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Original Article

DIVERSITY AND DISTRIBUTION OF TREES AND SHRUBS IN GURARA FOREST, KADUNA STATE

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ABSTRACT

The study assessed the diversity of tree and shrub species of Gurara forest in Kaduna State. Primary data on the field was collected by employing the plot count techniques by randomly selecting five plots within the forest, measuring a 50 by 50 meters plot (0.25) hectare on the ground for each plot. All the trees and shrubs species on the selected plots were identified and enumerated. A total of 31 species were identified, 23 of which were trees while the remaining 8 were shrubs. The tree stratum had 3,502 trees per hectare. Plot 3 had the highest number of trees per hectare (1,164 trees) followed by plot 2 (672trees) while plot 1 had the least number of trees per hectare (226 trees). *Acacia senegal* had the highest number of frequency (1,066trees) with a percentage composition of 30.44%. The species was more common in plots 2 and 3 with 250/ha and 800/ha respectively. Family Fabaceae with 10 species had the highest number of species. Others have 2 or single species in the family. Tree species diversity and evenness were highest in plot 5 (5.72 and 2.12 respectively) and least in plot 4 (0.95 and 0.36 respectively). Similarity amongst the plots was highest between plots 1 and 5 (65%) while plots 3 and 4 were very dissimilar with a similarity index of 34%. There were 8 shrub species belonging to 7 families, with a total of 642 individuals per hectare. Plot 3 had the highest shrub population of 323/ha. *Piliostigma thonningii* with 329 frequency per hectare was the most frequent of all the species. Though plot 3 had the highest number of individuals in almost all the species, diversity and evenness indices were highest in plot 1 (1.56 and 0.97 respectively). Plots 1 vs 2 and 2vs5 were very similar with index of 80% each.

Keywords: Species distribution, diversity index and similarity index

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INTRODUCTION

Vegetation provides us with an array of products that play important roles in our general well-being and economic life. They provide goods and services, including food, water, shelter, nutrient cycling and cultural and recreational values. Forests also store carbon, provide habitat for a wide range of species and help alleviate land degradation and desertification. Forests were estimated to provide approximately 6 billion people with food, medicines, fuel and other basic necessities (Millennium Ecosystem Assessment, 2005). About 6% of the earth's land area was once covered by forests but due to the explosive use of land for agriculture, dam construction, urbanization and industrialization, these forests are cut down (Malaka, 2011).

Common forms of anthropogenic and human induced disturbances involve logging; grazing, collection of non-timber forest products (NTFPS) and conversion of forest land to other forest use types (García-Montiel and Scatena, 1994). Tanko (2012) observed total debarking barking of trees for ethno-medicine as one of the major factor contributing to the decline of forests. Such disturbances might affect the availability of certain commodities on which the people depend for their livelihoods.
The consequences of these human - induced activities includes: desert encroachment, depletion of soil and water resources, destruction of the earth's web of life, loss of biodiversity, extinction of endemic species and globally, the global warming (Tanko *et al.*, 2013). The biggest problem with degraded environment is its inability to recover fully when it is excessively logged or cleared for farming or otherwise (Tanko *et al.*, 2013). Prolonged loggings, cultivation with shortening period of fallow and frequent bush burning were shown to have the consequences of converting an existing forest to derive savanna (Tanko *et al.*, 2010). In this case, the fire – tender forest tree species are replaced by fire – tolerant ones in such a way that most of the areas previously covered by forest species are replaced by savanna woodland , then subsequently grassland (Tanko *et al.*, 2013).

Vegetation analysis is used in the evaluation of vegetation response to management, estimation of carrying capacity, characteristics of cover and habitat components or long-term monitoring of the general trend of plant vigor or habitat condition (Higgins *et al.*, 1994). Gurara forest in Kaduna state is one of the forest that is being exploited daily for timber. The forest is rapidly degrading with little or no information on the current status of the vegetation of the area. There is high pressure on the forest due to urbanization, timber and fuel wood extraction with no apparent conservation strategies put in place to reduce loss of resources. Being a conserved area, the need for long term monitoring cannot be over-emphasized. This study was aimed at providing baseline data on the current vegetation status of the area, and this will be helpful in designing conservation strategies of the site and baseline for comparison in the future.

