	0	0.0063
Bombacaceae	*Ceiba pentandra*	45	27	0.0290	0.0427
Boraginaceae	*Cordia millenii*	0	4	0	0.0063
Burseraceae	*Canarium schweinfurthii*	5	0	0.0032	0
Burseraceae	*Dacryodes edulis*	0	1	0	0.0016
Caesalpiniodeae	*Antanotha macrophylla*	35	30	0.0226	0.0475
Caesalpiniodeae	*Daniella ogea*	10	5	0.0064	0.0079
Caesalpinioideae	*Brachystegia eurycoma*	10	0	0.0064	0
Caesalpinioideae	*Hylodendron gabunense*	5	0	0.0032	0
Capparaceae	*Bulchholzia coriacea*	15	7	0.0097	0.0111
Combretaceae	*Terminalia ivorensis*	25	36	0.0161	0.0570
Combretaceae	*Terminalia superba*	50	10	0.0322	0.0158
Ebenaceae	*Diospyros* spp.	70	51	0.0451	0.08070
Euphorbiaceae	*Bridelia ferruginea*	7	1	0.0045	0.0016
Euphorbiaceae	*Drypetes chevalieri*	5	0	0.0032	0
Euphorbiaceae	*Macaranga barteri*	5	8	0.0032	0.0127
Fabaceae	*Albizia ferruginea*	0	2	0	0.0032
Fabaceae	*Albizia zygia*	0	9	0	0.0142
Fabaceae	*Guibourtia* spp.	55	0	0.0354	0
Flacourtaceae	*Scottelia coriaceae*	15	0	0.0097	0
Gutteferae	*Allanblackia flouribunda*	30	41	0.0193	0.0649
Irvingiaceae	*Irvingia gabonense*	5	5	0.0032	0.0079
Irvingiaceae	*Irvingia wumbolo*	20	0	0.0129	0
Lauraceae	*Pycnathus angolensis*	20	9	0.0129	0.0142
Lecythidaceae	*Combredendron macrocapum*	45	0	0.0290	0
Leguminisae	*Desmodium adscendens*	0	4	0	0.0063
Leguminisae	*Distemonanthus benthamianus*	0	20	0	0.0317
Meliaceae	*Carapa procera*	10	0	0.0064	0
Meliaceae	*Entandrophragma angolensis*	35	6	0.0225	0.0094
Meliaceae	*Entandrophragma cylindricum*	5	0	0.0032	0

Table 1. Contd.

Meliaceae	*Guarea cedrata*	20	6	0.0129	0.0095
Meliaceae	*Guarea thompsonii*	5	0	0.0032	0
Meliaceae	*Khaya ivorensis*	35	13	0.0226	0.0206
Meliaceae	*Lovoa trichiloides*	25	5	0.0161	0.0079
Meliaceae	*Trichilia monadelpha*	5	0	0.0032	0
Mimosoideae	*Piptadeniastrum africanum*	10	9	0.0064	0.0142
Mimosoideae	*Tetrapleura tetraptera*	50	0	0.0322	0
Moraceae	*Ficus exaspirata*	5	2	0.0032	0.0032
Moraceae	*Ficus mucosu*	5	0	0.0032	0
Moraceae	*Musanga cecropioides*	10	6	0.0064	0.0095
Moraceae	*Treculia oblonga*	5	0	0.0032	0
Moraceae	*Treculia rhinopeta*	10	0	0.0064	0
Moraceae	*Treculia africana*	0	11	0	0.0174
Myristicaceae	*Staudtia stipitata*	20	6	0.0129	0.0095
Ochnaceae	*Lophira alata*	30	11	0.0193	0.0174
Olacaceae	*Strombosia pustulata*	85	27	0.0548	0.0427
Papilionoideae	*Baphia nitida*	45	9	0.0290	0.0142
Papilionoideae	*Pentracletra macrophylla*	10	1	0.0064	0.0016
Papilionoideae	*Pterocarpus indicus*	5	0	0.0032	0
Passifloraceae	*Barteria fistulosa*	65	34	0.0419	0.0517
Phyllanthaceae	*Margaritaria discoidea*	30	0	0.0193	0
Rhamnaceae	*Maesopsis eminii*	0	4	0	0.0063
Rubiaceae	*Canthium glabripholium*	15	0	0.0097	0
Rubiaceae	*Massularia acuminate*	5	0	0.0032	0
Rubiaceae	*Nauclea didirechii*	70	0	0.0451	0
Rubiaceae	*Pausnylstalia johimbe*	40	0	0.0258	0
Rubiaceae	*Porteranda clandata*	25	0	0.0161	0
Rubiaceae	*Ricinodendron heudelotti*	20	17	0.0129	0.0269
Rubiaceae	*Rothmania hispida*	40	0	0.0258	0
Rutaceae	*Zanthoxylium zanthozeloides*	30	3	0.0193	0.0048
Sapindaceae	*Blighia sapida*	10	0	0.0064	0
Simaroubaceae	*Hanoa klaneina*	5	0	0.0032	0
Sterculiaceae	*Cola gagantiea*	5	0	0.0032	0
Sterculiaceae	*Cola smithii*	30	0	0.0193	0
Sterculiaceae	*Cola schott*	0	16	0	0.0253
Sterculiaceae	*Mansonia altissima*	10	0	0.0064	0
Sterculiaceae	*Sterculia rhinopeta*	20	0	0.0129	0
Sterculiaceae	*Sterculia oblonga*	0	13	0	0.0206
Sterculiaceae	*Triplochyton scleroxylon*	5	4	0.0032	0.0063
Tiliaceae	*Desplatzia subericapa*	5	0	0.0032	0
Ulmaceae	*Celtis zenkeri*	45	19	0.0289	0.0301
Ulmaceae	*Celtis bonsai*	0	42	0	0.0664
Urticaceae	*Myrianthus arboreus*	35	2	0.0226	0.0032
Total		1552	618	1	1

