Growth characteristics of *Parkia biglobosa* (Jacq.) G. Don in Derived and Guinea Savanna Ecological Zones of Nigeria

[1*]Usman I.A., [2]Onyekwelu, J.C and [2]Lawal, A

[1]Department of Forest Production and Products, Joseph Sarwuan Tarka University, Makurdi Nigeria
[2]Department of Forestry and Wood Tecnology, Federal University of Technology, Akure, Nigeria
*Corresponding author email: aukwublie@yahoo.com

ABSTRACT: Forests contain many important indigenous tree species that play an essential role in the lives of rural dwellers. *Parkia biglobosa* (Jacq.) R.Br.ex. G.Don, an economically important multipurpose tree species, provides food, medicine and income for mankind. This study evaluated the growth characteristics of *P. biglobosa* populations across derived and guinea savanna zones of Benue, Kogi, and Nasarawa States in Nigeria. A total of 373 trees from 12 communities were assessed for diameter at breast height (DBH), total height (TH), basal area (BA), volume, and slenderness coefficient (SC). Means for each variable were computed, and the least significant difference at 5% probability was used to determine significant differences. Results showed that DBH ranged from 39.66 cm to 72.70 cm, while tree height ranged from 6.22 m to 8.07 m. Basal area values ranged from 0.01 m² to 0.50 m². Volumes ranged from 0.20 m³ to 2.60 m³. Diameter class distribution revealed J-shaped to normal distribution patterns, with most individuals concentrated in the 29–44 cm and 44–59 cm DBH classes, with a remarkable increase presence of individuals in the class of 59-74 cm. In contrast, trees in larger classes (>89cm and above) were scarce, with complete absence in the Kogi population. The low slenderness coefficient suggests strong stem stability and low susceptibility to wind damage. These findings highlight significant variation among populations, which would help support the continued population strength and sustainability of this multipurpose species with implications for the conservation, sustainable management, and domestication of *P. biglobosa* in Nigeria.

[Usman I.A., Onyekwelu, J.C and Lawal, A. **Growth characteristics of *Parkia biglobosa* (Jacq.) G. Don in Derived and Guinea Savanna Ecological Zones of Nigeria.** *Life Sci J* 2025;22(12):1-14]. ISSN 1097-8135 (print); ISSN 2372-613X (online). http://www.lifesciencesite.com. 01. doi:10.7537/marslsj221225.01

Keywords: *Parkia biglobosa; domestication; conservation; DBH; growth characteristics*

INTRODUCTION

Forests are valued as sources of diverse products, including timber and a wide array of Non-Timber Forest Products (NTFPs) (Shrestha *et al*., 2020). Over three-quarters of the population in many developing countries depend on NTFPs to meet essential needs such as food and medicine (Talukdar *et al*., 2021). Globally, NTFPs play a crucial role in the livelihoods of rural communities, offering both subsistence and income-generating opportunities. Many people depend almost entirely on the forest for food and nutrition. It has been estimated that globally, 60 million people rely virtually on forests for food, nutrition, livelihood, medicine, economic empowerment, employment, etc. (Bharucha and Pretty, 2010; Chao, 2012; Onyekwelu *et al*., 2015). Recognizing this importance, farmers have increasingly integrated valuable tree species into production systems to meet multiple household needs.

Rural households rely heavily on forest resources not only for staple and supplementary foods but also for enhancing food security and sustaining household economies. In Sub-Saharan Africa, indigenous agroforestry systems are widespread, often centered around multipurpose tree species that provide ecological and economic benefits. One such species is *P. biglobosa* (Jacq.) R. Br. ex G. Don, commonly known as the African locust bean tree. This deciduous leguminous tree species is native to West Africa and forms an integral part of traditional parkland agroforestry systems (Sacande *et al*., 2016).

Parkia biglobosa, which is widely distributed across the African savanna, stretching from Senegal and Guinea in the west to Uganda in Central Africa (Lompo *et al.,* 2018), belongs to the subfamily Mimosoideae of the family Fabaceae (Amusa *et al.*, 2014; Houndonougbo *et al*., 2020). The species holds considerable socio-economic and cultural importance, particularly the seeds, which are fermented to produce a protein-rich condiment known locally as "dawadawa" or "iru" (Oyerinde *et al.,* 2018). This condiment is widely consumed in soups, stews, and sauces, and is also often used in local drinks or stored for future use. Despite its value, *P. biglobosa* is rarely cultivated, but can be found in agroforestry systems in savanna regions, including Nigeria (Oyerinde *et al*., 2018). Increasing attention is now being directed at the tree species due to its multifaceted contributions to rural livelihoods, food security, and natural resource conservation (Josh and Josh, 2009).

