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An appraisal of tree and fauna species diversity and distribution of Osogbo sacred grove, Osun State, Nigeria

Abstract

Appraisal of tree and fauna species is crucial; this ensures effective conservation of the forests and their resources. This study aims at an appraisal of tree and fauna species diversity in Osun-Osogbo Sacred Grove, Nigeria for record update, knowledge, and monitoring species status for conservation management. A total of 70 tree species belonging to 26 families were recorded. The tree species in the *Fabaceae* and *Apocynaceae families* were the most abundant. Tree species richness indices for the three zones were 2.16, 1.89, and 1.72, respectively. Most of the tree species encountered were in the IUCN categories of *vulnerable* (6.7%), *least concerning (71.1%),* and *not evaluated* (71.1%). The result revealed that the core zone was richer and more diverse than the buffer and the outer zones, with diversity indices of 3.06, 2.995, and 2.16, respectively. The fauna species diversity and richness index were 3.40 and 2.35, respectively. The least vulnerable fauna species were 86.4%, with 6.8% vulnerable. Class *Aves* has the highest percentage of 61.4%, with *Gastropoda* being the least-represented (2.3%). Mona monkeys were the most sighted fauna species in the area. Thus, there is an urgent need to increase the level of security around the sacred grove and to ensure sustainable management strategies are fully implemented in the study area.

Keywords: conservation, fauna species, sacred-grove, sustainable management, tree species

Volume 5 Issue 1 - 2022

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Received: July 04, 2022 | **Published:** November 11, 2022

Introduction

Sacred groves are forests that have been protected throughout the ages by traditional societies and norms.[1] They have served as valuable storehouses for biodiversity. Local communities derive different benefits through the preservation of sacred sites while practising their faiths and upholding their traditional customs.[2] As a result of sacred groves' significant contributions to the preservation of in-situ biodiversity, they are now recognized as biodiversity hotspots and serve as safe havens for threatened and endangered species by Myers. Sacred groves are currently significant remnants of climax vegetation and frequently support populations of rare and endangered plants.[3]

There is no recent documentation to show the effect of encroachment due to farming activities, illegal felling of trees for timber, harvest of plant materials for medicinal purposes and fuel, which are being carried out in the buffer and outer zones of the grove, on the biodiversity of the area. It is rumored that increased use pressures and encroachments at the grove's buffer and outer zones harmed the area. The extent of the damage these may have caused is yet to be ascertained. Be it trees or fauna, it is possible that species once thought to be present in the grove may have been decimated, be it trees or fauna. However, present conditions of individual tree and animal species are not documented. Similarly, the status of many species may have changed, and previously abundant species may be endangered, while those thought to be endangered might be on the verge of extinction due to limited information on the biodiversity of the area. This study aims to appraise the status of tree and fauna species diversity and distribution in Osogbo sacred grove due to anthropogenic encroachment on the study area, in order to provide updated documentation and knowledge on the distribution and abundance of species in the area for the purpose of conservation management.

Methodology

Location of the study area

Osun Osogbo Sacred Grove (OOSG) is situated in Osogbo, the capital of Osun State in Nigeria. The study area is situated between longitudes 4:32:40 and 4:33:440 and latitudes 7:44:50 and 7:46:00. In Osogbo town, Osun State, Nigeria, the Sacred Grove is situated across the banks of the Osun River. It was established some 400 years ago, and it is Yorubaland's biggest remaining sacred grove.[4] The grove is surrounded by a 47-hectare buffer zone and contains a 75-hectare forest area.[5] OOSG was designated a UNESCO World Heritage Site in 2005.[6]

The National Commission for Museums and Monuments (NCMM), an agency of the Federal Government of Nigeria, is in charge of safeguarding cultural assets in Nigeria. In the instance of OOSG, armed guards are stationed there 24 hours a day.[7] More than 400 plant species can be found in Osun OSG, which also serves as a refuge for animals including the endangered red-capped mangabey (Cercocebus sp.), putty-nosed monkey (*Cercopithecus nictitans*), and white-throated monkey (Cercopithecus erytrogaster).[8,9] The forest sanctuary is home to 40 shrines, two historic castles, and several sculptures and works of art dedicated to Osun and other gods.[10] Around 27°C is the average annual temperature, while between 92 and 99 percent of the region is covered by relative humidity.[11] The average annual rainfall ranges from 1200 to 1450 mm. Within the grove, the microclimate is more humid than it is throughout most of southern Nigeria (Figure 1).[12]

