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Pentaclethra macrophylla Benth (African oil bean tree) and *Parkia biglobosa* Jacq (African locust bean tree): The Declining Giants of The Rainforest of Nigeria (The Northern Cross River Situation)

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ABSTRACT

The abundance, stem diameter and height of *Pentaclethra macrophylla* Benth and *Parkia biglobosa* Jacq was assessed in each of the five Local Government Areas (Ogoja, Yala, Bekwarra, Obudu and Obanliku) of Northern Cross River State, Nigeria using the Modified Whittaker Method. Two forest communities were chosen from each Local Government Area, constituting 10 sites. In each site a 30 × 90 m plot was laid out in a spoke design and tree species present on the plots were recorded. A total of 3, 4, 5, 7, 4, 5, 6, 5, 12 and 10 stands for *P. macrophylla* and 4, 5, 5, 6, 6, 6, 4,5,8 and 8 stands for *P. biglobosa* were recorded in Gbogbu, Omulako, Aragban, Abeya, Aguomoh, Ukpah, Alege, Beteh, Bechevie and Sankwala forests respectively based on the sampled plots. Results of population percentage frequency, density and abundance of the two tree species varied across the study sites. The highest percentage frequency recorded for the tree species was 24% while the lowest was 12%. The highest population densities of 1.6666/ha, 1.3333/ha and 1/ha were recorded for the tree species while the lowest was 0.5/ha. Results of abundance show that the species were mostly rare with abundance ratio of ($1.00 \leq AR \leq 2.99$). Results of diameter class sizes of the tree species encountered in this study show that there were trees with mature trunk size than wildlings. Majority of the trees of *P. biglobosa* and *P. macrophylla* were in the diameter class of 20 – 29 cm and 30 – 39 cm respectively while results of the height class of trees shows that the minimum and maximum height was 10 -19 ft and 20 -29 ft respectively. This study shows that the trees of *P. macrophylla* and *P. biglobosa* were mostly rare and are declining; this could be as a result of over exploitation.

***Keywords*:** *Pentaclethra macrophylla*; *Parkia biglobosa*; abundance; stem diameter; height

1. INTRODUCTION

The African oil bean (*Pentaclethra macrophylla* Benth), and African locust bean (*Parkia biglobosa* Jacq) are both depended upon for food, wood, fodder, fuel (charcoal), medicine and income [1]. They belong to the sub family mimoisodea, family fabaceae.

In Nigeria, the populations of *P. macrophylla* are presently more in South-eastern and South – south states of Abia, Anambra, Enugu, Imo, Akwa Ibom, Cross River, Delta, Edo, and Rivers [2]. The highest concentrations of trees of various age classes occur in the South-eastern states [2].

Pentaclethra macrophylla and *Parkia biglobosa* has gained interest in Cross River State over the last years because of their important nutritional and medicinal values [1]. *Parkia biglobosaa* Jacq is commonly found in the savanna/forest of Northern Cross River and in other region and is commonly grown for its pods that contain both sweet pulp and valuable seeds. Where the tree is found or grown, the crushing and fermenting of these seeds constitute an important economic activity [3]. *Parkia biglobosa* occurs in a variety of agro-ecological zones, ranging from tropical forests with high and well-distributed rainfall to arid-zones where mean annual rainfall may be less than 400 mm. It has a capacity to withstand drought conditions because of its deep tap root system and an ability to restrict transpiration and is a fire resistant helophyte [4].

Pentaclethra macrophylla Benth and *Parkia biglobosa* Jacq are species that are economically, socially and culturally important for local people in Northern Cross River State, Nigeria. In South-eastern states of Nigeria, some 30 million people depend on them for food, fuel, wood, fodder, medicine and income [2]. The trees grow wild in the forest or in guinea savanna/farmlands. Like most indigenous guinea savanna/forest trees of Africa, there is paucity of research data on their abundance and conservation status [5].

In view of the importance of these two tree species as a major source of food, fodder, wood, fuel (charcoal), income and medicine for rural dwellers of Northern Cross River and due to the exponential human population growth rate and its attendant consequences on seed exploitation and other deleterious ecosystem practices. It became imperative to know the distribution abundance and status of these economically, socially, culturally important tree species of Northern Cross River. From the forgoing, the objective of this study therefore, was to provide comprehensive information about the state and dynamics of *Pentaclethra macrophylla* and *Parkia biglobosa* in some communal forests of Northern Cross River, Nigeria. Having first-hand information on the abundance of these tree species, can help us to understand whether their population is growing, declining or stable over time and as such gives room for strategic and management planning.