Ab_p – Species Abundance in Okomu National Park; Ab_R – Species Abundance in Okomu Forest Reserve; R Ab_p – Species Relative Abundance in Okomu National Park; Rb_R – Species Relative Abundance in Okomu Forest Reserve.
Source: Field Work (2019).

Mimosoideae, Euphorbiaceae and Meliaceae families to be dominant families in Afi River Forest Reserve, Cross River State, Nigeria. Aigbe and Omokhua (2015) also reported Caesalpinioideae, Mimosoideae, Moraceae and

Table 2. Summary of the Various Diversity indices computed for Okomu National Park and Forest Reserve.

Characteristic	Okomu National Park	Okomu Forest Reserve
Species Richness (d)	12.76[a]	10.84[b]
Shannon Wiener Index (H^l)	3.920[a]	3.795[b]
Evenness Index (E)	0.914[a]	0.915[a]

Means followed by different superscripts are significantly different at 0.05 level of significance. Source: Field Work (2019).

Papilionoideae and Meliceae in Oban Forest Reserve, Cross River State, Nigeria. Salami and Akinyele (2018) reported Apocynaceae*,* Sterculiaceae*,* Papilionaceae and Moraceae in Omo Biospere Reserve, Ogun State, Nigeria, while Luna-Kamyshev, (2020) reported Fabaceae, Sapotaceae, Malvaceae, Sapindaceae and Moraceae as dominant families in tropical evergreen forest of Belize.

Among the 74 species documented for Okomu National Park, *Strombosia pustulata, Nauclea didirechii, Diospyros* species and *Barteria fistulosa* had the highest density which accounted for 5.5, 4.5, 4.5 and 4.2% of the total tree density, respectively (Table 1). In Okomu Forest Reserve, out of 55 tree species, *Diospyros* spp., *Allanblackia flouribunda, Terminalia ivorensis,* and *Antanotha macrophylla* had the highest density accounting for 8.1, 6.5, 5.6 and 4.7% of the total tree density, respectively (Table 1). By comparison, Salami and Akinyele (2018), reported *Diospyros dendo, Funtumia elastic, Sterculia rhinopetala, Nesogordonia papaverifera, Baphia nitida* and *Phyllanyhus discoideus* as species with the highest density while Luna-Kamyshev (2020), recorded *Attalea cohune, Terminalia Amazonia* and *Pouteria* species as the most dominant tree species. Smaller tree density recorded for Okomu National Park did not translate to fewer trees. There was accumulatively more number of trees species present in Okomu National Park. Some species have less than five trees per hectare, indicating that these species might be under threat of extinction probably due to anthropogenic factor. Tropical tree species (less than 10 individual per hectare) that are vulnerable and threatened with extinction are endangered species (FORMECU, 1999).