Data collection

Line transect sampling (random survey method) was adopted for the assessment of fauna diversity in the study area; while cluster and systematic sampling designs were adopted to assessed tree diversity

at the three vegetation zones (riparian forest, dry high forest, and derived savanna) of the grove, which cut across the core zone, buffer zone and outer zone of the area. Three quadrants of 50 × 50 m were established at 100 m intervals in each of the vegetation zones of the sacred Grove. Nine quadrants were laid in total (i.e. three quadrants in each zone) and 100% enumeration of tree species ≥10cm was carried out at the outer zone of the area. All the species in the sample plots were identified. Direct observations of wildlife was done using a line transect sampling design (Random method) within the hours of 7am - 10:30am and 4:30pm - 6:30pm; information on wildlife species sighted by the workers was also collected.[13]

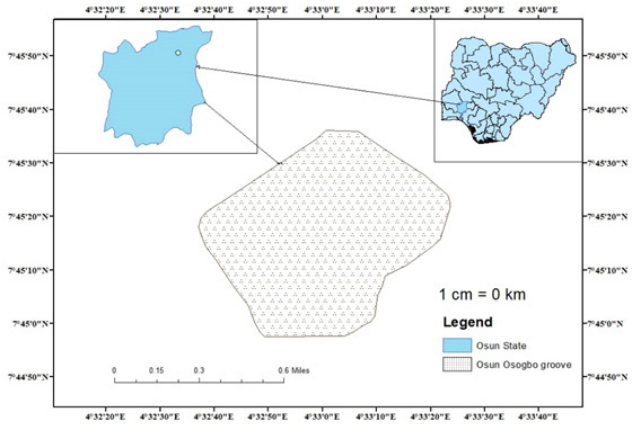

Figure 1 Map of Osun-Osogbo Sacred Grove.

Source: Adesoji et al.[13]

Data analyses

i. Tree species diversity

Tree species diversity index was calculated using Shannon - Wiener's diversity index as follows:

$$H' = -\sum_{t=1}^{S} Piln(Pi) \quad \ldots\ldots\ldots\ldots\ldots (1)$$

Where: *S,* total number of species in the community; P_i, proportion of S made up of the *i*th species; *ln,* natural logarithm.

ii. Tree species richness

Tree species richness in the area was computed using Margalef's index of species richness:[14]

$$d = \frac{S}{\sqrt{N}} \quad \ldots\ldots\ldots\ldots\ldots (2)$$

Where: S, number of species encountered; N, total number of individuals of all the tree species.

iii. Tree species evenness

The species evenness was computed using Piolu's index modified by Magurran[15] as:

$$E' = \frac{H'}{lnS} \quad \ldots\ldots\ldots\ldots\ldots (3)$$

Where: H', Shannon-Wiener diversity index; S, number of species; E' is constrained between 0 and 1 (the lesser the variation between the species in the communities, the lower the value of E' and vice versa).

iv. Fauna population estimation

Fauna population estimation was done using:

$$NH = \frac{nk + (1-)(nK - nK - 1)}{\alpha} \quad \ldots\ldots\ldots\ldots\ldots (4)$$

Where: NH, Estimated population, nk, highest value in observation, nk -1, next to highest value, α, confidence interval

v. Population density

Fauna population density was determined using:

$$\frac{NH}{A} \quad \ldots\ldots\ldots\ldots\ldots (5)$$

Where: A, area in km; NH, Estimated population

Results

A total of 32 tree species, belonging to 19 families were encountered at the core zone of the sacred grove. *Cola millenii* was the most frequently occurring species in the area with diversity index of 0.307. The least occurring species were *Alstonia boonei, Terminalia ivorensis, Zanthoxylum zamthoxyloides* with diversity index of 0.025 each (Table 1). At the buffer zone of the sacred grove 27 tree species belonging to 17 families were encountered. *Baphia nitida*has the most occurring frequency with diversity index of 0.2454. *Alstonia boonei, Ceiba pentandra, Hevea brasiliensis* and *Terminalia ivorensis* has the least frequency of occurrence in the area (Table 1). At the outer zone of the grove, 11 tree species were identified from 10 families; with Fabaceae having the highest occurrence of 11 tree stands in the area. This was followed by Arecaceae family which occurrence 6 while Piperaceae family was the least occurred family with a tree species (*Peperomia pellucid)* in the area (Table 1).

Table 1 Tree spcies occurrences in Osun Osogbo Sacred Grove

Common name	Scientific name	Family	Local name	Frequency
Mountain thistle	*Acanthus montanus*	Acanthaceae	Ahon ekun	2
Adenia	*Adenia cissampeloides*	Passifloraceae	Arokeke	4
African Mahogany	*Afzelia Africana*	Fabaceae	Apa	11
White siris or karoi tree	*Albizia procera*	Fabaceae	Ayunre	33
Murarahomba	*Alchornea laxiflora*	Euphorbiaceae	Ijan	9
Cheese wood,	*Alstonia boonei*	Apocynaceae	Ahun	2
Stool Wood	*Alstonia congensis*	Apocynaceae	Ahun	3
African custard-apple	*Annona senegalensis*	Annonaceae	Arere	3
Cabbage tree	*Anthocleista djalonensis*	Gentianaceae	Sapo	19
Sacking tree	*Antiaris toxicaria*	Moraceae	Ooro	16
Common bamboo	*Bambusa vulgaris*	Poaceae	Oparun	4

Table Continued...

