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Tree Species Biodiversity of a Sahelien Ecosystem in North-East Nigeria

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Abstract

Trees species are crucial part of the ecosystem, they provides tangible and intangible benefits. The need for periodic assessment of these resources for management and conservation purposes is imperative. This study was therefore carried out to assess the tree species composition, diversity and richness of a Sahel ecosystem with the view of providing information for management and conservation purposes. The study area was stratified into three (3) from which transect of 1000 m was laid in each of the strata. 12 Sample plots of 40 m × 40 m in size were established in alternate position along each transect at 40 m interval. The height and diameter at breast height (dbh) of all living trees with dbh ≥10.0 cm were measured and counted. The results from the study show that the study area has a total of 174 trees, 8 species and 14 Families. Margalef's index of species richness of 2.52, Pielou's species evenness index (EH) of 0.38, Shannon-Weiner index (H') of 1.97 and Simpson index of dominance (D) of 0.46 were recorded. The recorded biodiversity indices indicate a poor state of tree species, richness, composition and distribution within the environment.

Keywords: Tree species richness, Biodiversity conservation, Sahel Savanna.

Kuzeydoğu Nijerya'da Sahelien Ekosisteminin Ağaç Türü Biyoçeşitliliği

Öz

Ağaç türleri ekosistemin kritik parçalarıdır, somut ve soyut faydalar sağlamaktadırlar. Yönetimi ve dönüşüm amaçları için bu kaynakların periyodik değerlendirilme gereksinimi zorunludur. Bu çalışma yönetim ve dönüşüm maksatları için bilgi sunmak bakışıyla Sahel ekosisteminin tür bileşeni, çeşitlilik ve zenginliğinin değerlendirilmesi için yürütülmüştür. Çalışma alanı 1000 m alandan 3 kesit olarak tabakalandırılmıştır. 40 m × 40 m boyutunda 12 örnek alan 40 m aralıklarla her alan boyunca alternatif pozisyonda konumlandırılmıştır. dbh ≥10.0 cm tüm ağaçların göğüs yüksekliğindeki, çap ve yükseklik ölçülmüştür. Bu çalışmadan alınan sonuçlar bu alanda toplamda 174 ağaç, 8 tür ve 17 familya olduğunu göstermiştir. 2.52 tür zenginliğinin Margalef's indeksi, 0,38 Pielou's tür eşitlik indeksi, 1,97 Shannon-Weiner indeksi (H') ve 0.46 Simpson baskınlık indeksi saptanmıştır. Kayıt edilen çeşitlilik göstergeleri bölgenin ağaç türü, zenginliği, bileşimleri ve çevrede dağılımları bakımından fakir bir alan olduğunu göstermiştir.

Anahtar Kelimeler: Ağaç türü zenginliği, Biyoçeşitliliğin korunması, Sahel savanna.

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1. Introduction

Species diversity is regarded as a measure of the diversity within population that incorporates both species richness and their evenness (Osawaru et al., 2015); it is influenced by species richness (Swingland, 2001). Tress species are important components of the forest ecosystems. Therefore, they determine the architecture and influence the composition of forest communities. The measure of the biodiversity of an ecosystem is vital because it influenced the overall health status of the ecosystem (Naidu and Kumar, 2016). The stability and functions of ecosystem is influenced by the diversity of vegetation (Buba, 2015). There is also growing evidence on the benefits of high species diversity in environmental functions such as erosion control (Seitz et al., 2015). In Nigeria, about 560 spp. of trees was reported to be in existence (Redheed, 1971). However, the existence of these species worldwide is threatened by the activities of man and other factors such as demographic changes, surge in human population and urbanization (Varshney and Anis, 2014). Urbanization and agricultural activities are generally associated with many developmental activities, lands are cleared and trees are felled, in some situations trees are felled without taking into consideration their importance. It might not be surprising if endangered trees have been cleared in the course of these developments. It is common in the savanna region particularly within the arid zone for a plant species to be solely found in the entire environment. Trees species plays an important role in the environment, their benefits range from social, cultural, environmental and economical levels (Wakawa et al., 2016). Trees are usually planted for their aesthetics characteristics, shade supply, environmental amelioration, windbreak and shelterbelt in cities and around institutions. Urban trees provide diverse benefits and also contribute significantly in making the environment conducive for people (Endress, 1990). The type of trees that are grown or planted varies from one ecosystem or environment to another. The savanna ecosystem is characterized with scanty of vegetation dominated mainly by grasses and few trees scattered around (Scholes and Archer, 1997).

