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and Diversity in Rabadi Forest Reserve,
Jigawa State, Nigeria**

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WOODY PLANT SPECIES COMPOSITION, STRUCTURE, AND DIVERSITY IN RABADI FOREST RESERVE, JIGAWA STATE, NIGERIA

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ABSTRACT: Periodic inventory of forest resources is needed for proper understanding of the dynamism of flora and faunal resources in the ecosystem. Anthropogenic disturbances such as rampant felling of trees for fuel wood collection and conversion of forested areas to farmlands for arable crop cultivation is on the increase and these could negatively affect the stability of any ecosystem to provide the essential goods and services for the populace. Rabadi forest reserve is among the protected areas in Jigawa State for the conservation of diverse flora and fauna and environmental protect. It is therefore noteworthy to understand current status of woody plants species for planning the conservation strategies and policy formulation. The structure and diversity of woody plants in Rabadi Forest Reserves was assessed in the face of increasing anthropogenic disturbances. Three (3) lines transects of 150m length each were systematically laid at an interval of 100m from one another in the reserve. Point-Centred-Quarter Methods (PCQM) was used in selecting the plant samples for this study. The data collected includes; distance to the nearest woody plants with a stem diameter of at least 5cm. Measurements of stem diameter were taken at breast height (i.e., at a distance of 1.30m aboveground level). The study revealed a total of 16 families and represented by 25 species in the study area. The families of *Combretaceae*, *Fabaceae*, *Caesalpinioideae* and *Fabaceae*, *Mimosoideae* were the most abundant families in the Forest Reserve.

Keywords: Composition, Diversity, Rabadi Forest Reserve, Structure and Woody Plant Species

1. INTRODUCTION

Forest and Wildlife resources have abundant uses to humankind both directly and indirectly. From time immemorial, forests play a key role as the major providers of raw materials to the wood industries, food and pharmaceutical (Holland *et al.*, 1990). Forests provide a broad variety of highly valuable ecological

and social services including the conservation of biological diversity, carbon storage, soil and water conservation, provision of employment and enhanced livelihood, agricultural production systems, and improvement of urban living conditions (Salami *et al.*, 2020; Dagba *et al.*, 2017). Holland *et al.* (1990), reported that, the progress from primitive cave-dwellers to the present civilised state cannot be told

without making numerous references to trees and their products. In every land, and in all ages, trees have had an influence on the progress and welfare of humankind. Therefore, a better understanding of the ecology of woody plants is a key to the sustainable management of African Savanna because they stabilize these ecosystems. Also, there is need to provide adequate quantitative and qualitative ecological data to guide forest owners and managers in designing realistic and efficient management strategies which are essential (Salami and Akinyele, 2018). A general estimate of forest cover provided by the FORMECU in 1999 gave critical evidence of the serious vegetation changes and biodiversity loss, particularly in the northern part of the country. This provided insights and forewarnings on the increasing magnitude of the problems of desertification in Nigeria. Anthropogenic disturbances such as rampant felling of trees for fuel wood collection, uncontrolled grazing and indiscriminate bush burning couple with encroachment by farmers were the main causes of deforestation, which in turn also renders productive land unfertile and barren (Salami *et al.*, 2020; Adelusi, 2002). The degradation, fragmentation and conversion of the forests to other forms of land uses in Nigeria, are currently progressing at alarming rates. Between 1990 and 2000, Nigeria lost about 2.7% of its natural forests to deforestation which increased to about 18.56% (about 2.06 million ha) between 2000 and 2010 (Salami and Akinyele, 2018; FAO, 2011; FRA, 2010).

In few decades ago, forests resources were regarded as an open access resource that could be exploited at will just to serve the immediate needs and aspiration of the present generation without any plan to preserve such resources for the needs of future generations. Recently, there is a growing concern over the fate of the remaining forests as destruction and eventual disappearance of valuable fauna and flora species in the tropical forests soar. Therefore, forest management requires quantitative estimates of forest resources. Such information is indispensable for forest-policy decisions and management strategies. Forest and forestry researches require a great deal of additional information, for example about the density of forests and stands, species composition, diversity, spatial distribution of trees within stands, the size and size distribution of trees within stands, and the expected growth of trees and stands. Studies were conducted on woody plant diversity and composition in many constituted forest reserves in Nigeria and in Jigawa State. Rabadi Forest reserve is one of the constituted forest reserves in Jigawa State, set aside for the