Common name	Scientific name	Family	Local name	Frequency
Camwood	*Baphia nitida*	Fabaceae	Iyerosun	28
Ackee or akee	*Blighia sapida*	Sapindaceae	Isin-oko	8
Naga	*Brachystegia eurycoma*	Fabaceae	Ako	23
Crimson thyme	*Byrsocarpus coccineus*	Connaraceae		5
	Canthium hispidum	Rubiaceae		2
Cattle stick	*Carpolobia lutea*	Polygalaceae	Osunsun	2
White silk-cotton tree	*Ceiba pentandra*	Malvaceae	Araba	3
-	*Celtis zenkeri*	Ulmaceae		20
Monkey cola	*Cola millenii*	Sterculiaceae	Obi edun	52
African ebony	Diospyros mespiliformis	Ebenaceae	Bobori	12
-	*Enantia chlorantha*	Annonaceae	Awopa	9
Cape fig	*Ficus capensis*	Moraceae	Opoto	3
Silkrubber	*Funtumia elastic*	Apocynaceae	Ire	21
Madre	*Gliricidia sepium*	Fabaceae	Agunmaniye	10
Rubber tree	*Hevea brasiliensis*	Euphorbiaceae	Eyun	1
False Rubbertree	*Holarrhena floribunda*	Apocynaceae	Ako ire	12
Lannea .	*Lannea welwitschii*	Anacardiaceae	Opon	5
-	*Lecaniodiscus cupanioides*	Sapindaceae	Aka	17
African teak	*Milicia excels*	Moraceae		2
African nutmeg	*Monodora tenuifolia*	Annonaceae	Lakunsin	4
Monkey tamarind	*Mucuna pruriens*	Fabaceae	Yerepe	1
-	*Nesogordonia papaverifera*	Malvaceae	Ira	2
Boundary tree	*Newbouldia laevis*	Bignoniaceae	Akoko	22
-	*Olax subscorpioidea*	Olacaceae	Ifon	4
Palm tree	*Palmae sp*	Arecaceae	Ope	24
Pepper elder	*Peperomia pellucid*	Piperaceae	Rinrin	1
Monkey's Potato	*Solenostemon monostachyus*	Lamiaceae	Olojongbodu	3
Hog plum	*Spondias mombin*	Anacardiaceae	Iyeye	15
Black afara	*Terminalia ivorensis*	Combretaceae	Idigbo	2
Puncture vine	*Tribulus terrestis*	Zygophyllaceae	Peregun	6
African whitewood	*Triplochiton scleroxylon*	Malvaceae	Arere	12
Small-Fruit Wild Frangipani	*Voacanga Africana*	Apocynaceae	Dodo	22
Senegal prickly-ash	*Zanthoxylum zamthoxyloides*	Rutaceae	Ata	7

A total of 26 families were identified at the osun osogbo sacred grove (core, buffer and outer) while most species sighted were belonging to family of *Fabaceae* (15.7%) and *Apocynaceae* (12.9%) and the least represented families were Acanthaceae*, Connaraceae, Lamiaceae, Passifloraceae, Piperaceae, poaceae, Polygalaceae, Rubiaceae, Ulmaceae* and *Zygophyllaceae*as each had 1.4 % occurrence of tree stands (Table 2).

Table 2 Family composition of tree species in Osun Osogbo Sacred Grove

Family	Frequency	Percentage
Acanthaceae	1	1.4
Anacardiaceae	4	5.7
Annonaceae	3	4.3
Apocynaceae	9	12.9
Arecaceae	2	2.9
Bignoniaceae	2	2.9
Combretaceae	2	2.9
Connaraceae	1	1.4
Ebenaceae	2	2.9
Euphorbiaceae	3	4.3
Fabaceae	11	15.7
Gentianaceae	2	2.9
Lamiaceae	1	1.4
Malvaceae	6	8.6
Moraceae	4	5.7
Olacaceae	2	2.9
Passifloraceae	1	1.4
Piperaceae	1	1.4
Poaceae	1	1.4
Polygalaceae	1	1.4
Rubiaceae	1	1.4
Rutaceae	3	4.3
Sapindaceae	3	4.3
Sterculiaceae	2	2.9
Ulmaceae	1	1.4
Zygophyllaceae	1	1.4
Total	**70**	**100**