Savannah zone in Nigeria was categorized into Guinea savannah, Sudan savannah and Sahel savannah (Iloeje, 2001). Difference in precipitation is the major factor that determines the type of plant that grows and those that would thrive when introduced to each zone (Aregheore, 2009). However, it should be noted that eventually some of these agro-ecological zones in reality have changed to a different agro-ecological zones probably due to the activities of man and change in climate. Therefore area which are hitherto categorized as Guinea savannah are now more or less Sudan savanna while those categorized as Sudan are Sahel in reality. This requires periodic assessment of the vegetation status of an area for management and conservation purposes. This study was therefore carried out to assess the tree species richness, composition and diversity of a Sahel ecosystem in North-eastern Nigeria with the view of providing an update on the status of tree composition and diversity for management and conservation purposes.

2. Materials and Methods

2.1. The study Area

Gashua is located in Bade Local Government Area, Yobe State, Nigeria. Gashua lies between 12052' 5"N and 1102'47"E. The average elevation is about 299m asl. (above sea level). The hottest months are March and April with temperature ranges of 38-40°C. In the humid season, June-September, temperatures fall to 23-28°C, with rainfall between 500 and 1000mm. The vegetation zone of Yobe State is divided into two; Sahel Savanna to the north and Sudan Savanna to the south (Naibbiet al., 2014). Gashua falls within the Northern zone therefore the vegetation zone is Sahel. The common trees found in the area includes; Acacia seyel, Balanite aegyptiaca, Azadiracta indica, Adansonia digitata, Faidherbia albida, Tamarindus indica, Hyphaene thebaica, Anogeissus leiocarpus

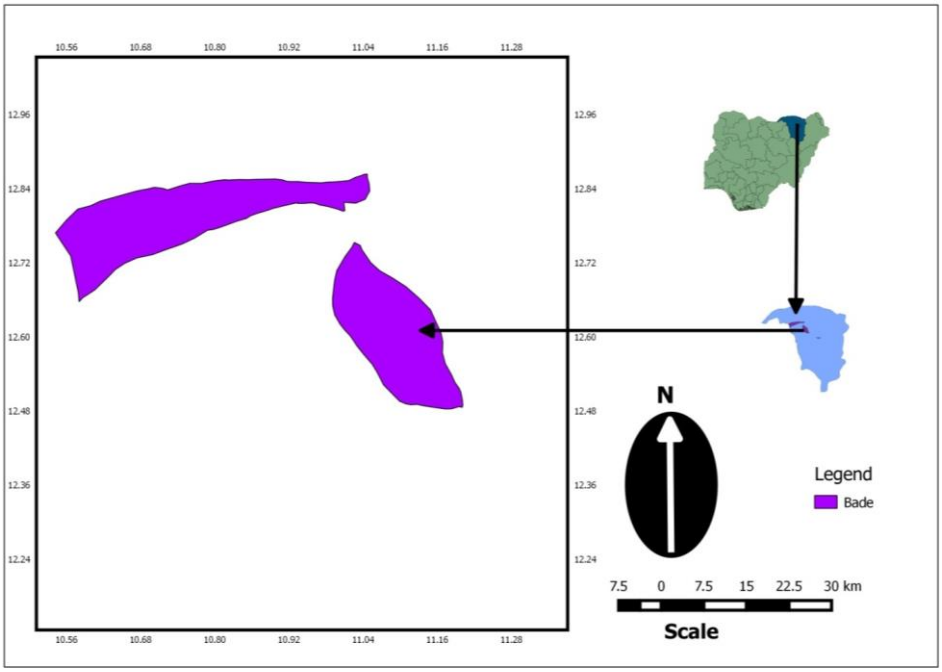

Fig. 1. Map of Bade Local Government Area, Yobe State, Nigeria

2.2. Metot

The study area is stratified into three (3) sites. Sampling technique was used in the laying of the temporary sample plots (Quadrats) in the study area. In each of the strata (site), transects of 1000m length were laid. Sample plots of 40m x 40m in size were established in alternate position along each transect at 40m interval; summing up to 4 plots per 1000m transect and a total of 12 plots in the study area. Living trees with dbh ≥10.0cm in the quadrats were counted and identified with their botanical name and measured. The data collected were grouped into species and families, and the following stand variables were computed from the inventory data: mean diameter, minimum diameter, maximum diameter, number of trees per hectare and basal area.

