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Inventory of Vascular Plants in Naraguta Mountains of Jos, Plateau State, Nigeria.

[1]K.I. Okeke-Agulu, [2]M.K. Peter, [1]S.K. Vihi, and [3]C.U. Bosah

[1]Department of Agricultural Extension and Management, Federal College of Forestry Jos

[2]Department of Forestry Technology, Federal College of Forestry Jos.

[3]Montane Forest Research Station, Forestry Research Institute of Nigeria.: okekeaguluki@gmail.com

Abstract

This Study was carried out in Naraguta Mountains of Jos Plateau State on inventory of vascular plants following increased concerns of rapid depletion of plant resources in the study area. Systematic sampling technique was adopted for plot selection. Two plots, measuring 50m x 50m each at 100m intervals were laid. Eight (8) sample sub-plots of 25m x 25m were located. The diameters of all the vascular plants with dbh ≥10 cm were measured. All measured plants were identified to species level. Data were analyzed using descriptive, parametric and non-parametric statistics such as frequencies and charts. Species relative frequencies, relative densities, relative dominance, importance value index, diversity and richness were also computed. Tree species were grouped into abundance, height and diameter classes. Results show a total of 83 vascular plants belonging to 23 families. Fabaceae (21.7 %.) was the most represented family. Conclusively, the study area is dominated by species of the families of Fabaceae, Anacantheceae and Longaniaceae. Species of *Cussonia aborea* was found to record more occurrence, higher relative frequency, relative density and higher important value index than any tree species in the study area. We recommend concerted awareness campaigns and protection efforts through massive enlightenment and afforestation efforts by all stakeholders.

Keywords: Vascular Plants, Species Relative Frequencies, Relative Dominance, Importance Value Index.

Introduction: Vascular plants also known as tracheophytes and higher plants, form a large group of plants that are defined as those land plants that have lignified tissues (the xylem) for conducting water and minerals throughout the plant. They also have a specialized non-lignified tissue (the phloem) to conduct products of photosynthesis. Vascular plants include the clubmosses, horsetails, ferns, gymnosperms (including conifers) and angiosperms (flowering plants). Scientific names for the group include Tracheophyta and Tracheobionta (Okali, 2010). Usually, plant inventories are expected to provide basic information on the plant population of a location in order to make informed management decisions. However, there is increasing concern for the status of Earth's biodiversity which has arisen from observations of rapid depletion of its resources (Okali, 2010). Understanding vegetation patterns and species diversity is basic for the conservation of natural areas (Zhang, Xu and Li , 2013).

Vegetation structure generally considers the composition of plant communities in terms of specific morphological characteristics while composition is the floristic assemblage of plant species that characterize the vegetation (Martin, 1996). Thus, knowledge of structural characteristics of vegetation is highly demanded both globally and locally. On the global scale, more detailed and standardized data on biomass and vegetation structure of vegetation units are needed in order to parameterize global vegetation maps (Loveland, Zhu, Ohlen, Brown, Reed and Yang, 1999). On the local scale, information on structural characteristics of vegetation as well as standardized inventories of these properties are important for detailed structural descriptions of woody plant species with respect to the stratified vegetation types, and secondly, to compare the vegetation types in terms of structural parameters (Jibrin and Jaiyeoba, 2013). There are two primary characteristics distinguishing Vascular plants. Vascular plants have vascular tissues which distribute resources through the plant. This feature allows vascular plants to evolve to a larger size than non-vascular plants, which lack these specialized conducting tissues and are therefore restricted to relatively small sizes. In vascular plants, the principal generation phase is the sporophyte, which is usually diploid with two sets of chromosomes per cell. Only the germ cells and gametophytes are haploid. By contrast, the principal generation phase in non-vascular plants is the gametophyte, which is haploid with one set of chromosomes per cell. In these plants, only the spore stalk and capsule are diploid (Zhang *et al*., 2013).

Abuses have been rendered in most Nigerian bio-diverse ecosystems the study area inclusive, in the utilization of forest resources and the attendant consequence has reached emergency proportions. Soil erosion has appeared to be most visible effect but other major consequences of these abuses include biodiversity loss, situation of inland water bodies and declining agricultural productivity. These has caused forests to face serious threats than at no other time in history, these threats vary in magnitude from total removal of forest cover to degradation of population beyond biologically accepted levels (Iheanacho and Udah, 2010). By far the greatest impact of seedless vascular plants on human life however comes from their extinct progenitors. The tall club mosses, horsetails, and tree-like ferns that flourished in the swampy forests of the Carboniferous period gave rise to large deposits of coal throughout the world (Iheanacho and Udah, 2010). The present study therefore focuses on inventory of vascular plants, Species Relative Frequencies, Relative Densities, Relative Dominance, Important Value Index, Diversity and Richness in Naraguta Mountains of Jos, Plateau State.