MATERIALS AND METHODS

Location of the study area

The study was conducted in Gurara forest, (Figure 1), Kachia Local Government Area of Kaduna State, Nigeria. The forest is located between coordinates of Latitudes

09°41′ and 09°46′ North of the Equator and at Longitudes 07°45' and 07°48' East of the Greenwich Meridian. The forest is having a land-mass of approximately 905km^2

Floristic Survey and Measurement

The study concentrated on the woody vegetation. The plot count technique also known as the modified Whittaker's technique or 1/10th of a hectare technique was used (Whittaker, 1975). According to the technique, representative plots of 50m × 50m sizes were mapped out using surveyors tape and twines used to demarcate the mapped out plots. Five sites were randomly selected for sampling and identified as sites 1, 2, 3, 4 and 5. The 50m ×50m plots were mapped from each of the five sites. These plots were further divided into 50 quadrats of 5m×5m each for easy counting. All the trees and shrubs species that falls within the mapped out plots were identified and enumerated as described by Muller-Dombois and Ellenberg (1974).

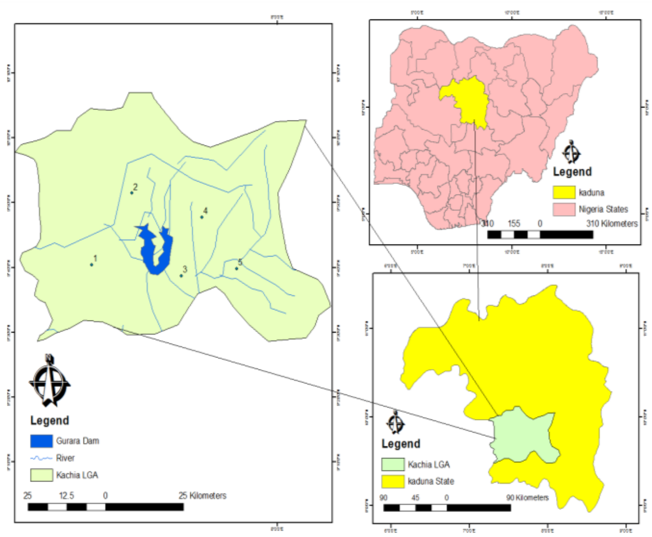

Figure 1: The Administrative Map of Kaduna State showing Kachia Local Government Area where the study area was located
Source: Modified from Kaduna State Administrative Map by Missamari, 2014

Data collected were summarized in a tabular form to provide species check list. Percentage composition was determined using the formula:

Percentage Composition = n/N X 100; where:

n = number of individuals of a species.

N = total number of individuals of all species

Paleontological statistics software (PAST) was used to compare the diversity indices between the plots.

Determination of species similarity between plots

The similarity between the five plots was estimated using the Jaccard similarity index

Jaccard index = $C_j =$ j/a+b-j, Where:

j = the number of common species found in both plots

a = number of species unique in plot 1

b = number of species unique in plot 2

C_j approaches 1.0 when species composition is identical between sites and 0.0 when two sites have no species in common (Magurran, 1988).

RESULTS

Tree Species Abundance and Diversity at the Gurara Forest

The total number of tree species enumerated from the five plots were twenty three (23) belonging to twelve (12) families with total number of occurrence, 2,860. Family Fabaceae had the highest number of species (10). *Acacia Senegal* had the highest numbers of individuals with 1,066 number of trees across the plots while *Khaya senegalensis, Anogeissus leiocarpus* and *Ceiba pentandra* had single stand in plots 2 and 3. *Monotes kerstingii; Vitex donianna,* and *Terminalia avecinoides* occurred in all the plots (Table 1). *Acacia Senegal* had the highest percentage of 30.44%; followed by *Isoberlinia doka* with 24.1% while *Khaya senegalensis*, *Anogeissus leiocarpus* and *Ceiba pentandra* had the least percentage of 0.03% each.