2.3. Analysis

Tree species density, frequency and abundance of tree species were determined as follows

Density

$$Density\ (D) = \frac{Total\ number\ of\ individuals\ of\ a\ species\ in\ all\ quadraats}{Total\ number\ of\ quadrats\ studied} \quad (1)$$

Frequency (%)

$$Frequency\ (\%) = \frac{Number\ of\ quadrats\ in\ which\ the\ species\ occurred}{Total\ number\ of\ quadrats\ studied} \times 100 \quad (2)$$

Abundance

$$Abundance = \frac{Total\ number\ of\ individuals\ of\ a\ species\ in\ all\ quadrats}{Total\ number\ of\ quadrats\ in\ which\ the\ species\ occured} \quad (3)$$

Relative density

The relative density was calculated according to Brashears et al. (2004) equation

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

Where: *RD* = relative density, n_i = number of individual of the species, *N* = number of individual of all species

Relative dominance

Relative dominance is the coverage value of a species with respect to the sum of coverage of the rest of the species in the area. It is calculated according to Curtes and McIntosh (1950); Naidu and Kumar (2016)

$$RDom. = \left({}^{\sum G_i}\!/_{\sum G_n} \right) \times 100 \quad (5)$$

Where: *RDom.*= Relative dominance of the species, G_i = total basal area for a particular species, G_n = total basal area of all the species.

Species richness

The species richness of the vascular plants was calculated according to Margalef (1968); Naidu and Kumar (2016)

$$Dmg = {}^{(S-1)}\!/_{Ln(N)} \quad (6)$$

Where: *Dmg* = Margalef's index of richness, *S* = total number of species, *N* = total number of individuals

Shannon–Weiner Index of diversity

The Shannon-Weaver index of diversity was calculated according to Kent and Coker, (1992)

$$H' = -\sum_{i=1}^{s} p_i . Ln(p_i) \quad (7)$$

Where: *H* ' = Shannon-Weiner index, *S* = total number of species in the community, p_i = proportion of important value of the ith species,

Importance value index of tree species

The importance value index of tree species as defined by Curtis, (1959) is the percentage values of the relative frequency, relative density and relative dominance are summed up together which is given as

$$IVI = {}^{1}\!/_{2} \left(\sum RD + RDom. \right) \quad (8)$$

IVI = important value index, *RD* = relative density, *RDom* = relative dominance

Simpson Index of Dominance

The Simpson index of dominance was computed based on Simpson, (1949); Naidu and Kumar (2016)

$$D = \sum_{i=1}^{s} (p_i)^2 \quad (10)$$

Where: *D* = Simpson index of dominance. Other variables are previously defined.

Species Evenness Index

The Pielou's species evenness index was computed according to Pielou (1966); Naidu and Kumar (2016)

$$E_H = \frac{1}{Ln(N)}\left(\sum_{i=1}^{s} p_i . Ln(p_i)\right) \quad (11)$$

Variables is as described earlier above

3. Results and Discussion

A total of one hundred and seventy four (174) trees were counted in the study area. This is represented in eight (8) families and fourteen (14) numbers of species (Table 1). The family Fabaceae contains the largest number of species (6) followed by Arecaceae which has two (2) while all the others recorded one (1). The family of Fabaceae also recorded the highest number of observation (100) while the family of Combretaceae recorded the least number of observations (1).

Table 1: Tree, species and family distribution of a Sahel ecosystem.

Family	No. of Species	No. Observation
Arecaceae	2	4
Balanitaceae	1	15
Capparaceae	1	5
Combretaceae	1	2
Fabaceae	6	100
Malvaceae	1	3
Meliaceae	1	44
Rhamaceae	1	1
Grand Total 8	**14**	**174**

Acacia seyel recorded the highest number of occurrence (74) followed by *Azadirachta indica* which recorded forty five (45) stands, this is followed by *Balanites aegyptiaca* which has fifteen (15) stands. *Tamarindus indica* recorded eleven (11) while species of *Acacia senegal, Phoenix dactylifera* and *Ziziphus spina-christi* each recorded one (1) stand which makes them the species with the least number of occurrence in the study area (Table 2). *Acacia seyel* recorded the highest value of percentage frequency (75.0%), followed by *Balanites aegyptiaca* (40.0%), while *Azadirachta indica* recorded the value of 41.7%. *Acacia nilotica* and *Faidherbia albida* recorded 25% each, while *Adansonia digitata* has 16.7%. Species of *Hyphania thebaica, Maerua crassifolia, Tamarindus indica, Acacia senegal, Anogeisus leiocarpus, Bauhinia refescence, Phoenix dactylifera* and *Ziziphus spina-christi* each recorded the value of 8.3% (Table 2) making them the species with the least percentage frequency representation in the study area.