Materials And Methods: Study Area: The study was carried out in Naraguta Mountains, located on latitude 9° 59'N and longitude 8° 54'E which has an elevation of about 1287m above sea level. It lies within the central Guinea savanna zone classified as woodland savannah vegetation (Figure 1) with the understory dominated by grasses (Keay, 1953). The area is characterized by alternating wet and dry season coded as 'Aw' by Koppen's classification. The area experiences a mean annual rainfall of 1260mm (1050 – 1403mm), peaking between July and August and the mean temperature ranges from 19.4℃ – 24.5℃ (Keay, 1953). The topography is undulating, sloping generally towards different directions in different locations.

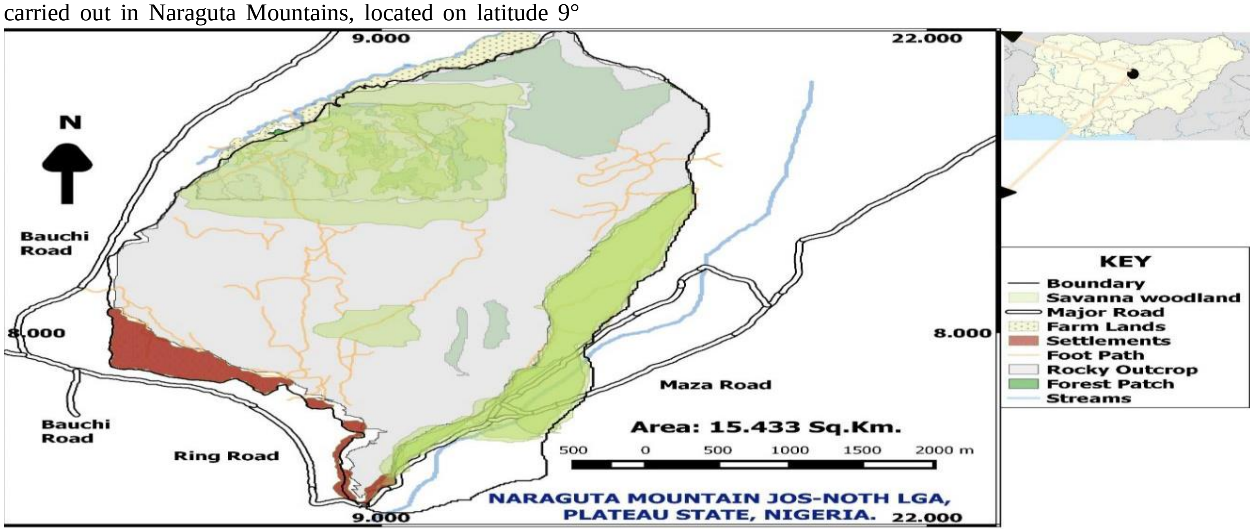

Figure 1: Layout of the Naraguta Mountain (Keay, 1953).

Data Collection: Reconnaissance Survey: A reconnaissance survey was carried out in order to familiarize with the terrain, thus having an overview of the total land area of the mountain.

Sampling Technique: Systematic sampling techniques were used for the sample plot selection. Two plots of 50m x 50m which involved taking samples at 100m interval were marked. Each plot was further divided into sub-plots of 25m x 25m to make a total of eight (8) sub-plots. Vascular plant species were identified, counted and recorded with the help of a taxonomist. The plants were identified using field keys developed by Hopkins and Stanfield (1996) and Akobundu and Agyakwa (1998), respectively. Measurement of woody plants was carried out. The parameters assessed include diameter at breast height using tree calliper and Spiegel relaskop. The height of all trees in each sub-plot were also measured using the Haga altimeter. The number and scientific names of all tree species found in each sub-plot were recorded. Family names and valuable uses of plants were recorded in a field notebook.

Data Analysis: Data generated were analyzed using descriptive, parametric and non-parametric statistics.