conservation of native flora and fauna and for environmental protection against challenging desertification threat. In any gazetted reserve or planted forests, there is a need for taking periodic inventory for forest resource assessments. However, in Rabadi Forest reserves, little information is documented on the conservation status of this reserve, and even the little data that is available need to be periodically updated for proper planning conservation and policy formulation. This study therefore conducted to fill that information gap. The findings of this study could be of immense importance to the State Government and researchers in the field of ecosystem science on the conservation status of woody plants in the study area which should ideally be assessed over time to get the up-to-date information.

2. MATERIALS AND METHODS

The research was conducted at Rabadi Forest Reserve located in Gwaram Local government, Jigawa State and stretches to Giade L.G.A of Bauchi State. It lies between the latitudes 12° 40" N to 12° 80" N and Longitude 4° 44"E to 4° 50"E.

2.1. Sampling Procedure

A simple random sampling technique was used to assess the woody species composition, structure and diversity in the Reserve. Three transect lines of 150m each were laid randomly across the forest reserve, and three sample plots were systematically located at every 20m intervals thereby making a total of three 30x30m plots per transect. A total of nine sampled plots of 30m x 30m size were used for this study following (Zhgilla *et al.*, 2016). The choice of the plot size (30x30m) was done to allow for optimum inclusion of species in the inventory due to the sparse nature of vegetation in the study areas (Zhgilla *et al.*, 2016; Ambasht and Ambasht, 2002).

2.2. Data Collection

In each sampled plot, identification and complete enumeration of all woody plant species with diameter measurements at breast height (Dbh) ≥ 5 cm was carried out. Similarly, stump cross-sectional area measurements of all woody plants were taken at 1.30m above ground level using a measuring tape, and such values were then divided by pi ($\pi=3.142$) to give diameter readings in centimetres.

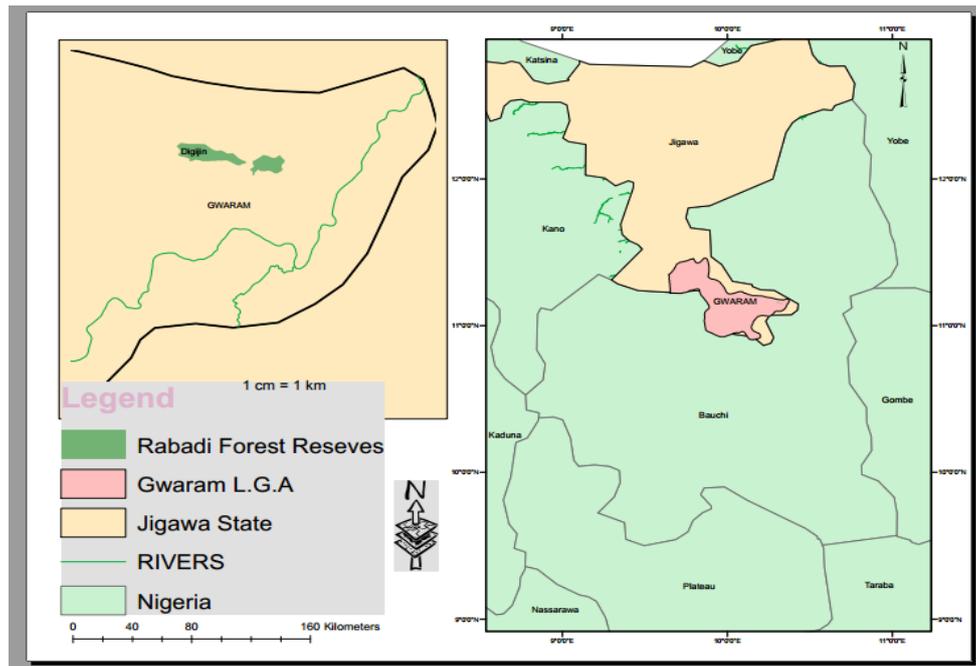


Figure 1: Map of Jigawa State Showing the Study area

2.3. Data Analysis

Analyses on woody plant community structure which include: basal area, Relative basal area, relative density, relative frequency and the Important Value Index (IVI) were performed using Microsoft Excel.