Azadirachta indica is the most abundant species; it recorded a value of 9.0, followed by *Acacia seyel* which has an abundance value of 8.2. *Tamarindus indica* recorded the value of 5.5 while *Acacia senegal, Phoenix dactylifera* and *Ziziphus spina-christi* which has an abundance of 1.0 each (Table 2) are the species which are less in abundance. Species of *Acacia seyel* are the species with the highest importance value index in the study area. They recorded the value of 29.4 followed by the species of *Azadirachta indica* which recorded a value of 25.1. The specie of *Tamarindus indica* recorded a value of 13.9. *Adansonia digitata* has 8.7, *Faidherbia albida* recorded 6.4 while *Balanites aegyptiaca* and *Maerua crassifolia* recorded 6.1 and 2.4 respectively. *Acacia nilotica* and *Anogeisus leiocarpus* each recorded a value of 2.1.Species of *Hyphania thebaica, Bauhinia refescence* and *Phoenix dactylifera* recorded the value of 1.5, 0.9 and 0.6 respectively. The species with the least importance value index are *Acacia senegal* and *Ziziphus spina-christi* each recording a value of 0.3 (Table 2).

Table 2: Tree species diversity, stand variables and diversity indices of a sahel ecosystem.

Species	N/ha	mDBH	mHt	BA/ha	Vol/ha	Den	Freq	Abun	RD (%)	R.Dom (%)	IVI
Acacia nilotica	5	22.2	6.0	0.20	1.21	0.42	25.0	1.7	2.9	1.3	2.1
Acacia senegal	1	13.7	4.0	0.01	0.06	0.08	8.3	1.0	0.6	0.1	0.3
Acacia seyel	74	19.9	4.7	2.45	12.68	6.17	75.0	8.2	42.5	16.3	29.4
Adansonia digitata	3	82.8	9.6	2.36	26.08	0.25	16.7	1.5	1.7	15.7	8.7
Anogeisus Leiocarpus	2	54.5	9.9	0.47	4.69	0.17	8.3	2.0	1.1	3.1	2.1
Azadirachta indica	45	31.2	11.5	3.63	43.06	3.75	41.7	9.0	25.9	24.2	25.1
Balanites eagyptiaca	15	21.1	4.5	0.55	2.57	1.25	50.0	2.5	8.6	3.7	6.1
Bauhinia refescence	2	23.1	5.4	0.10	0.59	0.17	8.3	2.0	1.1	0.7	0.9
Faidherbia albida	6	51.7	10.0	1.40	14.22	0.50	25.0	2.0	3.4	9.4	6.4
Hyphania thebaica	3	26.2	9.6	0.18	1.73	0.25	16.7	1.5	1.7	1.2	1.5
Maerua crassifolia	5	27.1	5.1	0.30	1.61	0.42	16.7	2.5	2.9	2.0	2.4
Phoenix dactylifera	1	35.0	9.6	0.10	0.92	0.08	8.3	1.0	0.6	0.6	0.6
Tamarindus indica	11	58.4	9.2	3.23	31.28	0.92	16.7	5.5	6.3	21.5	13.9
Ziziphus spina-christi	1	10.0	3.8	0.01	0.03	0.08	8.3	1.0	0.6	0.1	0.3

Note:N/ha = number of tree per ha; mDbh = mean diameter at breast height (cm); mHt = mean total height (m); G/ha = basal area per ha; Vol/ha = volume per ha; RD = relative density in percentage; RDom = relative dominance in percentage; IVI = important value index

The study area has a species richness of 2.52 and species evenness index (E_H) of 0.38. Species diversity of the study area is 1.97 while the index of dominance is 0.46 (Table 3). Tree species in the study area has a mean diameter at breast height (dbh) of 28.4cm and dominant dbh of 160cm. The mean height of trees in the study is 7.2m while the dominant height is 45.2m. The total basal area and total volume per hectares of tree species in the study area are 14.99 m^2 and 140.74 m^3 respectively (Table 3).