The species composition of the different sample plots were described using the following parameters:

$$\boldsymbol{Frequency} = \frac{Number\ of\ quadrant\ in\ which\ species\ occur}{Total\ number\ of\ quadrants\ sampled}$$

…… Brashears *et al*. (2004)

Relative Frequency : The degree of dispersion of individual species in an area in relation to the number of all the species occurred.

$$Relative\ frequency = \frac{Species\ frequency\ of\ individual\ species}{Total\ of\ frequency\ values\ for\ all\ species}\ x100$$

Density following Yang *et al*. (2008) density is modelled:

$$Density = \frac{Number\ of\ individual\ species}{Area\ sampled}$$

Relative Density following Yang *et al*. (2008)

Relative density is the study of numerical strength of a species in relation to the total number of individuals of all the species and which is calculated as:

$$Relative\ Density\ = \frac{Species\ density\ of\ individual\ species}{Total\ density\ for\ all\ species}\ x\ 100$$

Relative Dominance………..…………………………………. (Yang *et al*., 2008)

$$Relative\ Dominance\ = \frac{Basal\ area\ of\ individual\ species}{Total\ basal\ area\ of\ all\ species}\ x\ 100$$

Importance Value Index (IVI) = relative frequency + relative density + relative dominance (Brashears *et al*., 2004; Yang *et al*., 2008)

Basal Area

Basal area (BA) of all trees in the sample plots were calculated as:

BA = DBH^2 x 0.00007854

Where:

BA = Basal area

DBH = Diameter at breast height

Shannon – Wiener Diversity Index (H)

Data obtained were estimated using diversity indices such as species richness, diversity and evenness. Species richness was computed using Margalef (1968) as cited by Magurran (2004) as follows:

$$D\ = \frac{(S-1)}{lnN}$$

Where, D = species richness index (Margalef index), S = number of species and N = total number of individuals.

Species diversity was estimated using Shannon-wiener diversity index as cited by Magurran (2004). Shannon-wiener diversity index equation is stated below as:

$$H!\ =\ -\Sigma\, pi\ ln\ pi$$
$$i = 1$$

Where H! = species diversity index, pi= the proportion of individuals or the abundance of the ith species expressed as a proportion of the total abundance. The use of natural logs is usual because this gives information in binary digit.

Species evenness was estimated using Pielou's evenness (equitability) index (Pielou, 1975) as cited by Magurran (2004) as follows:

$$J!\ = \frac{H!\ (Observed)}{Hmax}$$

J! = Pielou's evenness index, H!(Observed)/Hmax, where Hmax is the maximum possible diversity, which would be achieved if all species will be equally abundant (=Log S). The indices were computed for all plant species in various forms (trees and shrubs), in each of the sub-plot. The values for these indices (abundance) were compared using a one-way analysis of variance to test for significance of differences between these variables for each of the subplots.

Results And Discussion: Species Richness/Composition across Plots in the Study Area Number of Trees per Plot, Height Class and Diameter Class: The result of the total number of trees enumerated in the study area based on plots, height classes and diameter class were presented in Figure 2, 3 and 4. As revealed in the result, the numbers of trees include 9 trees in plots 1, 6 trees in plot 2, 7 trees in plot 3, 10 trees in plot 4 and 6, 12 trees in plot 5, 13 in trees in plot 7 while the number of trees in plot 8 is 16. This gave a total of 83 tree species enumerated. Plot 8 had the highest number of trees (16), and the order of abundance from the highest to lowest plot ranges from Plot 8 > 7 > 5 > 4 and 6 >1 > 3 > 2 (Figure 2) The result thus reveals a significant difference in the abundance of tree species across the different sub-plots in the study area.

The total number of trees based on height class (Figure 3) indicated that 52 tree species was recorded in 1-5m height class, 25 tree species in 6-10m height class, 5 tree species in 11-15m height class and 1 tree species in 15m and above height class. The highest number of trees (52) was observed in 1-5m height class, while the lowest number of tree species was observed in the height class of 15m and above. The total number of trees based on diameter class (Figure 4) indicated that 55 tree species was recorded in 10-15cm diameter class, 20 tree species in 16-20cm diameter class, 8 tree species in 21-25cm diameter class, the highest number of trees (55) was observed in10-15cm diameter class and the order of decrease in diameter class include: 10-15 cm > 16-20 cm > 21-25 cm > 26-30 cm.