Furthermore, Dallmeier (1992) formulae for calculating Basal Area Relative basal area, Relative density, Relative frequency and the Important Value Index were analysed using Microsoft Excel. Similarly, Simpson’s and Shannon’s indices for woody plant diversity were used (Shannon, 1949).

- i. Basal area computation was analysed following (Husch *et al.*, 2003).

$$BA = \frac{\pi D^2}{4} \dots \dots \dots (1)$$

- ii. Species frequency

$$F = \frac{\text{number of plots in which a species occurs}}{\text{total number of plots sampled}} \times 100 \dots (2)$$

- iii. Relative frequency

$$RF = \frac{\text{number of occurrence of a species in a samled plot}}{\text{number of occurrence of all species in all the samped plots}} \times 100 \dots (3)$$

- iv. Species abundance

$$Abundance = \frac{\text{total number of individuals of a species in all plots}}{\text{total number of plots in which the species occurred}} \times 100 \dots (4)$$

- v. Species density

$$D = \frac{\text{total number of individuals of a species in all plots}}{\text{total number of plots sampled}} \times 100 \dots (5)$$

- vi. Species relative density

$$R.D = \frac{\text{number of individuals of the species in all plots}}{\text{number of individuals of all species in all plots}} \times 100 \dots (6)$$

- vii. Relative dominance

$$R.Do = \frac{\text{total basal area of the species in all the plots}}{\text{total basal area of all the species in all the plots}} \times 100 \dots \dots (7)$$

viii. Importance value index

The importance value index of the species was calculated using the formula of Kent and Coker (1992) as written below:

$$IVI = (R.D + RF + RDo) \dots \dots (8)$$

ix. Shannon-Wienna Index of diversity

The method of determining species diversity indices developed by Shannon and Weaver (1949) was used. It is mathematically computed as follows:

$$H^1 = \sum_{i=1}^n Pi \ln(Pi) \dots \dots (9)$$

3. RESULTS

3.1. Diversity of Woody Plant Species

The Study investigated the diversity of woody plant species and the results are displayed in Table 1 as follows: *Combretum glutinosum* and *Hyphaene*

thebaica are the least diverse species with diversity values of 0.1 each. The most diverse species are *D. mespiliiformis* with values of 0.31 and *G. senegalensis* and 0.28 respectively. The overall woody plant diversity of the reserve is 2.90. This signifies that the reserve is diverse in woody plants.

Table 1: Summary of woody plants structure and Diversity in the study site

SPECIES	R.F (%)	R.D (%)	R.do (%)	IVI	Diversity Index
<i>A. leiocarpus</i>	6.58	6.84	7.73	21.15	0.18
<i>D. mespiliiformis</i>	3.02	59.15	2.79	10.95	0.31
<i>A. Senegal</i>	5.01	4.44	3.58	13.03	0.14
<i>A. digitata</i>	0.77	1.11	2.09	3.97	0.05
<i>B. aethiupum</i>	0.22	0.18	1.04	1.45	0.01
<i>G. senegalensis</i>	14.3	14.23	13.41	41.67	0.28
<i>Z. mauritiana</i>	6.10	5.18	4.18	15.45	0.15
<i>C. Africana</i>	2.31	2.22	3.13	7.66	0.08
<i>H. thebaica</i>	3.18	2.77	3.92	9.87	0.10
<i>T. indica</i>	1.99	2.59	2.44	7.02	0.09
<i>B.aegyptiaca</i>	13.6	13.68	11.05	38.27	0.27
<i>V.doniana</i>	1.70	2.03	2.30	6.03	0.08
<i>A. nilotica</i>	3.82	3.14	3.55	10.52	0.11
<i>A. indica</i>	5.07	5.91	5.57	16.56	0.17
<i>P. reticulatum</i>	10.9	10.35	8.36	29.56	0.23
<i>A. comosa</i>	1.12	0.92	1.31	3.35	0.04
<i>P. africana</i>	3.53	3.70	3.48	10.71	0.12
<i>P. biglobosa</i>	4.33	3.88	4.39	12.60	0.13
<i>Z. spina-christi</i>	9.44	11.09	10.45	30.98	0.24
<i>C. glutinosum</i>	3.37	2.77	5.22	11.37	0.10
Total	100	100	100	300	2.90

3.2. Results on Woody Plant Composition

The composition of woody plant species in the study area was analysed and the results are presented. There are 16 families of woody plants, represented by 25 species and 12 genera. It clearly indicates that Combretaceae, Mimosoideae and Aracaceae are the

dominant family that are equally represented by three family each, followed by Mimosoideae with two species, whereas Olacaceae, Caesalpiniaceae and Annonaceae are the least family represented with only one species each.