Table 3:Tree species diversity indices and growth variables of a sahel ecosystem

Biodiversity Indices		Tree Growth Variables	
Indices	Values	Variables	Values
Margalef's Index of Species Richness	2.52	Mean Dbh (cm)	28.4
Pielou's Species Evenness Index (E_H)	0.38	Dominant Dbh (cm)	160
Shannon-Weiner Index (H')	1.97	Mean Height (m)	7.2
Simpson Index of Dominance (D)	0.46	Dominant Height (m)	45.2
		Total Basal Area/ha (m^2)	14.99
		Total Volume/ha (m^3)	140.74

The trees are relatively few in number, have few families and few species in the study area in comparison to Guinea Savannah or tropical forest ecosystems (Ikyaagba et al. 2015; Ogunjemite, 2015; Adekunle et al. 2013), a typical characteristics of Savanna ecosystem where few tree species are scattered across the landscape. However, the number of trees recorded is higher than that reported by Saka et al. (2013) in Girei forest reserve in Adamawa state which falls within the Sudan Savanna. Theoretically, the vegetation in the Sudan Savannah (Girei forest reserve) would be expected to be richer in comparison to the study area which is in the Sahel zone. This is because the amount of precipitation an area received has been regarded as the major driving force that determines the vegetation of the area (Aregheore, 2009). Sudan savannah usually experience more rainfall than the Sahel savannah. However, difference in sample size and intensity, plot size, environmental conditions, and other site factors are possible reasons that could be responsible for the observed differences (Aigbe and Omokhua, 2015).

The family Fabaceae recorded the highest number of observation in the study area. This is not surprising because trees belonging to the family of Fabaceae are generally in abundance in the Savanna region and plays a significant role in the socioeconomic life of the people. Attua and Pabi, (2013) and Wakawa et al. (2006) also

report a similar observation when they carried out tree assessment in a Savanna region. Trees belonging to the Fabaceae family such as *Faidherbia albida*, *Tamarindus indica*, *Acacia nilotica*, *Acacia seyel* and *Acacia senegal* are valued by the inhabitant because of their role in soil improvement and conservation, feeds for animals, medicinal and economic value. No wonder they are among the tree species which recorded some of the highest most important value index (IVI) in the study area. Due to their importance to people, they are generally spared from felling. Species in the families of Rhamaceae and Combretaceae are in danger of extinction in the study area if adequate measures are not taken. This is because only one and two trees respectively were encountered in the entire study area. Species of *Azadirachta indica*, *Acacia seyel*, *Acacia nilotica*, *Balanites aegyptiaca*, *Tamarindus indica*, *Adansonia digitata* are the most abundant in the study area. The presence of such species is common in the savannah region and has been reported by many authors (Wakawa et al. 2016; Tukur 2013). Species of *Phoenix dactylifera*, *Acacia senegal and Ziziphus spina-christi* which are common in the Sahel and expected to be in abundance were encountered only once. There population might have been affected by land clearing for building, agriculture and other developmental activities taken place. This implies that unless deliberate and concerted efforts are made towards their conservation they may be extinct in the study area in no distant future.

The species richness, diversity and evenness of 2.52 , 0.38 and 1.97 respectively of the study area is poor when compared with 6.01, 0.82 and 2.24 value of Federal University of Agriculture Makurdi, Benue State, Nigeria (Ikyaagba et al. 2015), 0.78 Species evenness and 2.60 diversity index of Kogo forest reserve in Katsina Sate, Nigeria (Bello et al. 2013) and 2.61 diversity index of Girei forest reserve in Adamawa State, Nigeria (Saka et al. 2013) but higher species richness in comparison with Kogo forest reserve in Katsina which has 1.84 (Bello et al. 2013). Even though all the study area are in the savannah, a closer look at the climate of each study area will revealed a difference in amount of precipitation received annually. This could be responsible for the difference in biodiversity indices recorded by each study area since precipitation has been regarded as one of the most important environmental factor affecting the growth and distribution of vegetation (Zakaluk and Ranjan, 2008; Aregheore, 2009). The variation in climates, topography, soil properties and their interaction as well as sampling intensity employed could also be another possible explanation for the observed difference across the study areas.

4. Conclusion

Conclusively the area studied is dominated by species of the family of Fabaceae. Species of Acacia seyel were found to record more occurrence, higher percentage frequency and higher importance value index than any tree species in the study area. However, Azadirachta indica was found to be more abundant. Other common tree species recorded includes; Faidherbia albida, Tamarindus indica, Acacia nilotica, Adansonia digitata, Balanites aegyptiaca, Acacia seyel, Maerua crassifolia and Bauhinia refescence. The tree species richness of the study area is poor and the composition is less diverse. Some species such as Acacia senegal, Phoenix dactylifera and Ziziphus spina-christi are in danger of going into extinction in the study area if concerted efforts are not made towards their conservation.

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Kaynaklar

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