Four hundred and sixty six individual trees were identified with 70 species, 44 genera and 26 families. Tree species diversity index of the study area had an estimated index of 3.88, dominance of 0.027, species richness of 3.24 and evenly distributed index of 0.69. Trees identified at the buffer, Core and Outer zones were 220, 205 and 41

respectively; tree species were recorded at the Core zone (32), 27 (Buffer zone) and 11 at Outer zone. Tree species diversity index of 3.06 was recorded at the Core zone; this was followed by Buffer zone (3.00) while the Outer zone had 2.16 diversity indexes. The species richness index of 2.16 was recorded at the Core zone, followed by Buffer zone which had 1.89 and Outer zone had an evenly distributed species richness of 1.72 in the study area (Table 3). Tree species composition and status of the study area were assessed and the result of the finding is presented on Table 4. Based on this finding, the grove was composed of 46 tree species; 8 tree species had a status of "Least concern" on IUCN list, 3 species had a status of "Near threatened", 32 species had a status of "Not evaluated" and 3 species had a status of "Vulnerable" on the IUCN list.

Table 3 Tree species diversity and distribution in Osun-Osogbo Sacred Grove, Osun State-Nigeria

Indices	Buffer zone	Core zone	Outer zone
Individuals	205	220	41
Taxa_S	27	32	11
Dominance_D	0.06	0.07	0.14
Shannon_H	3.00	3.06	2.16
Evenness_e^H/S	0.74	0.67	0.79
Menhinick	1.89	2.16	1.72
Pooled diversity of the study area			
Individuals	466	466	466
Taxa_S	70	69	71
Dominance_D	0.02749	0.02372	0.03126
Shannon_H	3.883	3.815	3.951
Evenness_e^H/S	0.6939	0.6495	0.7383
Menhinick	3.243	2.243	4.243

Table 4 Tree species composition and status in the study area

Scientific name	Family	IUNC status
Acanthus montanus	*Acanthaceae*	Least concern
Albizia procera	*Fabaceae*	Least concern
Baphia nitida	*Fabaceae*	Least concern
Carpolobia lutea	*Polygalaceae*	Least concern
Ceiba pentandra	*Malvaceae*	Least concern
Celtis zenkeri	*Ulmaceae*	Least concern
Tribulus terrestis	*Zygophyllaceae*	Least concern
Triplochiton scleroxylon	*Malvaceae*	Least concern
Lannea welwitschii	*Anacardiaceae*	Near threatened
Milicia excels	*Moraceae*	Near threatened
Adenia cissampeloides	*Passifloraceae*	Not evaluated
Alchornea laxiflora	*Euphorbiaceae*	Not evaluated
Alstonia boonei	*Apocynaceae*	Not evaluated
Alstonia congensis	*Apocynaceae*	Not evaluated
Annona senegalensis	*Annonaceae*	Not evaluated
Anthocleista djalonensis	*Gentianaceae*	Not evaluated
Antiaris toxicaria	*Moraceae*	Not evaluated
Bambusa vulgaris	*Poaceae*	Not evaluated
Blighia sapida	*Sapindaceae*	Not evaluated
Brachystegia eurycoma	*Fabaceae*	Not evaluated
Byrsocarpus coccineus	*Connaraceae*	Not evaluated
Canthium hispidum	*Rubiaceae*	Not evaluated
Cola millenii	*Sterculiaceae*	Not evaluated
Dalium guineense	*Fabaceae*	Not evaluated
Diospyros mespiliformis	*Ebenaceae*	Not evaluated
Enantia chlorantha	*Annonaceae*	Not evaluated
Ficus capensis	*Moraceae*	Not evaluated
Funtumia elastic	*Apocynaceae*	Not evaluated
Gliricidia sepium	*Fabaceae*	Not evaluated
Hevea brasiliensis	*Euphorbiaceae*	Not evaluated
Holarrhena floribunda	*Apocynaceae*	Not evaluated
Lecaniodiscus cupanioides	*Sapindaceae*	Not evaluated
Monodora tenuifolia	*Annonaceae*	Not evaluated
Mucuna pruriens	*Fabaceae*	Not evaluated
Newbouldia laevis	*Bignoniaceae*	Not evaluated
Olax subscorpioidea	*Olacaceae*	Not evaluated
Palmae	*Arecaceae*	Not evaluated
Peperomia pellucid	*Piperaceae*	Not evaluated
Solenostemon monostachyus	*Lamiaceae*	Not evaluated
Spondias mombin	*Anacardiaceae*	Not evaluated
Voacanga Africana	*Apocynaceae*	Not evaluated
Zanthoxylum zamthoxyloides	*Rutaceae*	Not evaluated
Afzelia Africana	*Fabaceae*	Vulnerable
Nesogordonia papaverifera	*Malvaceae*	Vulnerable
Terminalia ivorensis	*Combretaceae*	Vulnerable