In comparism, the species diversity across the plots showed that Shannon wiener index and evenness were highest in plot 5 with index values of 5.74 and 2.12 respectively. Jaccard's index showed an association between plots 1 and 5 to be higher (65%) followed by association between plots 2 and 5 with 61% association. Plot 1 showed equal, but least (34%) associated with plots 2, 3 and 4 despite their close proximity (Table 3).

Shrubs Species Abundance and Distribution

The study revealed a low number of shrub species (8 species) belonging to seven (7) families, out of which *Piliostigma thonningii* had the highest frequency of occurrence (329 individuals), followed by *Annona senegalensis* with 155 individuals. *Ficus* exasperata had the least frequency of 2 individuals in plot 3. *Annona senegalensis, Monotes Kerstingii* and *Piliostigma thonningii* occurs in all the plots while *Nauclea latifolia* was absent only in plot 4. However, species such as *Ficus exasperata* and *Sercuridaca longipedunculata* occurred only in plots 3 and 5 respectively (Table 2). Shannon-wiener index and Evenness of distribution was highest in plot 1 with values of 1.56 and 0.97 respectively. Plot 5 had the least diversity and evenness values of 0.65 and 0.4 respectively. Jaccard's similarity index showed that association/similarity between plots 1 and 2 and between plots 2 and 5 were highest with 80% each. All the associations between the plots were above 50% except between plots 1and 4 which had 43% similarity index (Table 3).

Table 1 : Tree species diversity and evenness in the sample plots

S/N	Species	Family	Total ha-1 Plot 1	Total ha-1 Plot 2	Total ha-1 Plot 3	Total ha-1 Plot 4	Total ha-1 Plot 5	Total frequency	% frequency
1	*Afrormosia laxiflora (*Benth) Harms	Fabaceae	0	79	14	9	17	119	3.4
2	*Albizia lebbeck* (L) Benth	Fabaceae	0	0	30	0	0	30	0.86
3	*Anogeissus leiocarpus(*D.C)Guill&Perr.	Fabaceae	0	0	1	0	0	1	0.03
4	*Bombax buonopozense* P.Beauv	Bombacaceae	0	0	0	1	2	3	0.09
5	*Ceiba pentandra (L.)*Gaertn.	Malvaceae	0	0	1	0	0	1	0.03
6	*Crossopteryx febrifugia(* G.Don) Benth	Rubiaceae	13	0	35	0	12	60	1.71
7	*Daniella oliveiri* (Rolfe) Hutch & Dalzel	Fabaceae	0	3	4	8	5	20	0.57
8	*Detarium microcarpum* Guill & Perr	Fabaceae	10	22	3	18	21	74	2.11
9	*Diospyros mespiliformis* Hochstex. DC	Ebenaceae	0	0	6	0	0	6	0.17
10	*Entanda africana* Guill & Perr.	Fabaceae	0	2	0	2	6	10	0.29
11	*Ficus glumosa* Delile.	Moraceae	4	1	0	0	0	5	0.14
12	*Gardenia aquala* Stapf & Hutch	Rubiaceae	12	6	72	13	46	149	4.25
13	*Isoberlinia doka* Craib& Stapf	Fabaceae	144	246	0	387	107	884	24.1
14	*Khaya senegalensis* (Desr,) A Juss	Meliaceae	0	1	0	0	0	1	0.03
15	*Lannea microcarpa* Engl. & K.Krause	Anacardiaceae	16	0	3	3	27	49	1.4
16	*Parkia biglobosa*(Jacg) R.Br. ex G. Don	Fabaceae	2	0	19	2	2	25	0.71
17	*Prosopis africana* Guill. & Perr.) Taub.	Fabaceae	1	3	9	11	14	38	1.09
18	*Acacia senegal* (L.) Willd.	Fabaceae	0	250	800	16	0	1066	30.44
19	*Terminalia avicennioides* (Guill & Perr.	Combretaceae	9	11	101	2	14	137	3.91
20	*Terminalia mollis* (M.A Lawson)	Combretaceae	1	0	23	0	0	24	0.69
21	*Uapaca togoensis* (Pax.)	Euphorbiaceae	6	32	0	13	21	72	2.1
22	*Vitex doniana* sweet	Verbenaceae	2	11	6	1	4	24	0.69
23	*Vitteleria paradoxa (*Gaertn.f) Hepper	Sapotaceace	6	5	37	0	14	62	1.77
	TOTAL		226	672	1164	486	312	2860	80.58
	Species Richness		13	14	17	14	15	73	
	Shannon-wiener diversity index (H)		2.42	1.64	3.55	0.95	5.74	14.3	
	Evenness (E)		0.94	0.62	1.25	0.36	2.12	5.29	