Tree Composition across Sub-plots in Naraguta Mountain: A total of 83 tree species in 23 families were recorded in all (Table 3). The most occurring tree species in plot one were *Cussonia arborea, Terminalia laxiflora, Entenda africana with* the highest relative frequency (RF) of 33.33%, in plot two and three, *Cussonia arborea* was also the most occurring tree species with RF of 50% and 33.3% respectively. *Bombax costatum,* was the most occurring tree species in plot four with RF of 33.3% while *Cussonia arborea* and *Entenda Africana* were the most occurring tree species in plot five with RF of 33.3% respectively. The most occurring tree species in plot six were *Cussonia arborea* and *Lannea microcarpa with* RF 33.3% and the most occurring tree species in plot seven was *Cussonia arborea, Parkia biglobosa*, *Clausena anistata* and *Bombax custatum* with RF of 22.2%, while *Entenda africana Bombax custatum* and *Parkia biglobosa* were the most tree species in plot eight with RF of 22.2% (Table 4). *Cussonia arborea* was the most populated tree species in plot one with relative density (RD) of 77.8%, plot two 50% and plot three 42.9%, while *Bombax costatum* was also the most occurring species with RD 50% in plot four.In plot five, *Cussonia arborea* was also the most occurring specie with RD of 58.3%, inplot six *Lannea microcarpa* was the most populated with RD of 40% and the most occurring tree species in plot seven was *Cussonia arborea*, with RD of 46.2% while in plot eight *Bombax custatum* was the most populated species with RD of 31.3%. Important value index provides knowledge on the important species of a plant community. Based on IVI, *Cussonia aborea* was the most dominant tree species in plot one with IVI of 192.5, 175.7 for plot two and 113 for plot three. The most dominant tree species in plot four was *Bombax costatum* with IVI of 122 while *Cussonia aborea* was the most dominant tree species in plot five, six and seven with IVI values of 160.8, 120.1 and 105 respectively. *Bombax costatum* was the most dominant tree species in plot eight with IVI of 79.9 **Family Composition across Sub-plots in Naraguta Mountain**

23 (100%) families were obtained from tree species across sub-plots in the study site (Table 5). The result thus reveals that out of the whole families, Fabaceae recorded highest and was dominantwith 18 (21.7%).

Tree Species Diversity and Evenness: Plot 8 had the highest value for tree species diversity (H = 1.63). This was followed by plot three with diversity of 1.48, plot seven (H = 1.42), plot four (H = 1.36), plot six (H = 1.28), plot five (H = 1.12), plot two (H = 1.01) while plot one was the least with a diversity of 0.68. The result on species evenness for tree species shows highest value (J' = 0.92) in plot two, three and six respectively and was closely followed by plot eight (J' = 0.91), plot seven (J' = 0.88), plot four (J' = 0.84), plot five (J' = 0.81) and plot one was the least with J' = 0.62 (Table 6). **Tree Composition :** The present study therefore recorded 83 tree species in the study area. It reveals low population of trees species when compared with the value of 174 species as reported by Lucky *et al.* (2017) for Sahelian Ecosystem in North-East Nigeria. 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). More importantly, the decreased number of tree species could be caused by increased urbanization rate of Jos metropolis and their increased dependence on fuelwood sourced from the study area. The study thus reveals clear distinction between the different sub-plots in terms of abundance, richness, evenness and diversity in the study area. The value ranges between tree diversity (0.63-1.63) and evenness (0.62-0.92). This therefore shows a less tree diversity in the study area. The study also shows that there was no discernible pattern of the species occurrence as one move from plot to plot of Naraguta Mountain. They had close species richness and diversity values. This similar pattern was reported by Zapfack *et a*l. (2002), Bobo *et al.* (2006) and Mbue *et al.* (2009). This closeness could be an indication of recovery of the study area from human disturbance especially logging activities, which allow for re-establishment of species which are usually considered old growth forest specialist in the study area.According to Bobo *et* al. (2006); Gradstein *et al.* (2007) and Saga *et al*. (2008), the decrease in diversity indices from the different plots suggest that trees diversity is affected by land use types. This decrease in diversity indices in the study area may also be as a result of changes in decomposition rates and litter fall within the forest (Barlow *et al*., 2007). In all the sub-plots, the evenness of trees was relatively low (0.62-0.92) indicating that some few species like; *Cussonia arborea*, *Terminalia laxiflora*, *Entenda africana* and *Bombax costatum*, clearly dominates the different plots in the study area. The lower values of species evenness recorded in the study shows poor representation of some species and families even though they contribute greatly to the diversity indices. It also indicates that most of the families in the study area have species that are not evenly distributed, giving rise to fragile nature of most of the families and species of which may suggest the presence of rare species (Mbue *et al*. 2009). This observation agrees with the findings of Duran *et al*. (2006) and Mbue *et al.* (2009) who reported that the ecological implication may be that little disturbance of an ecosystem may cause extinction of some plant species or even some families. Comparison of species based on abundance produced significant difference at p=0.05 among all the sub-plots and between the different plots at different intervals.

Family Composition: Fabaceae which are recorded as the most dominant 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*. (2016) report a similar observation when they carried out tree assessment in a Savanna region. Trees belonging to the Fabaceae family are valued by the inhabitants because of their role in soil improvement and conservation, feeds for animals, medicinal, economic value and which are strongly associated with land use intensity unlike other families.