Table 2: List of woody plant species enumerated in the Study Area

S/N	Family	Woody Plant Species
1	Combretaceae	<i>Anogeissus leiocarpus</i> <i>Guerra senegalensis</i> <i>Combretum glutinosum</i>
2	Ebenaceae	<i>Diospyros mespiliformis</i>
3	Caesalpiniaceae	<i>Deuterium macrocarpum</i>
4	Mimosoideae	<i>Acacia senegal</i>
5	Bombacaceae	<i>Adansonia digitata</i>
6	Arecaceae	<i>Borassus aethiupum</i> <i>Hyphaene thebaica</i> <i>Phoenix dactylifera</i>
7	Olacaceae	<i>Ximenia americana</i>
8	Rhamnaceae	<i>Zizipus mauritiana</i> <i>Zizipusspina-christi</i>
9	Burseraceae	<i>Commiphora africana</i>
10	Fabaceae	<i>Tamarindus indica</i> <i>Parkia biglobosa</i> <i>Piliostigma reticulatum</i>

Table 2 Cont,d.

S/N	Family	Woody Plant Species
11	Balanitaceae	<i>Balanite aegyptiaca</i>
12	Verbenaceae	<i>Vitex doniana</i>
13	Mimosoideae	<i>Acacia nilotica</i> <i>Prosopis africana</i>
14	Meliaceae	<i>Azadirachta indica</i>
15	Annonaceae	<i>Annona senegalensis</i>
16	Moraceae	<i>Ficus platyphylla</i> <i>Ficus ovate</i>

There are 16 woody plant families, 14 genres, represented by 25 species in the study area.

3.3. Relative Frequency

The relative frequencies of woody plant species in the study area were assessed and the results are shown in Figure 2. The relative frequency for trees ranged from 0.22% for *Borassus aethiupum* to 14.03% for *Guerra senegalensis* in the study area. The highest species frequency of 14.03% was observed with *Guerra senegalensis* followed *Balanites aegyptiaca* with 13.55%.