Table 2: Shrub Species Diversity and Evenness in the Sample Plot

S/N	Species	Family	Total ha-1 Plot 1	Total ha-1 Plot 2	Total ha-1 Plot 3	Total ha-1 Plot 4	Total ha-1 Plot 5	Total Frequency	% Frrequency
1	*Annona senegalensis* Pers.	Annonaceae	8	25	67	20	35	155	24.1
2	*Borrassus aethiopum*Mart	Arecaceae	0	0	0	4	4	8	1.24
3	*Ficus exasperata* Vahl.	Moraceae	0	0	2	0	0	2	0.31
4	*Ficus sycomorus L.*	Moraceae	0	0	4	1	0	5	0.77
5	*Monotes kerstingii*Gilg	Dipterocarpaceae	0	4	3	8	79	94	14.6
6	*Nauclea latifolia* Smith	Rubiaceae	1	2	18	0	19	40	6.23
7	*Piliostimga thonningii* (Schum.) Miline-Redh.	Fabaceae	3	28	229	15	54	329	51.2
8	*Sercuridaca longipedunculata* Fresen.	Polygalaceae	5	0	0	0	0	5	0.77
	TOTAL		21	59	323	48	191	642	
	Species Richness		4	4	6	5	4	23	
	Shannon-Weiner index		1.56	0.97	1.2	1	0.65	5.38	
	Evenness		0.97	0.7	0.64	0.62	0.4	3.33	

Table 3: Jaccard Similarity Index Showing Species Association between Plots

Plots Association	Trees(%)	Shrubs (%)
Plots 1 and 2	50	80
Plots 1 and 3	50	57
Plots 1 and 4	50	43
Plots 1 and 5	65	67
Plots 2 and 3	41	67
Plots 2 and 4	47	50
Plots 2 and 5	61	80
Plots 3and 4	36	57
Plots 3 and 5	34	57
Plots 4 and 5	45	67