Conclusion and Recommendations : Conclusively the area studied is dominated by species of the families of Fabaceae. Species of *Cussonia aborea* was found to have more occurrence, higher relative frequency, relative density and higher importance value index than any tree species in the study area. Other tree species recorded includes; *Entenda africana*, *Terminalia laxiflora, Bombax costatum*, *Lannea macrocarpa* and *Parkia biglobosa*. The study thus provides insight and facts about the status of vascular plants (trees) which are reported to be more reactive to environmental changes and of which shows drop in species richness and diversity from the different plots as well as dominant by few species in Naraguta Mountains.Based on the findings of this study; we recommend that conservation efforts be given more attention by all stakeholders, since biodiversity plays a significant role in soil improvement and conservation, feeds for animals, medicinal and economic value. The current decline in population of flora species makes it very imperative for concerted awareness campaigns, protection and afforestation efforts in the study area.

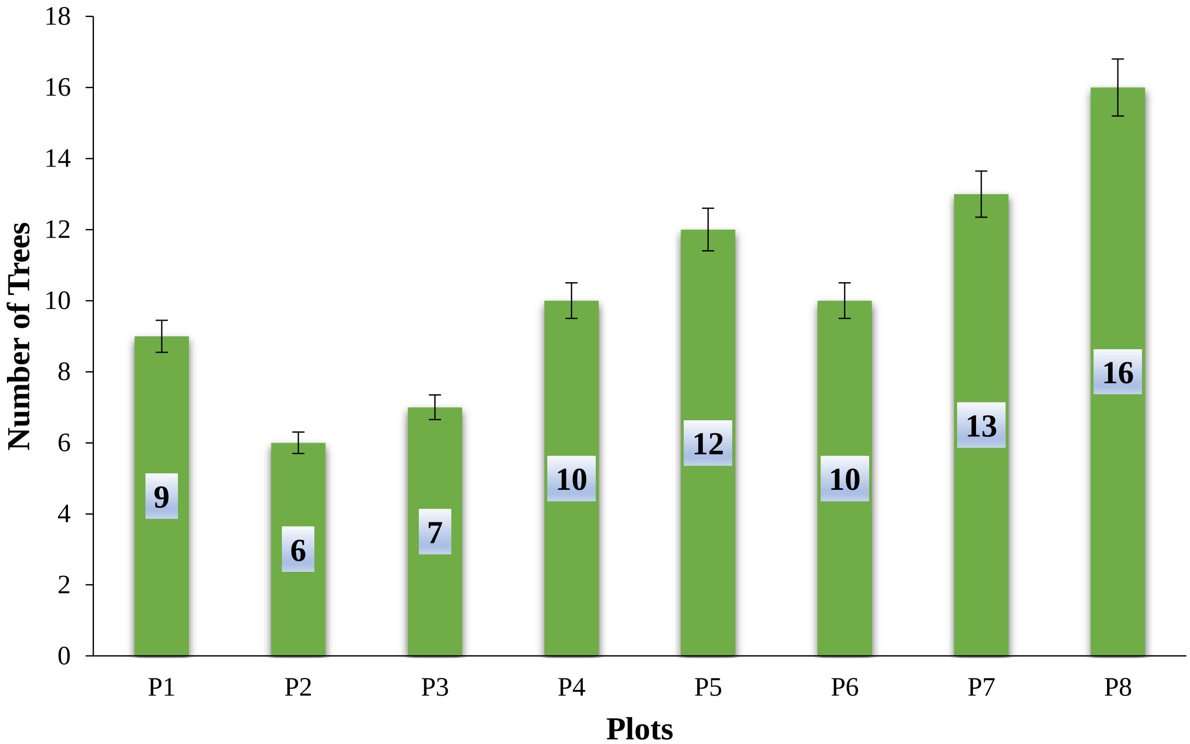

Figure 2: Abundance of trees across different plots in Naraguta Mountains

The result in table 1 and 2 shows comparative mean and one sample T-test on abundance of trees across different sub-plots in Naraguta Mountain. The result thus reveals a significant difference (0.000) on the different sub-plots in Naraguta Mountain with a mean difference of 10.38.