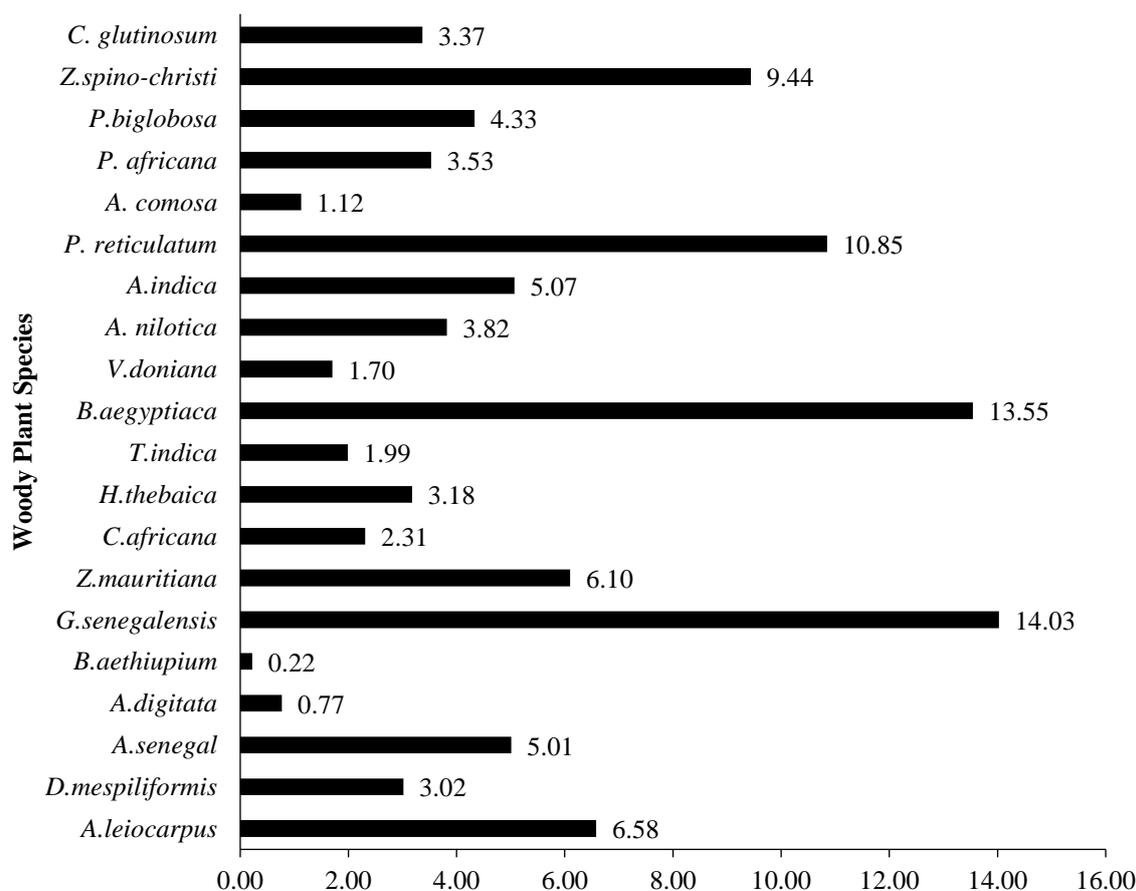


Figure 2. Relative Frequency of woody plants

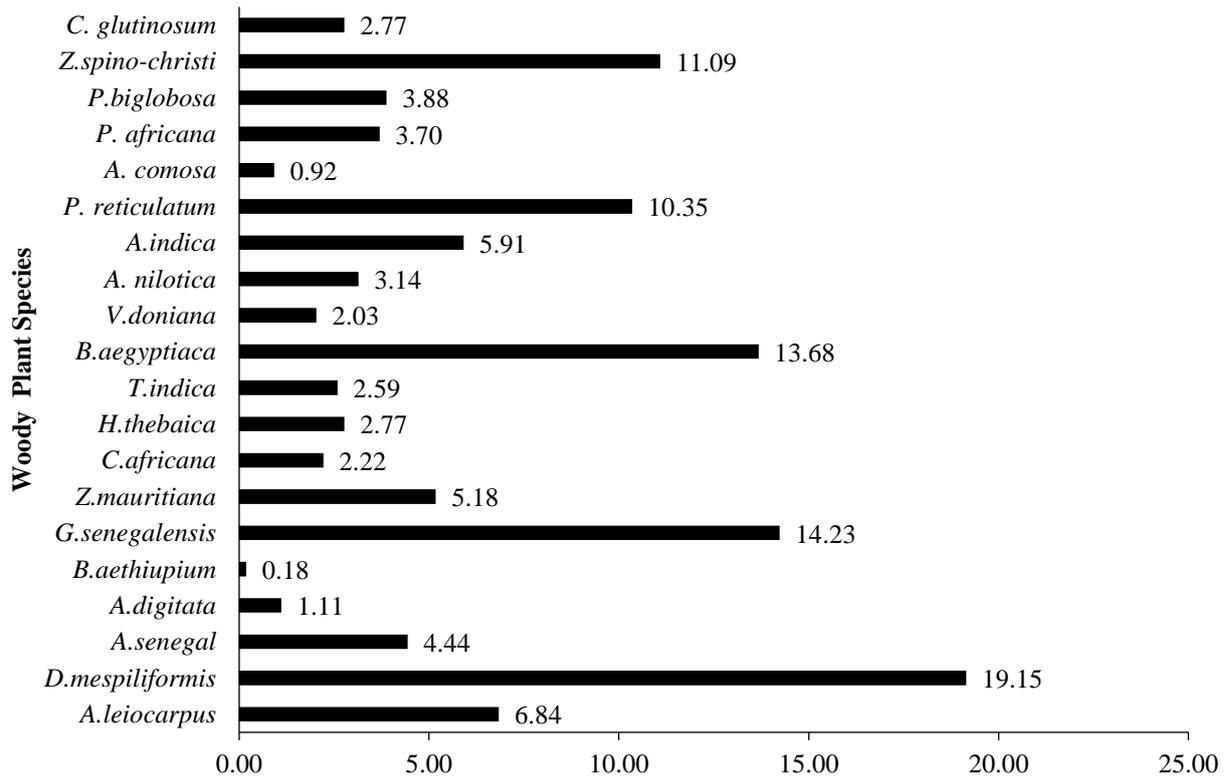