2. MATERIALS AND METHODS

2. 1. Study Area

The study was carried out in Northern Cross River covering five Local Government Areas (Ogoja, Yala, Bekwarra, Obudu and Obanliku). Two forest villages in each Local Government Area were chosen for the study (Figure 1). It was carried out from (November, 2015 – May, 2016). The area falls within the Southern Forest/Guinea savanna agro ecological

zone of Nigeria, situated in the Northern Cross River State, it lies between latitudes 6°39' and 6°41' North of the Equator and longitude 8°47' and 8°58' East of the Greenwich meridian.

The topography is generally low lying, ranging from below 80 – 140 M (on the average) above sea level with three soil types namely, clay, loam and sandy. It covers a total landmass of 972 km^2 (375 sq mi). The areas have a humid tropical climate of (1250 – 1300 mm) rainfall and a mean annual temperature of 30 °C [6]. The source of livelihood is subsistence agriculture, basically farming of cassava, yams, palm oil and palm wine among others [6].

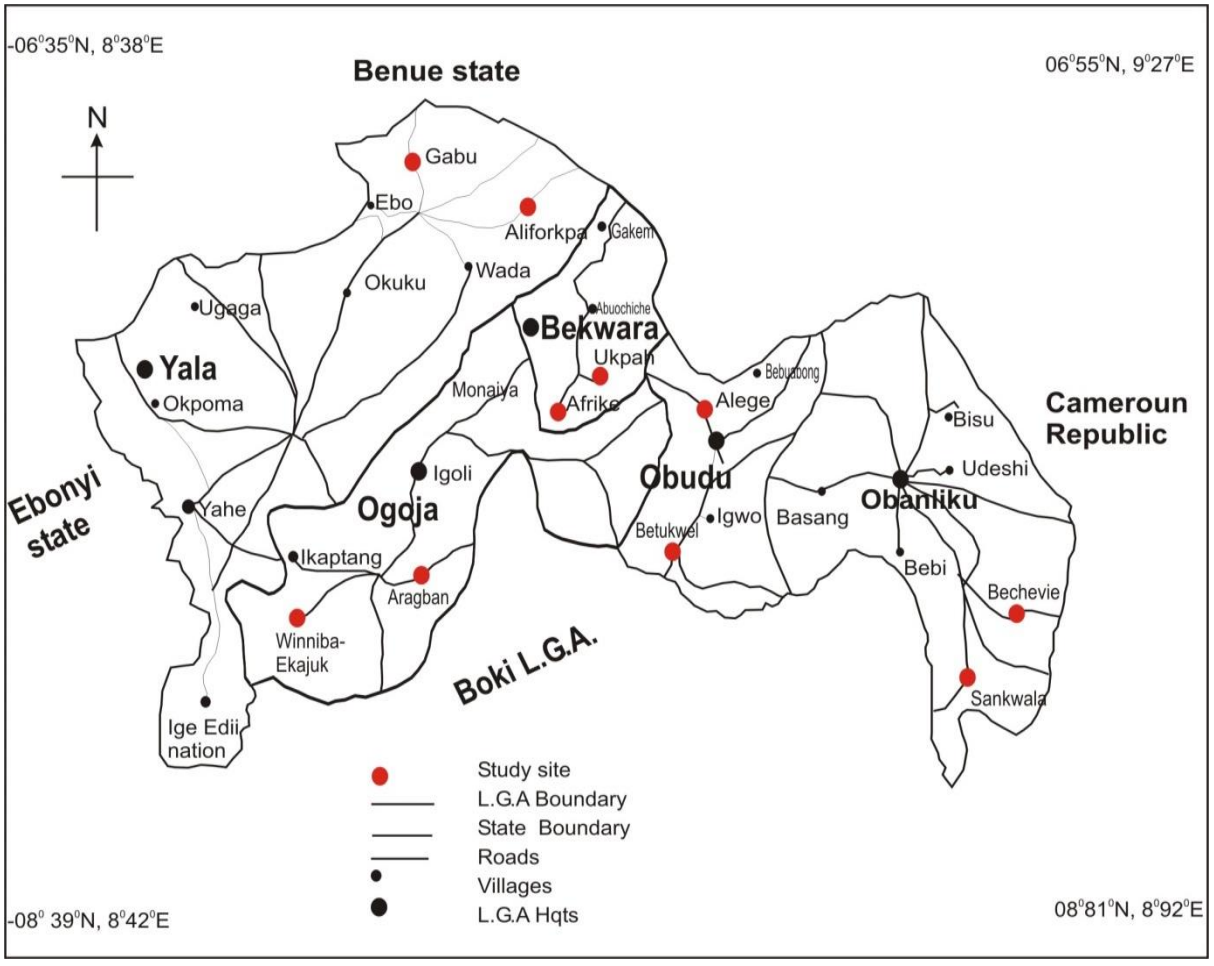

Fig. 1. Map of Northern Cross River showing the study sites

2. 2. Sampling method and design

The study was carried out using Systematic Sampling Method (a type of probability sampling where each element in the population has a known and equal probability of being selected) and the Modified Whittaker design [7]. To obtain tree species richness, three 10 m × 30 m plots were marked out in a spoke design. Within each of these plots, a 2 m × 5 m subplot and four 0.5 × 2 m subplots were established. Starting with the smallest subplots, the subplots and plots were searched and the tree species found recorded. This was supplemented by the use of quadrats in areas of difficult terrains. The survey consisted of enumerating all

free standing trees at least 10 cm and above in diameter at breast height (dbh) in each study site.

2. 3. Tree species identification

Tree species in this study were identified by a certified plant taxonomist. The plant materials were collected, pressed and preserved in the Herbarium of the Department of Botany, University of Calabar, Calabar, Cross River State, Nigeria.

2. 4. Tree species population frequency, density and abundance

Data collated from the field were analysed to obtain tree species Percentage frequency (%), Relative Density (RD), Abundance and diversity indices.

The (%) frequency of the species was calculated using the formula:

$$\text{Frequency (\%)} = \frac{\text{Number of plots in which species is recorded}}{\text{Sum of all frequencies}} \times 100 \qquad [8]$$

The relative density of the population was determined using the formula:

$$\text{Density} = \frac{\text{Number of individuals of a species}}{\text{Total area sampled}} \times 100 \qquad [8]$$

While the relative abundance (Pi) of the species was calculated thus:

$$\text{Abundance} = \frac{\text{Ni}}{\text{Sum of all individuals recorded}} \times 100 \qquad [8]$$

where; Ni is the sum or proportion of each individual species in the sample.

The different tree species recorded in this study were scored according to their Abundance ratio (AR); that is abundant (AR ≥ 5.00); frequent (4.00 ≤ AR ≤ 4.99); occasional (3.00 ≤ AR ≤ 3.99); rare (1.00 ≤ AR ≤ 2.99) and threatened/endangered (0.00 ≤ AR ≤ 1.00) [8].

2. 5. Measurement of stem diameter and tree height

Tree species including wildlings in the entire sample plot were identified, measured, marked and enumerated. However, only trees whose diameters at breast heights (dbh) are 10 cm and above were enumerated and measured for dbh (wildlings (dbh ≥ 2.5 cm but ≤ 10 cm). Tree diameter and height was used to evaluate the ratio or proportion of mature trees to wildlings of *P. macrophylla* and *P. biglobosa*. The Diameter at Breast Height (DBH) was measured at 1.4 – 1.5 m from ground, at a value of ≥ 10 cm and above. Height of the trees was measured using an Electronic Clinometer (INVICTA® USA), while DBH was measured using a metre tape and recorded using the methods of [7,9,10]. Using class intervals, average DBH was used to determine the wildling size and mature trunk size. The stem diameters of the trees was classified into eleven class intervals (sizes), as follows: dbh ≥ 2.5 cm but ≤ 10cm (diameter class 1), 10 cm – 19 cm (diameter class 2), 20 cm – 29 cm (3), 30 cm – 39 cm (4),

40 cm – 49 cm (5), 50 cm – 59 cm (6), 60 cm – 69 cm (7), 70 cm – 79 cm (8), 80 cm – 89 cm (9), 90 cm – 99 cm (10), 100 cm and above (diameter class 11) while that of height was classified into three intervals (classes) (height class 1) 0 ≤ 10 ft, 10 – 19 ft (class 2) and 20 – 29 ft (class 3).

Percentage distribution of the various diameter class sizes and height of tree species in each study site/study area was calculated as follows:

$$\frac{\text{No. of trees in class interval}}{\text{Total no. of trees in populatio}} \times \frac{100}{1}$$

3. RESULTS

3. 1. Population frequency, density and abundance of *P. macrophylla* and *P. biglobosa* in the study area

The results of population frequency, density and abundance of *P. macrophylla* and *P. biglobosa* in the study area showed that the trees were mostly rare (1.00≤AR≤2.99) except in Bechevie and Sankwala forest where there were occassional (3.00≤AR≤3.99) for *P. macrophylla* as presented in Tables 1 and 2.