Most families sighted within the study area were categorized using the IUCN list (version 2018); "not evaluated" had 71.1%, followed by "least concern" had 17.8%, "vulnerable tree species had 6.7% while "near threatened" had 4.4% of the tree species identified in the area. The result on diversity index of fauna species sighted at Osun-Osogbo sacred grove is presented on Table 5. Based on the result from the finding, *Cercopithecus mona* had a relative frequency of 17.76%, followed by *Gastropoda spp* had 6.55%, *Sciuridae spp* had 5.65% of relative frequency, *Chiroptera spp* had 4.17% of relative frequency; while fauna species sighted with the least relative frequency (less than 1) include: *Cuculus gularis, Centrochelys sulcata, Lonchura bicolor, Atherurus africanus, Falco tinnunculus, Erythrocebus patas, Dendrohyrax dorsalis, Ploceus cucullatus* and *Milvus migrans.*

Table 5 Fauna species relative occurrence and status in osun osogbo sacred grove

Common name	Scientific name	Families	Occurrence	Relative occurrence	Status
African civet	*Civettictis civetta*	Mammalia	7	2.08	least concern
African Cuckoo	*Cuculus gularis*	Aves	3	0.89	least concern
African giant rat	*Cricetomys gambianu*	Mammalia	13	3.87	least concern
African giant snail	*Gastropoda spp*	Gastropoda	22	6.55	not evaluated
African Grey Hornbill	*Tockus nasutus*	Aves	8	2.38	least concern
African Grey Hornbill	*Tockus nasutus*	Aves	5	1.49	least concern
African Palm Swift	*Cypsiurus parvus*	Aves	6	1.79	least concern

Citation: Ugbe JA, Kuje ED. An appraisal of tree and fauna species diversity and distribution of Osogbo sacred grove, Osun State, Nigeria. *Forest Res Eng Int J.* 2022;5(1):44–50. DOI: 10.15406/freij.2022.05.00106

Table Continued...

Common name	Scientific name	Families	Occurrence	Relative occurrence	Status
African tortoise	*Centrochelys sulcata*	Reptilia	3	0.89	least concern
Bat	*Chiroptera spp*	Mammalia	14	4.17	least concern
Black and white Mannikin	*Lonchura bicolor*	Aves	3	0.89	least concern
Blue-breasted Kingfisher	*Halcyon malimbica*	Aves	6	1.79	least concern
Broad-billed Roller	*Eurystomus glaucurus*	Aves	4	1.19	least concern
Bronze Mannikin	*Lonchura cucullata*	Aves	5	1.49	least concern
Brush tailed porcupine	*Atherurus africanus*	Mammalia	3	0.89	least concern
Cassin's Spinetail	*Neafrapus cassini*	Aves	4	1.19	least concern
Chestnut-winged Starling	*Onychognathus fulgidus*	Aves	6	1.79	least concern
Collared Sunbird	*Hedydipna collaris*	Aves	6	1.79	least concern
Common Bulbul	*Pycnonotus barbatus*	Aves	8	2.38	least concern
Common Kestrel	*Falco tinnunculus*	Aves	3	0.89	least concern
Duiker	*Sylvicapra grimmia*	Mammalia	6	1.79	least concern
Fork-tailed Drongo	*Dicrurus adsimilis*	Aves	5	1.49	least concern
Grasscutter	*Thryonomys swinderianus*	Mammalia	6	1.79	not evaluated
Little Greenbul	*Eurillas virens*	Aves	2	0.6	least concern
Lizard Buzzard	*Kaupifalco monogrammicus*	Aves	3	0.89	least concern
Mona monkey	*Cercopithecus mona*	Mammalia	58	17.26	least concern
Mush Shrew	*Soricidae spp*	Mammalia	4	1.19	Vulnerable
Nile monitor lizard	*Varanus niloticus*	Reptilia	6	1.79	least concern
Oil palm squirell	*Sciuridae*	Mammalia	19	5.65	least concern
Oriole Warbler	*Hypergerus atriceps*	Aves	5	1.49	least concern
Pale belled pangolin	*Phataginus tricuspis*	Mammalia	11	3.27	Vulnerable
Patas Monkey	*Erythrocebus patas*	Mammalia	2	0.6	least concern
Red-bellied Paradise Flycatcher	*Terpsiphone rufiventer*	Aves	6	1.79	least concern
Red-headed Malimbe	*Malimbus rubricollis*	Aves	10	2.98	least concern
Royal Antelope	*Neotragus pygmaeus*	Mammalia	4	1.19	least concern
Senegal Coucal	*Centropus senegalensis*	Aves	5	1.49	least concern
Tree Hyrax	*Dendrohyrax dorsalis*	Mammalia	3	0.89	least concern
Village Weaver	*Ploceus cucullatus*	Aves	3	0.89	least concern
Vinaceous Dove	*Streptopelia vinacea*	Aves	16	4.76	least concern
Western Bluebill	*Spermophage haematina*	Aves	1	0.3	least concern
Western Nicator	*Nicator chloris*	Aves	4	1.19	least concern
White throated monkey	*Cercopithecus erythrogaster*	Mammalia	11	3.27	Vulnerable
White-throated Bee eater	*Merops albicollis*	Aves	10	2.98	least concern
Yellow-billed Kite	*Milvus migrans*	Aves	3	0.89	not evaluated
Yellow-fronted Tinkerbird	*Pogoniulus chrysoconus*	Aves	4	1.19	least concern
			336	100	