Figure 3: showing the Relative density

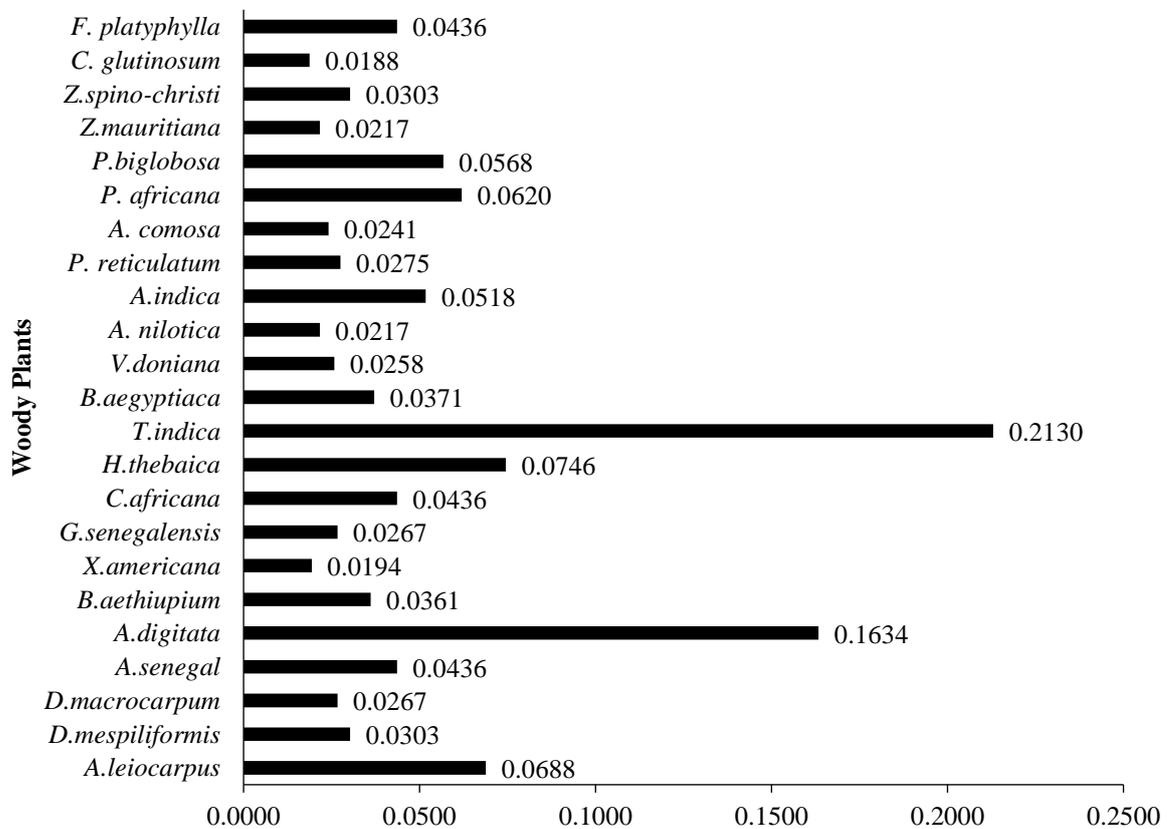


Figure 4: Relative Dominance of Woody Plants in the Study Area (%)