Results Table 1 shows that *P. macrophylla* has the highest number of stands in Bechevie forest (12) this was followed by Sankwala forest with 10 stands while the lowest was recorded in Gbogbu forest with 3 stands. The highest population frequency was 24% (Abeya and Bechevie) while the lowest was 12% (Gbogbu, Omulako and Aragban forests). The highest density was 2/ha (Bechevie) while the lowest was 0.5/ha (Gbogbu forest). The highest Abundance ratio (A/R) was 3.30 (Sankwala forest) this was followed by Bechevie forest with 3.00 while the lowest was 1.33 (Aguomoh forest).

Table 1. Percentage frequency, density and abundance ratio (A/R) of *P. macrophylla* in the study area.

S/N	Study sites (forests)	Total no. of individuals	Total no. of segments the species occurred	Total no. of segments	Frequency	Density	A/R
1.	Gbogbu	3	2	6	12	0.5	1.50
2.	Omulako	4	2	6	12	0.6666	2.00
3.	Aragban	5	2	6	12	0.8333	2.50
4.	Abeya	7	4	6	24	1.1666	1.75
5.	Aguomoh	4	3	6	18	0.6666	1.33
6.	Ukpah	5	3	6	18	0.8333	1.66

7.	Alege	6	3	6	18	1	2.00
8.	Beteh	5	3	6	18	0.8333	1.66
9.	Bechevie	12	4	6	24	2	3.00
10.	Sankwala	10	3	6	18	1.6666	3.30

Results Table 2 shows that *P. biglobosa* has the highest number of stands in Bechevie and Sankwala forests with 8 stands each while the lowest was recorded in Gbogbu and Alege forest with 4 stands each. The highest population frequency is 18% (Omulako, Aragban, Abeya, Aguomoh, Ukpah, Alege, Beteh, Bechevie and Sankwala forests) while the lowest is 12% (Gbogbu forest). The highest density is 1.3333/ha (Bechevie and Sankwala forests) while the lowest is 0.666/ha (Gbogbu and Alege forests). The highest Abundance ratio (A/R) is 2.66 (Bechevie and Sankwala forests) this was followed by Gbogbu, Abeya, Aguomoh and Ukpah forests) with 2.00 each while the lowest is 1.33 (Alege forest).

Table 2. Percentage frequency, density and abundance ratio (A/R) of *P. biglobosa* in the study area

S/N	Study sites (forests)	Total no. of individuals	Total no. of segments the species occurred	Total no. of segments	Frequency	Density	A/R
1.	Gbogbu	4	2	6	12	0.6666	2.00
2.	Omulako	5	3	6	18	0.8333	1.66
3.	Aragban	5	3	6	18	0.8333	1.66
4.	Abeya	6	3	6	18	1	2.00
5.	Aguomoh	6	3	6	18	1	2.00
6.	Ukpah	6	3	6	18	1	2.00
7.	Alege	4	3	6	18	0.6666	1.33
8.	Beteh	5	3	6	18	0.8333	1.66
9.	Bechevie	8	3	6	18	1.3333	2.66
10.	Sankwala	8	3	6	18	1.3333	2.66

3. 2. Diameter class sizes of *P. macrophylla* and *P. biglobosa* in the study area

Figure 1 shows the various diameter class sizes of *Pentaclethra macrophylla* trees enumerated and measured in the study area (Gbogbu, Omulako, Aguomoh, Ukpah, Abeya, Aragban, Alege, Beteh, Bachevie and Sankwala) forests. Of the 61 trees measured in the study area, 30 were in the diameter class of 30 – 39 cm making up 49.18% of the total trees measured for diameter. This was followed by the diameter class of 40 – 49 cm with 15 stands which is 24.59% of tree population in the site. The diameter class of 20 – 29 cm had 9 stands (14.75%); 50 – 59 had 3 stands (4.92%) while the diameter class of 0 – 10 cm and 10 – 19 cm had the least stands of 2 each making up 3.28% each of the total tree population. The diameter class of 60 – 69, 70 -79, 80 – 89, 90 – 99 and 100 cm and above had no stands of *P. macrophylla* in the study area. Results of the various diameter class sizes of *P. macrophylla* trees enumerated and measured across the study area shows that there were trees with mature trunk sizes than wildlings. It is also noteworthy to state that only two wildlings of *P. macrophylla* were observed in the study area (Bechevie forest).