S=43.

A total of 43 fauna species was sighted at the sacred grove. Mona monkey was the most frequently occurring species in the area with diversity index of 0.303; while the least occurring species was Western Bluebill with diversity index of 0.0173 (Table 5). Figure 2 of this result shows status of fauna species in the IUCN categories list of 2018. Based on the result of this finding, fauna species that had a status of "least concern" on IUCN list were mostly sighted, this had a86.36% of all the sighted fauna species in the area, while the status of "not evaluated" and "vulnerable" fauna species had a 6.82% each. The fauna species family of Aves was recorded with the highest (61.36%) fauna species sighted, followed by the family of Mammalia which had 31.82%of the fauna species sighted in the area, followed by reptiles which had 4.55% of the sighted fauna species while Gastropoda family had 2.27% of the sighted fauna species in the area based on the result of this finding (Table 6).

Table 6 Fauna species diversity and distribution in Osun-Osogbo Sacred Grove, Osun State, Nigeria

Parameters	Indices	Lower	Upper
Taxa_S	43	42	44
Dominance_D	0.05	0.04	0.07
Shannon_H	3.40	3.30	3.50
Evenness_e^H/S	0.68	0.62	0.75
Menhinick	2.40	1.90	2.90
Margalef	7.39	6.89	7.89

A total of 336 individual fauna were identified belonging to 43 species, 41genera and 4 families. Fauna species diversity index of the study area had an estimated index of 3.40, dominance of 0.05, species richness of 2.40 and evenly distributed index of 0.68. The fauna population estimate and density in the area is presented in

Table 7. The result of this finding showed that, core zone of the area was the most populated area with 0.39 population estimate and 0.06 population density per hectare, followed by buffer zone which had 0.26 estimate and population density of 0.005; while the out zone was d least populated area with 0.21 and 0.003 density population per hectare (Table 6).

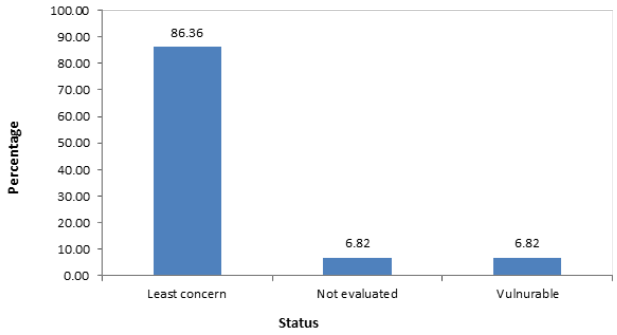

Figure 2 Percentage of fauna species in each of the IUCN categories.

Table 7 Fauna population estimate and density in the study area

Locations	Population estimate	Density(Pop/ha)
Core	0.39	0.06
Buffer	0.26	0.005
Outer	0.21	0.003

Discussion

A total of 466 individual trees were identified from 70 tree species belonging to 44 genera and 26 families. The tree species diversity index of the study area had an estimated index of 3.88, dominance of 0.027, species richness of 3.24, and an evenly distributed index of 0.69. A total of 43 fauna species belonging to 4 classes were sighted in the study area, which corresponds to what Scheiner reported in 2003.[16] The most numerous tree species belonged to the groups Fabaceae and Apocynaceae; Pausas and Austin[17] reported a similar situation regarding species richness in respect to the environment. According to Austin et al.,[18] edaphic conditions are very important for the establishment and richness of species in an ecosystem. The Fabacea family was listed by Iheyen et al.,[19] as being the most prevalent family in the Ehor forest reserve in Edo State. This family's dominance may be due to their effective seed distribution system and regeneration potential. Most members of the Fabaceae and Apocynaceae families are wind disseminated, which would explain why they are so common.