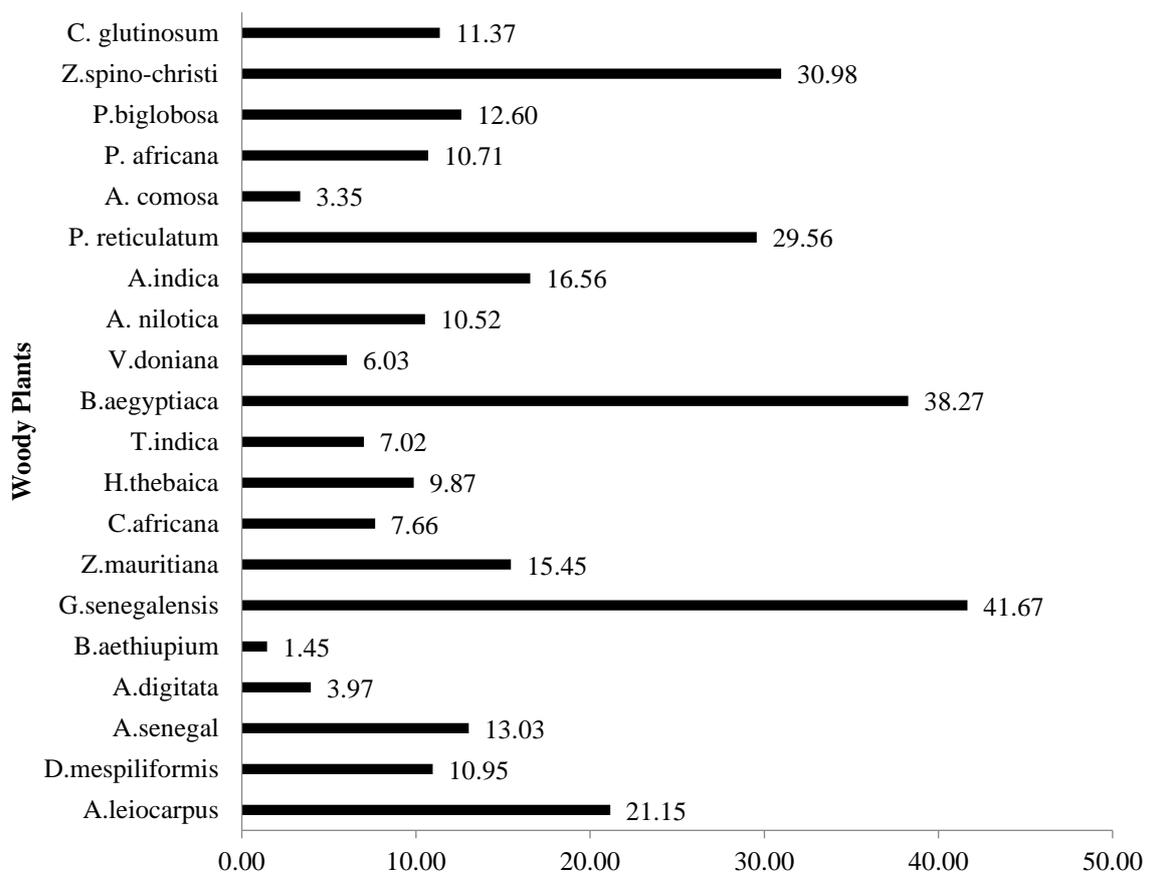


Figure 5: Woody Plant IVI

4. DISCUSSION

4.1. Woody Plant Species Frequency

The results of woody plant species frequencies are shown in Table 2. The values ranged from 1% to 62.43% for different species in the study area. *Guerra senegalensis* had 62.43% and it was followed by *Balanites aegyptiaca* with 60.29%, whereas *Borassus aethiupum* and *Adansonia digitata* recorded the least Species frequencies 1% and 3.43% respectively. The highest of *Guerra senegalensis* could be explained by the fact that the species is not among the preferred trees for fuel wood due to low energy efficiency. This is in line with the report of FAO, (2010a) that, the major cause of deforestation in Nigeria is unsustainable exploitation of wood fuels. The fact that fuel wood sellers do not prefer *G. senegalensis* but rather go for well-grown trees that could provide large quantity and high-quality fuelwood to maximise their profit. While the *Balanites aegyptiaca* could be due to the prohibition of felling of fruit-bearing trees by the State government. The lowest frequency of *B. aethiupum* in

the study area could not be unconnected with the high seed dormancy of the species, as well as the overexploitation of the seedling for food called “Muruci” in Hausa dialect.