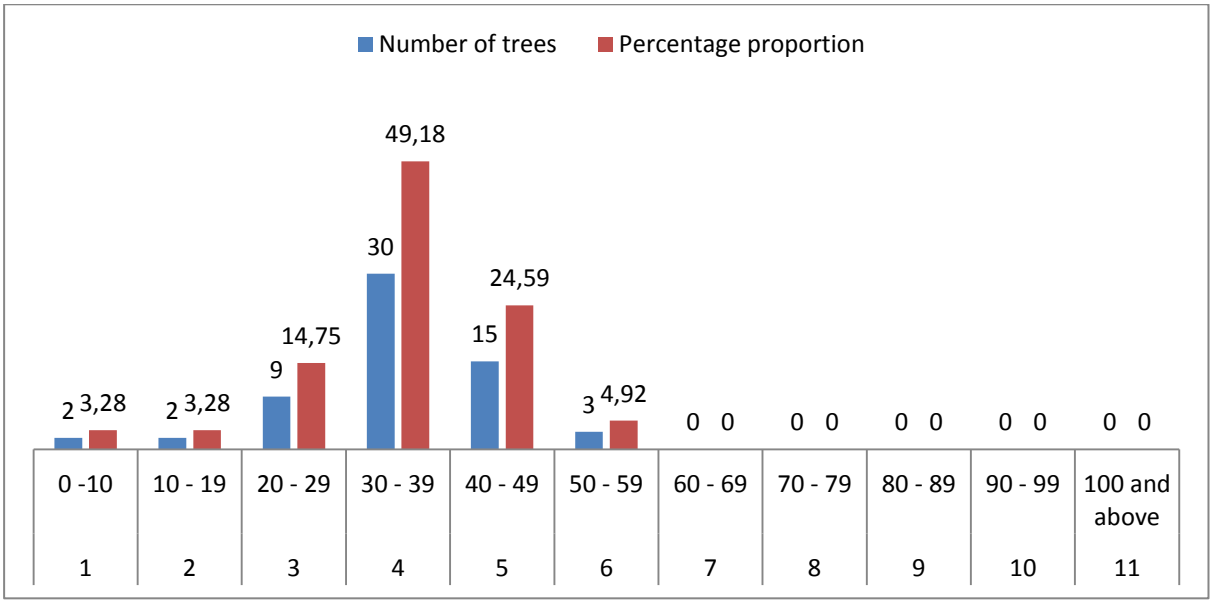

Figure 1. Percentage distribution of the various stem diameter class sizes of *Pentaclethra macrophylla* in the study Area (Gbogbu, Omulako, Aguomoh, Ukpah, Abeya, Aragban, Alege, Beteh, Bechevie and Sankwala) forests

Figure 2 shows the various diameter class sizes of *Parkia biglobosa* trees enumerated and measured in the study area (Gbogbu, Omulako, Aguomoh, Ukpah, Abeya, Aragban, Alege, Beteh, Bachevie and Sankwala) forests. Of the 57 trees measured in the study area, 43 were in the diameter class of 20 – 29 cm making up 75.44% of the total trees measured for diameter. This was followed by the diameter class of 30 – 39 cm with 10 stands which is 17.54% of tree population in the site. The diameter class of 10 – 19 cm had the least stands of 4 (7.02%) of the total tree population. The diameter class of 40 – 49 cm, 50 – 59, 60 – 69, 70 -79, 80 – 89, 90 – 99 and 100 cm and above had no stands of *P. biglobosa* in the study area. Results of the various diameter class sizes of *P. biglobosa* trees enumerated and measured

across the study area therefore, shows that there were trees with mature trunk sizes than wildlings. It is noteworthy to state that there were no wildlings observed for *P. biglobosa* across the study area.