The class of aves made up 61.36 percent of the fauna in the area. When the diversity of tree species in the Afi Mountain wildlife sanctuary was evaluated, Edet et al.,[20] reported less disturbance than what this study found. This is a result of the rapid tree cutting for construction projects in the grove's outer zone, which is extending into the buffer zone, as well as the hunting for food and profit by poachers. It is impossible to overstate the importance of biodiversity as a source of renewable resources for rural and urban populations, which makes biodiversity protection important. Before any significant conservation efforts can begin, surveys of both flora and fauna species that are an essential component of the animal and forest ecology in wildlife-based protected areas are required.[2] The biodiversity indices for tree species in the area's core zone are consistent with Daniel et al.,[2,20] observations, whereas those for the area's outer and buffer zones are lower.

There may be a significant number of species under threat since human activity has an impact on how new species are produced. Since there aren't enough rangers to police the entire grove, they only focus on the central region. Similar cases involving plant communities on anthropogenic disturbed locations in the Chukotka Peninsula have been documented by Marshal and Swaine.[21] This study suggests that there were a variety of tree and animal species in the area, some of which are threatened by anthropogenic activity. To maintain ecosystem productivity and biodiversity, sustainable management practises are needed.[22] Due to competition for nutrients, restricted light from canopy trees, and destruction of undergrowth during illegal logging on the forest floor, several families with low species representation did not develop well. Furthermore, it could be due to the majority of players (such as governments and non-governmental organizations) paying little to no attention to the successful conservation of local biodiversity. A similar incident was recorded by Egbe et al.,[23] in the Cameroonian Korup national park's degraded and naturally regenerating forest.

The Fauna species diversity index of 3.40, species richness of 2.40, and species evenness of 0.68 indices were derived from the study area. The values obtained indicate high values, which confirm that the study area (Core zone) is of rich tree and fauna species diversity. This observation agrees with the earlier reports of Joshi and Joshi,[24] who reported a rich and varied biodiversity in various ecosystems of Syabru village, in Langtan National Park, Nepal. Due to high anthropogenic activity and encroachment, the buffer zone and outer zone of the grove had a low diversity index, species richness, and evenness for trees and fauna species. This result is in line with the report of Yager *et al*.,[25] on Makurdi Zoological Garden, Benue, Nigeria.

The area's relatively high population of vertebrate species is typically made up of taxa from West Africa.[26] The fact that people in the nearby towns do not eat primates as meat may be related to the high prevalence of Mona monkeys and other primates in the area. Mbaya and Malgui[27] made a comparable observation in the Sambisa game reserve. A significant incidence of poaching for traditional medicine and meat is suggested by the relatively low status of various mammals and reptiles in the forest. According to the IUCN classification, the majority of tree and animal species were of least concern, and only a small number of them were threatened species. Estimates were made of the density and number of the fauna. Due to their home ranges and potential for reproduction, some animal species are more tolerant of hunting pressure than others.[28] Some animal species are also influenced by vegetation patterns that give them a good perspective of their surroundings and allow them to move quickly and deftly through the underbrush.

Conclusion

Based on the results of this finding, there is continuous forest exploitation in the study area. Most of the tree species and fauna encountered in the area are of least concern, and very few species are threatened globally. This could be due to use-pressure and anthropogenic activities such as tree felling in the buffer and outer zone of the area, obtaining tree parts for herbs in the core zone of the area, farming and grazing in the buffer and outer zone of the area, resulting in a rapid decrease in the number of tree species in the area. *Fabaceae* and *Apocynaceae* were the families encountered with dominant tree species in the area. All stakeholders should give more attention and managerial resources to the conservation of the sacred grove. There is an urgent need to block all the known routes used by poachers and loggers in the study.

Acknowledgments

None.

Conflicts of interest

The authors declared that, there is no any conflict of interest exists.

Funding

None.