Biodiversity Indices

The species richness indices were 12.76 and 10.84 for Okomu National Park and Forest Reserves, respectively (Table 2). The results indicated that Okomu National Park has higher tree species richness than Okomu Forest Reserve. This was collaborated by the result of t-test, which showed that species richness of Okomu National Park was significantly higher than that of Okomu Forest Reserves. The values of the species richness is quite high when compared with the value (10.44) obtained for Afi River Forest Reserve, Cross River State, Nigeria (Aigbe et al., 2014) and 10.61 for Oban Forest Reserve, Cross River, Nigeria (Aigbe and Omokhua*.,* 2015). According to Aigbe (2014), anthropogenic factors and soil quality play a greater role in influencing value of biodiversity indices. The implication for high species richness for the two sites is that the forest environments are stable, thus there is high possibility of sustainability if the forests are well managed.

The values of Shannon-Wiener diversity index (H') for Okomu National Park and Forest Reserve were 3.920 and 3.795, respectively (Table 2). The results of t-test revealed a significant difference ($p < 0.05$) in species diversity indices of the two sites, which indicated that Okomu National Park is significantly ($p < 0.05$) higher in species diversity than Okomu Forest Reserve. Comparable values reported for tree species diversity values in tropical forests of Kalakad Reserved Forests in Western Ghats were 3.31 and 3.69 (Parthasarathy et al., 1992). In Strict Nature Reserve in South Western State of Nigeria and Akure Forest Reserve, the values were 3.74 (Adekunle et al., 2013a) and 3.037/3.16 (Adekunle et al., 2013b), respectively. While in some other tropical rainforest sites in Southern Nigeria, the values range between 3.34 and 3.66 as was reported by Adekunle (2006) and Adekunle and Olagoke (2008).

The evenness indices had a high value of 0.914 and 0.915 in Okomu National Park and Forest Reserve, respectively. The values are indications of high species distribution in the study sites. Onyekwelu (2008) and Salami and Akinyele (2018) reported high species distribution similar to high value reported in the study sites. The higher evenness index, the more species are proportionally distributed and vice versa.

Similarity index

As shown in Table 3, the Sorenson's similarity index of the floristic comparison between Okomu National Park and Forest Reserve is 52%. This value indicates that the variation in the species composition of the two sites is close to critical level of 50% significant in similarity. This implies that about 52% of the species in the two sites are similar, which means that Okomu National Park and

Table 3. Sorenson's index of Okomu National Park and Forest Reserve.

Site	Okomu National Park	Okomu Forest Reserve
Okomu National Park	0.52	-
Okomu Forest Reserve	-	0.52

Forest Reserve have an average floristic similarity. The lesser the variation in the species composition of two forest communities the higher the species similarity index value. The similarity of species in Okomu National Park and Forest Reserves is lower than reports of some tropical rainforest ecosystems in Nigeria. For example, Aigbe et al. (2014) reported higher species similarity index of 84% between Afi River and Oban Forest Reserves in tropical rainforest ecosystems of Cross River State, Nigeria. By contrast, Gebreselasse (2011) reported range of 25 to 39% of similarity indices for some tropical forest ecosystems in Kenya.

Conclusion

Okomu National Park and Forest Reserve were established to conserve the rich flora and fauna resources of both sites. While Okomu National Park was primarily established to protect and conserve the rich flora and fauna resources, Okomu Forest Reserve was created to primarily manage rich timber resources. The question is that, how have this two establishment succeeded in achieving their aim using these conservation strategies in conserving this rich flora resources. From the results, it is evident that there were more trees per hectare in Okomu National Park than Okomu Forest Reserve. The diversity indices showed more tree species diversity in Okomu National Park. The implication is that, the conservation strategy in establishing Okomu National Park produced better impact in conserving the rich flora resources than Okomu Forest Reserve. Although, there is an indication that the vegetation in Okomu Forest Reserve has been disturbed in the recent past, however, there is a strong signs of recovery if a sound management programme is put in place.

CONFLICT OF INTERESTS

The authors have no conflict of interests to declare.

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