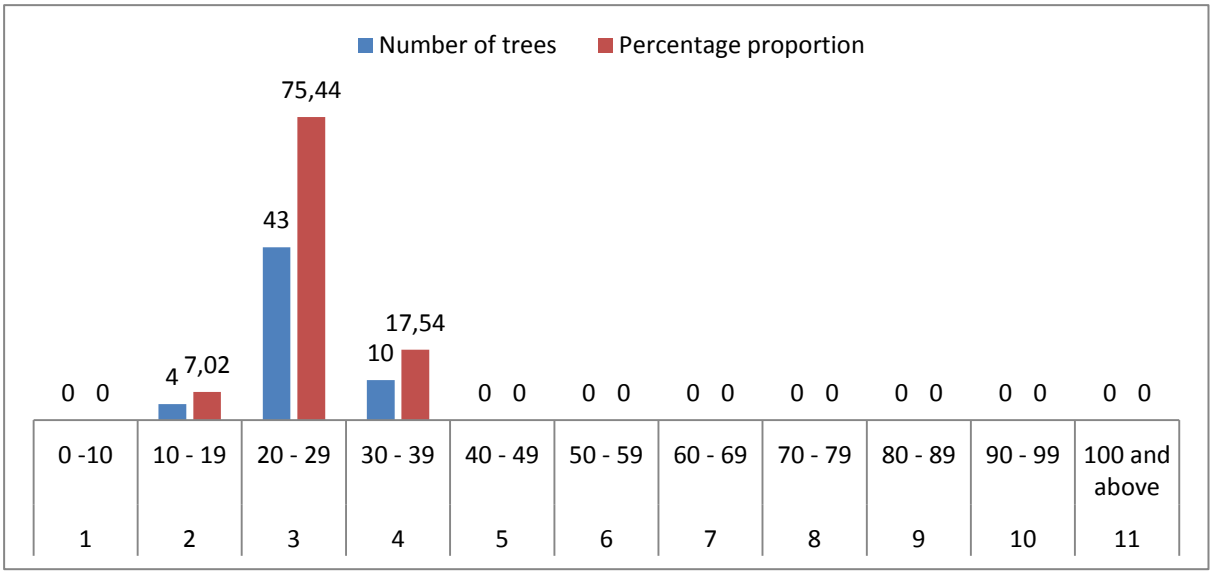

Figure 2. Percentage distribution of the various stem diameter class sizes (cm) of *Parkia biglobosa* in the study Area (Gbogbu, Omulako, Aguomoh, Ukpah, Abeya, Aragban, Alege, Beteh, Bechevie and Sankwala) forests

3. 3. Height classes of *P. macrophylla* and *P. biglobosa* in the study area

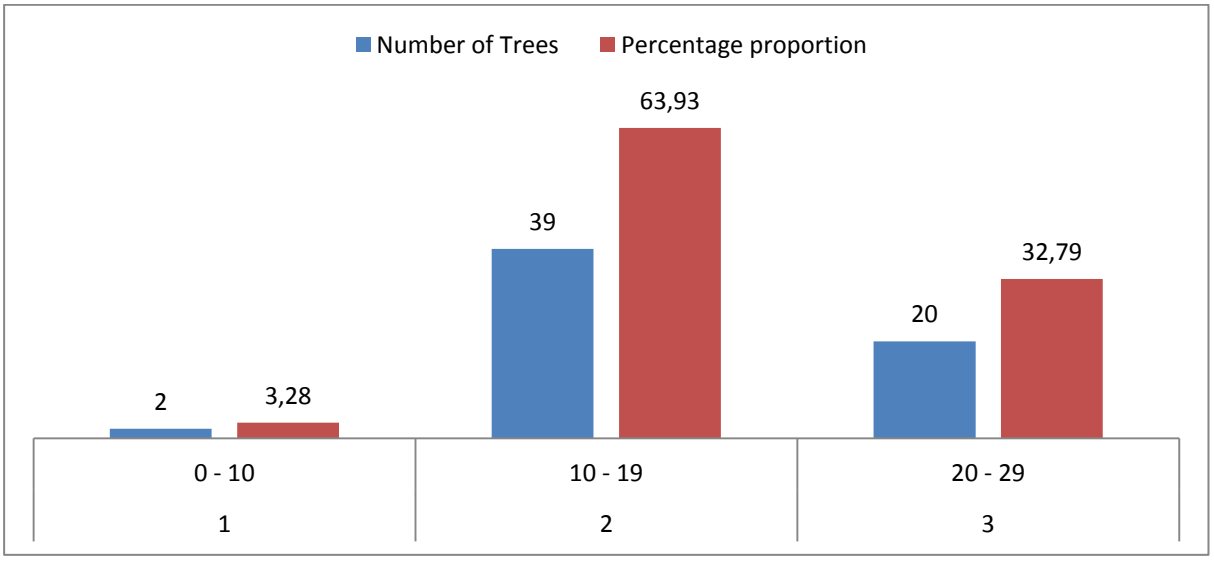

Figure 3. Percentage distribution of the various height classes (ft) of *Pentaclethra macrophylla* in the study Area (Gbogbu, Omulako, Aguomoh, Ukpah, Abeya, Aragban, Alege, Beteh, Bechevie and Sankwala) forests

Figure 3 shows the various height classes of *Pentaclethra macrophylla* trees assessed in the study area (Gbogbu, Omulako, Aguomoh, Ukpah, Abeya, Aragban, Alege, Beteh, Bechevie and Sankwala) forests. Of the 61 stands assessed for height in the study area, 39 were in the height class of 10 – 19 ft making up 63.93% of the total trees assessed. This was followed by the height class of 20 – 29 ft with 20 stands which represents 32.79% of tree population assessed in the area. The height class of 0 – 10 ft had the least stands of 2 making up 3.28% of the total tree population of *P. macrophylla* assessed for height in the study area.