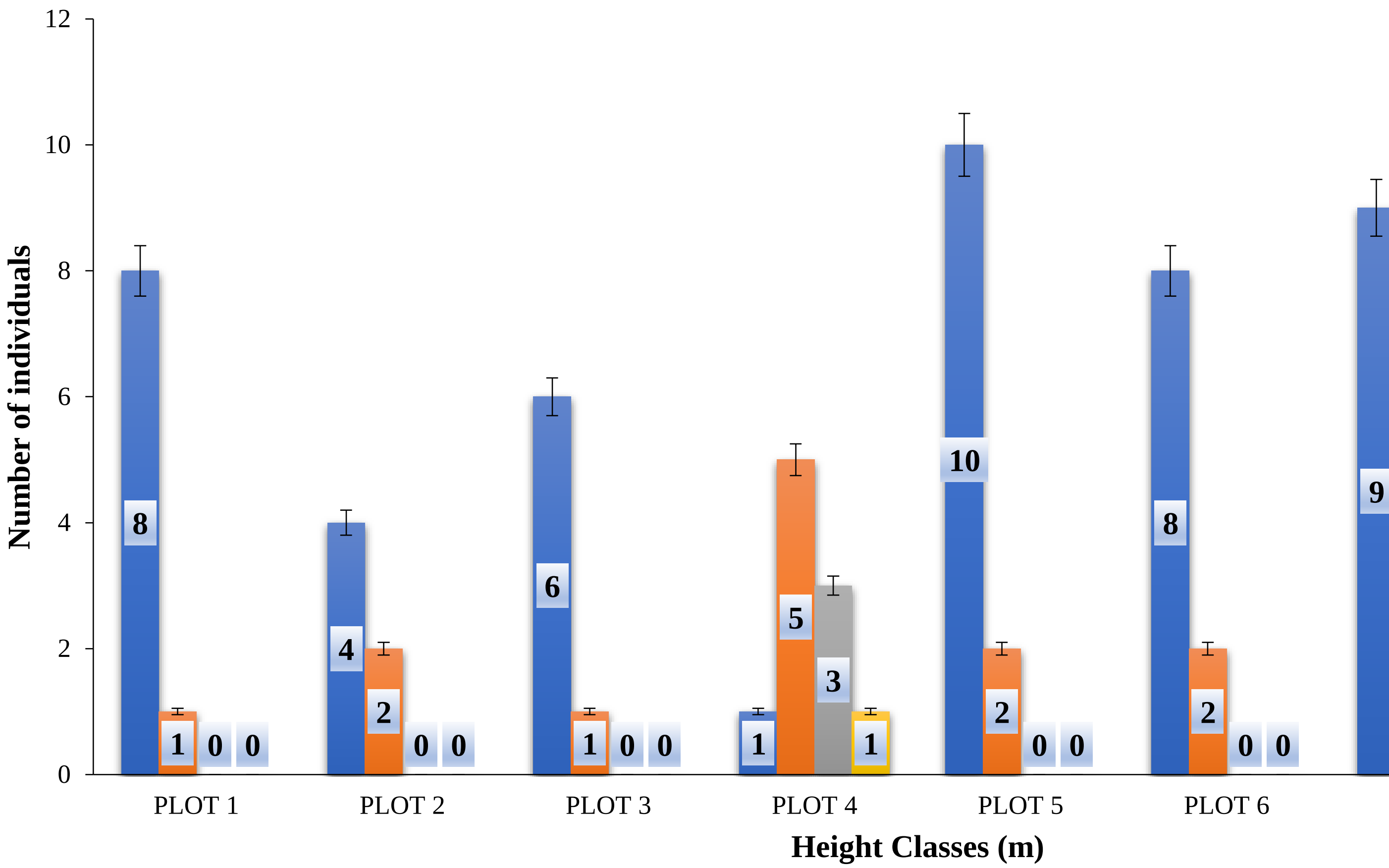

Figure 3: Height distribution of trees in the different plots in Naraguta Mountains