DISCUSSION

Species composition of 23 trees and 8 shrubs belonging to 15 families is low when compared to other research works conducted in guinea savanna. Tanko *et al.* (2013) reported 63 woody species associated with inserlbergs surroundings at Dumbi, Zaria in the northern guinea savanna. The low species richness is probably due to the fact that the site was a forest conservation area unlike other places where other researchers worked; the conservation effort might have given the plants allowance to grow to forest status which is always characterized by fewer numbers of species. This claim can be supported by the fact that the timber lumbering can only take place in forested areas and this was observed at the study site. Results from the species checklist, shows that some species occurred in all the plots while some were predominant and absent in others. These variations on species distribution between the plots could be attributed to either environmental conditions or methods of pollination or dispersal in the various plots. Deka *et al.* (2012), attributed the success of the Fabaceae to their fast germination ability, associated with symbiotic properties which enabled species to easily get established within the habitat types. The Vegetation assessment of trees and shrubs indicates that legumes were prominent species recorded in the study area. Moraceae, Meliaceae and Fabaceae also have the ability to produce numerous seeds and seedlings which eventually get established at the site. Tanko (2012) observed that some species of these families had high seed production ability which he attributed was one of the reasons for their success in life. The reasons for the low number of species observed in some families could also be attributed to over-exploitation through wood logging and browsing by herbivores as observed by Tanko (2012), which resulted in poor growth and establishment of the species. Tanko *et al.* (2013) observed species of *Anogeisus leiocarpus* and *Piliostigma thonningii* has been stunted while some species died out as a result of over-grazing. These activities were equally observed at the study site. Seeds of some species needed treatment to break dormancy before germination, this might have affected the germination and growth of those species thereby giving opportunity to the other species to predominate. Also competition could be a possible factor. The species with low competitive ability will be faced out.

High Shannon-wiener diversity value of trees in plot 5 may be due to high protection, terrain, thickets and lack of access road for wood lumbering, while the low diversity of trees in plot 4 could be attributed to high anthropogenic activities which was so obvious during the study. Also, this plot had interspersion of rock outcrops, bare portions of land and water bodies. This could be a possible reason for the low diversity observed. Within a plot it was observed that some species were more exploited than others. This could be due to their value for timber and fuel wood. Those less exploited could be due to their less value in terms of timber and fuel wood or probably due to difficulty in handling or due to other economic value such as fruits, seeds and medicine. Tanko *et al.* (2013 had a similar observation at Dumbi inselbergs and concluded that *Parkia biglobossa* and *Tamarindus indica* were left out due to economic value of the fruits and seeds. Also they observed low exploitation of

Piliostigma thonningii and *Acaia ataxacantha* were left untouched probably due to the hard and thorny nature of the wood which made harvesting and handling of the species difficult by the fuel wood gatherers.

Tree species in plots 5 and 3 are still highly diverse which indicates species richness in the area. This could also means that changes due to anthropogenic activities has not affected all the areas. Species diversity is one of the most important indices to evaluate an ecosystem, a rich ecosystem with high diversity has a large H value while an ecosystem with low H value would have a low species diversity (Sobuj and Rahman; 2011 Deka *et al*., 2012). Distribution of trees in the study area is quite even for plots 5 and 3 but very low for plot 2. Similarities between the plots indicated the presence of high identical species among the trees in the two plots in comparism. The least similarities among tree species recorded between plots 3 and 5 is indication that most of the species between the two plots are not common. When similarities in tree cover between any two plots is less than 50%, it indicated that the plots had not too many tree species in common.

CONCLUSION

The objectives of this research were to identify the tree and shrub species of the area, their frequency of occurrence, family composition, diversity and the spatial distribution of the forest. From the primary data collected in the field and computed, our results showed that there were more tree species in the study area than the shrub species. Species evenness for shrubs had generally low values all through the plots. Tree species with higher values were recorded in three of the plots. For species similarities, shrub species were more identical among the plots than the trees within the plots.

RECOMMENDATIONS:

Deforestation and other human activities on the forest is not an unstoppable or irreversible process. Increased and concerted efforts in forest plantation 'rebirth' and rejuvenation will bring to use the type of forest reserve we envisaged. In order to reduce the effects of deforestation in Gurara forest in Kaduna state, the study has the following as its recommendations:

Government by way of policy should strict illegal encroachers in order to preserve the Forest Reserves.

Government should promote alternative energy source for fuel wood in order to reduce the pressure on the forest.

Carbon economy as a way of generating income can be introduced by government and international agencies; this will encourage people to protect the forest. Carbon economy generates more income than any other forest encroachment activities.

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