Figure 4 shows the various height classes of *Parkia biglobosa* trees assessed in the study area (Gbogbu, Omulako, Aguomoh, Ukpah, Abeya, Aragban, Alege, Beteh, Bechevie and Sankwala) forests. Of the 57 stands assessed for height in the study area, 47 were in the height class of 10 – 19 ft making up 82.46% of the total trees assessed. This was followed by the height class of 20 – 29 ft with 10 stands which accounts for 17.54% of tree population assessed in the area. The height class of 0 – 10 ft had no tree stands in the study area.

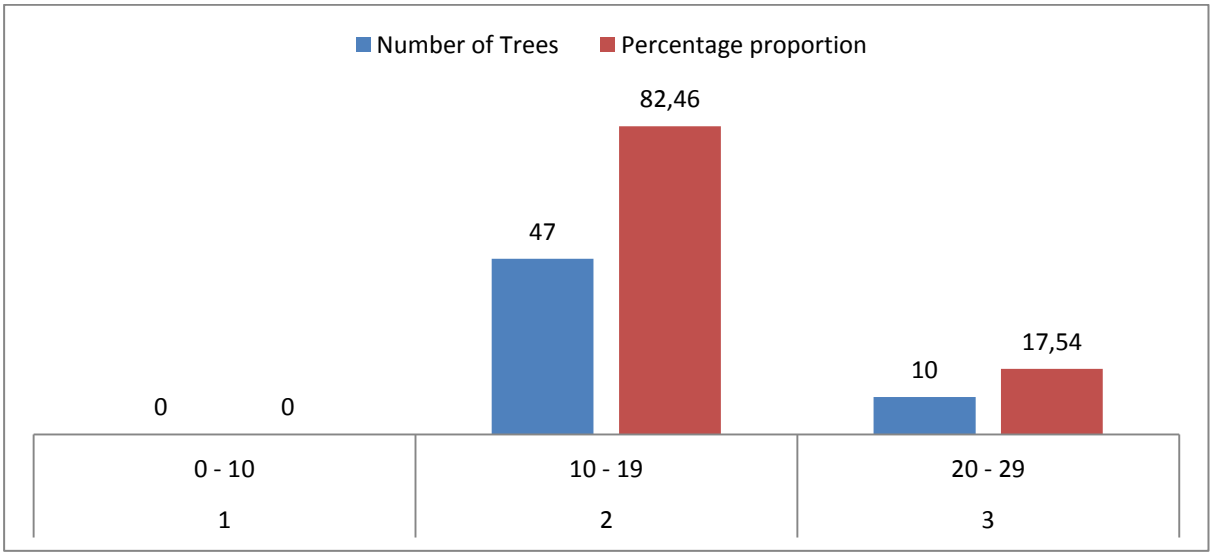

Figure 4. Percentage distribution of the various height classes (ft) of *Parkia biglobosa* in the study Area (Gbogbu, Omulako, Aguomoh, Ukpah, Abeya, Aragban, Alege, Beteh, Bechevie and Sankwala) forests

4. DISCUSSION

Pentaclethra macrophylla and *Parkia biglobosa*, found in the southern and middle belts region of Nigeria serve as sources of food, wood, fuel (charcoal), fodder, medicine and income for rural dwellers. These species face severe anthropogenic challenges due to unsustainable exploitation characterized by burning and destruction of seedlings during agricultural practices, seed predation by wild animals and overexploitation of bark by farmers and traditional medicine practitioners. These challenges require precautionary measures to mitigate genetic erosion and loss of livelihood. Data on abundance of these two species have been well documented for the North central and South eastern states in Nigeria [11,2], but are lacking in Cross River State. Knowledge of their abundance and distribution in Cross River

State will enhance their sustainable utilization and management. This research provides reliable database on the abundance of these two species in ten selected communities in Northern Cross River State.