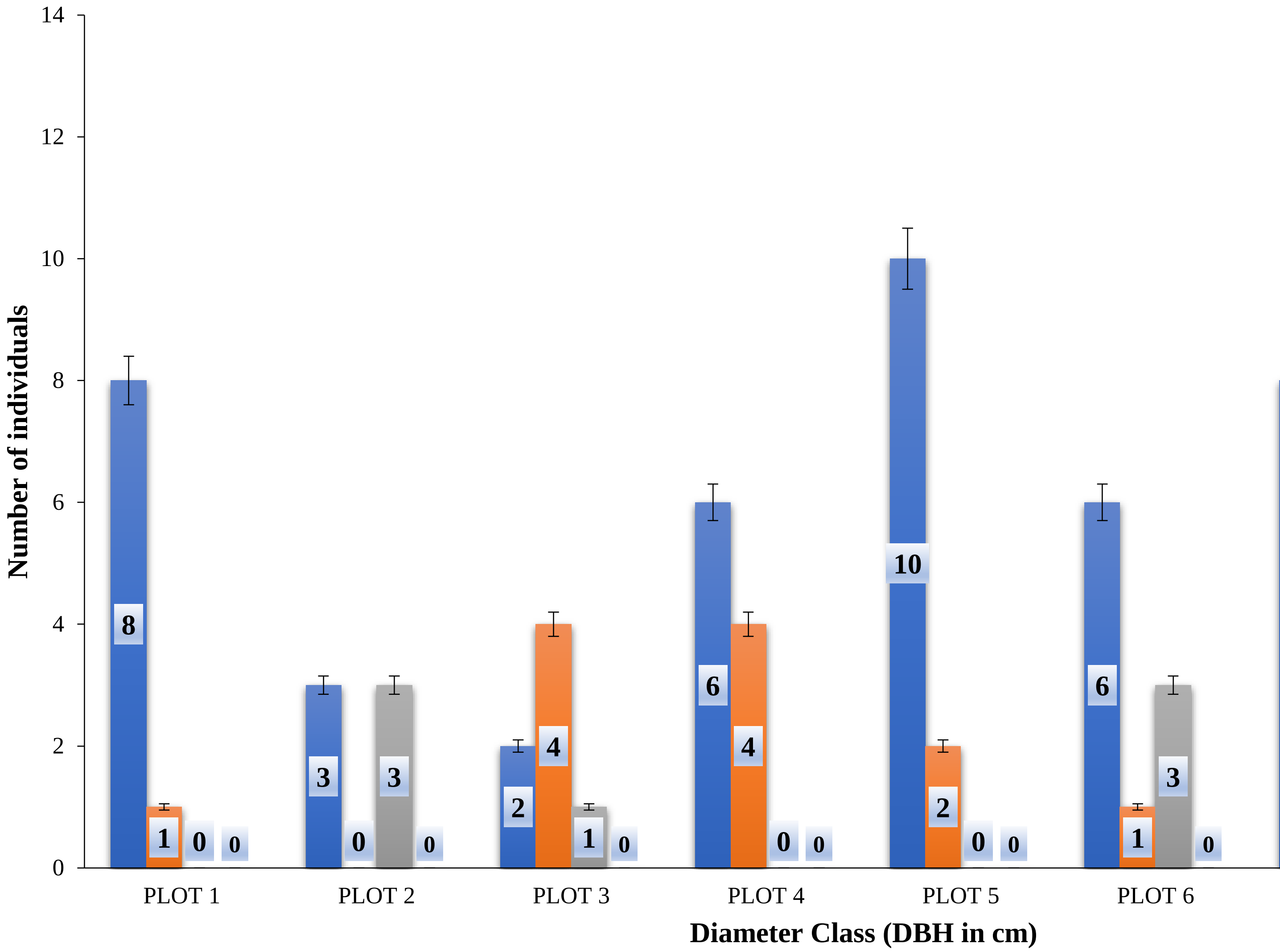

Figure 4: Diameter distribution of trees (≥ 10cm) in the different plots in Naraguta Mountain

Table 1: Comparative mean on Abundance of trees across different Sub-plots in Naraguta Mountains

	N	Mean	Std. Deviation	Std. Error Mean
Abundance of trees in the different sub-plots	8	10.38	3.249	1.149

Table 2: One sample T-test analysis on Abundance of trees across different Sub-plots in Naraguta Mountains

	Test Value = 0					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Abundance of trees in the different sub-plots	9.033	7	0.000**	10.375	7.66	13.09

Where: ** = Significant

Table 3: Tree species distribution according to families in the study area (Naraguta Mountain)

S/N	**Life Form**	**Frequency (F)**	**Percentage (%)**	**Families**
1	**Tree**	83	100	23
Total		**83**	**100**	