4.2. Relative Density of Woody Plants

The result of relative density of woody plants in the study area was assessed, and the results show the relative density for tree species in the study area, it ranged between 0.18 and 19.15 (Table 1, Fig 3), it was discovered that *D. mespiliformis* recorded the highest value 19.15%, while *Guerra senegalensis* is the second most densely populated species with relative density of 14.23% while *Borassus aethiupum* recorded the least relative density for tree in the study area with 0.18 and 0.92 respectively. In Kwari-Kwasa Forest Reserves, Kebbi State, which is in a similar ecological zone, Ambursa *et al.* (2018) found that *G. senegalensis* recorded the highest density. The predominance of *D. mespiliformis* could be attributed to the fact that the species are mostly found in agroforestry farms abundant fruits that attract a lot of buyers, and the

farmers claim ownership of such trees thereby protecting them from all forms of encroachments.

4.3. Relative Dominance for Woody Plants

The relative dominance of woody plants in Rabadi Forest Reserves was assessed and the results obtained from the study revealed that, the relative dominance for different tree species ranged between 1% and 21% (Fig 4). The chart shows that *Tamarindus indica* has the highest value of 21.30%, followed by *Adansonia digitata* with 16.34%, while *Combretum glutinosum* had the lowest value of 1.9% (Fig 4). The dominance by *T. indica* could be explained by the fact that, the societies are very conversant with wide range of benefits derive from the species such as fruits, medicines among others and thus became very conscious about their conservation. And, the species are among those that are banned from harvesting such trees for fuel wood by the State Government. These results when compared with the findings of Wakawa *et al.*, (2017) in GashuaYobe State, revealed that the relative dominance of these species is higher than the values obtained in this study. Their results showed that *Azadirachta indica* recorded the highest value of 24.2% for relative dominance followed by *Tamarindus indica* with a value of 21.5% while *Acacia Senegal* and *Ziziphus spina-christi* recorded the least value of 0.1%

4.4. Importance value index (IVI)

According to Ambasht and Ambasht (2002), Importance Value Index gives the total picture of sociological structure of a species in a community. The importance value index of Rabadi Forest reserve was investigated and the results are presented in Figure X. It could be seen in the table that the results obtained from this study ranged between 1.41 and 41.67%. *Guerra senegalensis* and *Balanites aegyptiaca* had the highest IVI values of 41.67% and 38.27%, respectively. *Borassus aethiupum* recorded the least value of 1.41. The result is presented in chart (Figure 4). The findings of this study conform to that of Zhigilla *et al.* (2015) in Tangaza West Forest Reserves Sokoto, who reported that *Guerra senegalensis* had the highest important value index (127.70%). Therefore, the values obtained in this this study is lower than the values obtained by the previous studies. This could be explained by the fact that, although the two studies were conducted in the same ecological zones, but in different locations. It is reported by Zhigilla *et al.* (2015) that, high importance value index (IVI) of a species indicated its dominance and ecological success, thus its good power of regeneration and greater ecological amplitude and also those plants need-monitoring management, while, species which were grouped as low therefore need high conservation efforts.

5. CONCLUSION

From this study, the following conclusion can be made:

1. Rabadi Forest Reserve is richly endowed with diverse woody plant species, but there is evidence of anthropogenic encroachment such as clearing of existing woody vegetation for arable crop cultivation. However, despite being the hotspot for diverse woody plants, rampant felling of trees for fuel wood is on the increase.
2. The dominant trees in these families are *Diospyros mespiliformis* and *Guerra senegalensis* with the highest R.do of 13.41% for *G. senegalensis* and 11.05% for *B. aegyptiaca* respectively. The true picture of the reserve shows preponderance of families Combretaceae and Fabaceae highest IVI of 60.54 and 20.94% respectively.
3. *Borassus aethiupum* and *Annona senegalensis* have the lowest IVI of 0.71 and 1.58% respectively, and are therefore at risk of disappearing. This is evident from the slow growth rate of the species which could negatively affect the regeneration potentials of the species.
4. More regeneration and conservation effort should therefore be put to safeguard these species from going to extinction. Similarly, periodic resource assessment of all woody species within the reserve should be carried out to enable the early detection of anthropogenic activities which may lead to unwholesome ecological changes in the reserve.

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