References

1. Liu H, Xu Z, Xu Y, et al. Practice of conserving plant diversity through traditional beliefs: a case study in Xishuangbanna, southwest China. *Biodiversity and Conservation*. 2001;11:705–713.
2. Daniel IE, Henry MI, Augustine UO. Preliminary assessment of tree species diversity in Afi Mountain Wildlife Sanctuary, Southern Nigeria. *Agriculture and Biology Journal of North America*. 2012;3(12):486–492.
3. Sukumaran S, Jeeva S. A floristic study on miniature sacred groves at Agastheeshwaram, Southern peninsular India. *Eurasian Journal of Biological Science*. 2008;2(8):66–72.
4. National Commission for Museums and Monuments (NCMM). Nomination to the World Heritage List of Osun–Osogbo Sacred Grove, Osogbo, Osun State, Nigeria; 2005.
5. Oyekwelu JC, Olusola JA. Role of sacred grove in in–situ biodiversity conservation in rainforest zone of south–western Nigeria. *Journal of Tropical Forest Science*. 2014;26(1):5–15.
6. Probst P. Modernism Against Modernity: A Tribute to Susanne Wenger. *Critical Intervention*. 2009;2(3/4):245–255.
7. Ogundiran A. The Osun–Osogbo grove as a social common and an uncommon ground: An analysis of patrimonial patronage in postcolonial Nigeria. *International Journal of Cultural Property*. 2014;21(2):173–198.
8. NCMM. Osun Osogbo Sacred Grove. UNESCO World Heritage Site. *Conservation Management Plan*. 2015–2019.
9. Yusuf TG. A micro analysis of tourists, other participants and tourism activities at Osun Osogbo Sacred Grove, Nigeria. *Journal of Economics and Sustainable Development*. 2016;7(7):96–104.
10. Oseghale G, Omisore E, Gbadegesin JT Exploratory survey on the maintenance of Osun–Osogbo sacred grove, Nigeria; African. *Journal of Hospitality Tourism and Leisure*. 2014;3(2):232–254.
11. Adewale AB, Ola YY. Infrastructural Vandalism in Nigerian Cities: The Case of Osogbo, Osun State. *Journal of Research on Humanities and Social Sciences*. 2014;4(3):49– 60.
12. Adebisi LA. Biodiversity of selected sacred groves in Osun state, Nigeria Ph.D. Thesis submitted to Department of Forestry, University of Ibadan; 1999.
13. Adesoji Akinwumi Adeyemi, Tolulope Hannah Oyinloye Effectiveness of Alternative Conservation Means in Protecting the Osun–osogbo Sacred Grove in South–West, Nigeria. *Plant*. 2020;8(1): 1–9.
14. Margalef R. Temporal Succession and Spatial Heterogeneity in Phytoplankton. In: Buzzati–Traverso AA, editor. Perspectives in Marine Biology; University of California Press, Berkeley, CA, USA; 1958. p. 323–347.
15. Magurran AF. Ecological Diversity and its Measurement; Princeton University Press, Princeton, NJ, USA; 1988. 179 p.
16. Scheiner SM. Six types of species–area curves. *Global Ecology and Biogeography*. 2003;12:441–447.
17. Pausas JG, Austin MP. Patterns of Plant Species Richness in Relation to Different Environments. *Journal of Vegetation Science*. 2001;12:153–166.
18. Austin MP, Pausas JG, Nicholls AO. Patterns of Tree Species Richness in Relation to Environment in South Eastern New South Wales. *Australian Journal of Ecology*. 1996;21:154–164.
19. Iheyen J, Okoegwale EE, Mensah JK. Composition of tree species in Ehor ForestReserve, Edo State, Nigeria. *Nature and Science*. 2009;7(8): 8–18.
20. Edet DI, Ijeomah HM, Ogogo AU. Preliminary assessment of tree species diversity in Afi Mountain Wildlife Sanctuary, Southern Nigeria. *Agriculture and Biology Journal of North America*. 2011;3(12):486–492.
21. Marshall AG, Swaine MD. Tropical rain forest: Disturbance and recovery*; Journal of Tropical Ecology*. 1992;9(2):211–212.
22. Reddy SC, Ugle P. Tree Species Diversity and Distribution Patterns in Tropical Forest of Eastern Ghats, India: A case study. *Journal of Life Science*. 2008;5(4):87–93.
23. Egbe EA, Chuyong GB, Fonge BA, et al. Forest Disturbance and Natural Regeneration in African Rainforest at Korup National Park. *Cameroon International Journal Biodiversity Conservation*. 2012;4(11):377–384.
24. Joshi A, Josh, K. Biological Diversity: Present Status and Agenda for Conservation; Environmental Management and Sustainable Development at the Crossroad, Ankus, Nepal; 2009. p. 30–67.
25. Yager GO, Enefola JO, Tyowua BT. Comparative study of fauna species diversity of Makurdi Zoological Garden, Benue State, Nigeria. *International Journal of Development and Sustainability*. 2017;6(12):2163–2172.
26. Osunsina IOO, Inah EI, Ogunjinmi AA, et al. Distribution and diversity of flora and fauna in International Institute of Tropical Agriculture (IITA) forest and nature reserve, Ibadan. Oyo State. Nigeria. *Journal of Agriculture, Forestry and the Social Sciences*. 2012;10(2):289–302.
27. Mbaya YP. Malgwi H. Species list and status of mammals and birds in Sambisa game reserve, Borno State, Nigeria. *Journal of Research in Forestry, Wildlife and Environment.* 2010;2(1):135–140.
28. Yager GO, Alarape AA, Onuwa OA. Preliminary Assessment of Fauna Species Diversity in Ipinu Igede Community Range Forest in Oju Local Government of Benue State, Nigeria. *Asian Journal of Biology*. 2018;5(4):1–11.