Source: *Field Survey, 2019*

Table 4: Tree Species based on IVI across Plots in Naraguta Mountains

S/N	SPECIES	PLOT 1			PLOT 2			PLOT 3			PLOT 4			PLOT 5			PLOT 6			PLOT 7			PLOT 8		
		RF	**RD**	**IVI**	**RF**	**RD**	**IVI**	**RF**	**RD**	**IVI**	**RF**	**RD**	**IVI**	**RF**	**RD**	**IVI**	**RF**	**RD**	**IVI**	**RF**	**RD**	**IVI**	**RF**	**RD**	**IVI**
1	*Cussonia aborea*	33.3	77.8	**192.5**	50	50	**175.7**	33.3	42.9	**113**	0.0	0.0	**0.0**	33.3	58.3	**160.8**	33.3	30	**120.1**	22.2	46.2	**105**	11.1	12.5	**29.5**
2	*Entenda africana*	33.3	11.1	**54.2**	0.0	0.0	**0.0**	0.0	0.0	**0.0**	16.7	20	**65.7**	33.3	16.7	**60.9**	0.0	0.0	**0.0**	0.0	0.0	**0.0**	22.2	18.8	**67.4**
3	*Terminalia laxiflora*	33.3	11.1	**53.3**	25	33.3	**74.3**	0.0	0.0	**0.0**	0.0	0.0	**0.0**	16.7	8.3	**32.9**	16.7	20	**48.7**	0.0	0.0	**0.0**	0.0	0.0	**0.0**
4	*Margaritria spp*	0.0	0.0	**0.0**	25	16.7	**50.0**	0.0	0.0	**0.0**	0.0	0.0	**0.0**	0.0	0.0	**0.0**	16.7	10	**32.9**	0.0	0.0	**0.0**	0.0	0.0	**0.0**
5	*Bombax costatum*	0.0	0.0	**0.0**	0.0	0.0	**0.0**	16.7	14.3	**46.3**	33.3	50	**122**	0.0	0.0	**0.0**	0.0	0.0	**0.0**	22.2	15.4	**53.4**	22.2	31.3	**79.9**
6	*Parkia biglobosa*	0.0	0.0	**0.0**	0.0	0.0	**0.0**	16.7	14.3	**50.1**	16.7	10	**45.6**	0.0	0.0	**0.0**	0.0	0.0	**0.0**	22.2	15.4	**58.8**	22.2	25	**76.6**
7	*Lannea microcarpa*	0.0	0.0	**0.0**	0.0	0.0	**0.0**	16.7	14.3	**37.0**	16.7	10	**34.3**	0.0	0.0	**0.0**	33.3	40	**98.3**	11.1	7.7	**22.6**	11.1	6.3	**23.2**
8	*Clausenaanistata*	0.0	0.0	**0.0**	0.0	0.0	**0.0**	16.7	14.3	**53.9**	0.0	0.0	**0.0**	0.0	0.0	**0.0**	0.0	0.0	**0.0**	22.2	15.4	**59.9**	0.0	0.0	**0.0**
9	*Uvaria chamae*	0.0	0.0	**0.0**	0.0	0.0	**0.0**	0.0	0.0	**0.0**	16.7	10	**33.0**	16.7	16.7	**45.5**	0.0	0.0	**0.0**	0.0	0.0	**0.0**	11.1	6.3	**23.2**

Source: *Field Survey, 2019*

Table 5: Family representations of tree species with corresponding number of species in Naraguta Mountain

Family	Tree	Percentage (%)
Acanthaceae	3	3.6
Annonaceae	2	2.4
Apocynaceae	1	1.2
Araliaceae	4	4.8
Asparagaceae	2	2.4
Burseraceae	2	2.4
Combretaceae	10	12.0
Ebenaceae	4	4.8
Fabaceae	18	21.7
Hypericaceae	2	2.4
Longaniaceae	2	2.4
Malverceae	2	2.4
Meliaceae	2	2.4
Menispermaceae	7	8.4
Myrtaceae	4	4.8
Ochnaceae	2	2.4
Opiliaceae	2	2.4
Phyllantaceae	2	2.4
Polygalaceae	2	2.4
Rubiaceae	2	2.4
Sapindaceae	3	3.6
Verbenaceae	3	3.6
Vitaceae	2	2.4
TOTAL	**83**	**99.7 approx. 100**

Source: *Field Survey, 2019*

Table 6: Summary Characteristics of Species Diversity amongdifferent plots in Naraguta Mountains

Specie Variables	PLOT 1		PLOT 2		PLOT 3		PLOT 4		PLOT 5		PLOT 6		PLOT 7		PLOT 8	
	Shannon wiener index (H)	Evenness index (%)	Shannon wiener index (H)	Evenness index (%)	Shannon wiener index (H))	Evenness index (%)	Shannon wiener index (H)	Evenness index (%)	Shannon wiener index (H)	Evenness index (%)	Shannon wiener index (H)	Evenness index (%)	Shannon wiener index (H)	Evenness index (%)	Shannon wiener index (H)	Evenness index (%)
Trees	0.68	0.62	1.01	0.92	1.48	0.92	1.36	0.84	1.12	0.81	1.28	0.92	1.42	0.88	1.63	0.91

Source: *Field Survey, 2019*

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