In this study carried out in ten communal forests, two each in the five Local Government Areas (Ogoja, Yala, Bekwarra, Obudu and Obanliku) of Northern Cross River State, Nigeria, Results of population frequency, density and abundance of *Parkia biglobosa* and *Pentaclethra macrophylla* (Tables 1 and 2) varied across the study sites. The highest percentage frequency recorded for tree species was 24% while the least was 12% indicating that the tree species in the study area are rare and endangered species. Similar report of low percentage frequencies of 11, 12, 16, and 23% was reported by [12] in Ikot Efre Itak community forest in Akwa Ibom State, Nigeria. The highest population densities of 1.6666/ha, 1.3333/ha and 1/ha were recorded for some tree species including *P. biglobosa* and *P. macrophylla* in some study sites while the least density was 0.5/ha. Results of abundance of each tree species in the study sites/area shows that the species were mostly rare with abundance ratio of 1.00 – 2.99 except in some few cases where they were occasional (3.00 – 3.33). The highest abundance recorded for *P. biglobosa* is 2.66 while that of *P. macrophylla* is 3.00 and 3.33 in Bechevie and Sankwala forest respectively while the lowest is 1.00. The presence and population density and abundance of a tree species in a tract of rainforest is greatly influenced by the microclimate within the forest and the quantity of viable seeds produced by the tree concerned. For instance, a tree species that is not shade tolerant would find it difficult to regenerate in a rainforest with closed canopy. Consequently, the population density and abundance of such a tree species would be low in the forest, while the adult trees of same species would die. The low population density and abundance of *P. biglobosa* and *P. macrophylla* in the study sites studied may be attributed to the unfavourable microclimate within the forests and the paucity of viable seeds of the trees to sustain regeneration or it may be due to anthropogenic factors. Workers like [13] reported very low population densities and abundance of quite a number of economically viable tree species occasioned by dearth of viable seeds and poor micro-sites for regeneration while [14] reported low population densities and abundance of tree species in Oban Forest Reserve in Cross River State, Nigeria due to anthropogenic factors.

In this study, results of diameter class sizes of trees encountered in the study area shows that majority were trees with mature trunk sizes than wildlings (Figures 1 and 2). There was however, no trees observed in the higher diameter classes of 70-79 cm, 80-89 cm, 90-99 cm and 100 cm and above in the study area. There was no wildling observed for *P. biglobosa* across the study area while *P. macrophylla* had two. Of the 58 trees of *P. biglobosa* studied for diameter in the study area, 75.44% were in the diameter class of 20-29 cm while of the 62 trees of *P. macrophylla* studied for diameter, 49.18% were in the diameter class of 30-39 cm. This result contradicts that of [15] who reported that all plots studied by them had the smallest diameter class of below 10 cm at the Okomu permanent sampled plots. They also had the smallest number of trees in the diameter class of 25-30 cm. Also, [16] reported the highest number of trees for diameter class of 1-30 cm followed by those of between 0-10cm at Onigambari Forest Reserve, Ibadan. Aigbe *et al.,* (2014) reported the abundance of trees with small diameter in Afi River Forest Reserve in Cross River State, Nigeria. Similar results have also been reported by previous workers in other tropical rain forests of Nigeria [17,18]. The reason for the relatively absence of trees in the higher diameter classes in this study can be attributed to forest degradation activities which may have removed large individuals as well

as the fact that some large-sized trees would have been removed through logging operation for some uses in the past [19]. Of the 58 and 62 stands of *P. biglobosa* and *P. macrophylla* assessed for height in the study area (Figures 3 and 4), 17.54% of trees were in the height class of 20-29 ft and 32.79% for *P. biglobosa* and *P. macrophylla* respectively. [20] reported the minimum and maximum heights of trees at 2.7 m and 55.0 m respectively and 12.0 m to 62.2 m respectively in Afi River Forest Reserve of Nigeria.

5. CONCLUSIONS

This study reveals that *P. macrophylla* and *P. biglobosa* were mostly rare, scantily populated the study area, likely due to unrestrained exploitation and hence are declining. Since these tree species are mostly depended upon for timber and non-timber forest products across the study sites, it is necessary to ensure the sustainability. In order to prevent the extinction of these valuable tree species, the government should out-law their exploitation for timber. Communities (villages) close to the forests should be incorporated into the conservation programme; this will prevent the exploitation of these tree species for timber and ensure sustainable production of their valuable non-timber products which are heavily depended upon by the people living in adjoining villages to the forests. Also, further research on the propagation of these tree species should be carried out. This will aid in the establishment of organized forestry plantations (conservation) of these tree species in the study area.

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