Parkia biglobosa is characterized by high genetic diversity, which is vital for its adaptation to changing climatic and environmental conditions. Among the traits that reflect this adaptability are growth characteristics, which are central to understanding plant conservation potential and guiding sustainable ecosystem management. Trees exhibit significant variability and adaptability in terms of their height, stem diameters, and crown sizes (Heuze *et al.*, 2019). Diameter at breast height (DBH) and tree height (H) are critical for evaluating forest structure and health status. Tree slenderness coefficient is an important attribute for determining tree stability or resistance to windthrows (Shamaki and Oyelade, 2022).

Effective forest management requires reliable data on tree growth and productivity. This information supports decision-making processes, helps in predicting tree performance under different conditions, and ensures the sustainability of forest resources (Ige, 2017). Onyekwelu *et al.* (2022) noted that limited tree regeneration poses a significant threat to forest sustainability, and knowledge of plant regeneration status aids in the development of management options and setting conservation priorities. The structure of *P. biglobosa* populations is characterized by small-diameter individuals and a low regeneration rate (Padakale *et al*., 2015). The species faces threats from old age, poor regeneration, overexploitation, inappropriate harvesting practices, and agricultural activities, which are collectively endangering its population and productivity (Lamien *et al*., 2011). The knowledge of growth characteristics of *P. biglobosa* is essential for developing effective management strategies, especially in the face of a decrease in the population of the tree species. Moreover, understanding growth traits is essential for monitoring how species respond to environmental variability and for identifying areas suitable for conservation or genetic improvement. Variability studies are necessary to increase plant productivity and for future breeding programmes (Freigoun *et al*., 2017).

Despite the ecological and economic importance of *P. biglobosa,* there remains limited research on its growth characteristics in Nigeria. Most studies have concentrated on morphological traits such as flowers, fruits, leaves, and seeds (Olorunmaiye *et al*., 2011; Kelly *et al*., 2022). Only a few researchers have investigated the tree growth characteristics of *P. biglobosa,* particularly in Chad, Benin, Cameroon and Mali (Moksia *et al*., 2019; Avana-Tientcheu *et al.*, 2019; Kelly *et al.*, 2021), with limited studies in Nigeria, especially within the tropical rainforest zone (Akinyemi and Oke, 2014; Oyerinde *et al*., 2018; Adio *et al*., 2019; Ogidan *et al*., 2023).

To address this knowledge gap, this study assesses the growth characteristics of *P. biglobosa* in the derived and guinea savanna zones of Nigeria. These regions represent agro-climatic zones where the species naturally occurs, and understanding its growth characteristics is crucial for supporting its sustainability. The findings will support targeted conservation measures, promote sustainable resource management, and enhance the species' potential to withstand environmental stress, inform reforestation and regeneration efforts for potential domestication to ensure the continued existence and ecological contributions of this important agroforestry species in Nigeria.

Material and Methods

Study Area

This study was conducted in two savanna ecological zones (Derived savanna (DS) and Guinea savanna (GS)) of Benue, Kogi and Nasarawa States (Figure 1). A total of 12 sampling locations were selected based on accessibility, economic importance and population of *P. biglobosa* trees (Table 1). Benue state is situated between Longitude 7° 4' and 10° 0' E, and Latitude 6° 25' and 8° 8' N. The mean annual rainfall varies from 1120 to 1500 mm. The climate is characterized by a high temperature regime, with an annual temperature of 21-37^{o}C27-28^{o}. The relative humidity is dependent on seasons but varies from 50% to 80% with the dry and rainy seasons having the lowest and highest values, respectively. Kogi State extends from Latitude 6.33 ^{o}N to 8.44 ^{o}N and from Longitude 5.40 ^{o}E to 7.49 ^{o}E. It encompasses a landmass of about 75,000 km^2, with a population of 3,278,487, with more than 70 % living in the rural region (Ibitoye, 2012). The annual rainfall ranges from 800 to 1100 mm (Sani and Haruna, 2010). The mean daily temperature ranges from 24.4 °C to 33.8^{o}C, depending on the season. The relative humidity is highest during the rainy season (mean value of 82.2%) and lowest during the dry season (mean value of 61.1%). Nasarawa State is located between latitude 7^{o} 45' and 9^{o} 2 'N and Longitude 7^{o} and 9^{o} 37'E. It has a total landmass of about 27,137.8 km^2, it is home to 1,863.275 people with population density of 130 as per the 2006 census data. The mean annual precipitation varies from 1100 mm to about

2000 mm. The State often records its highest temperature during the day, especially in months of March and April. The daily temperature range is from 20 to 34°C.

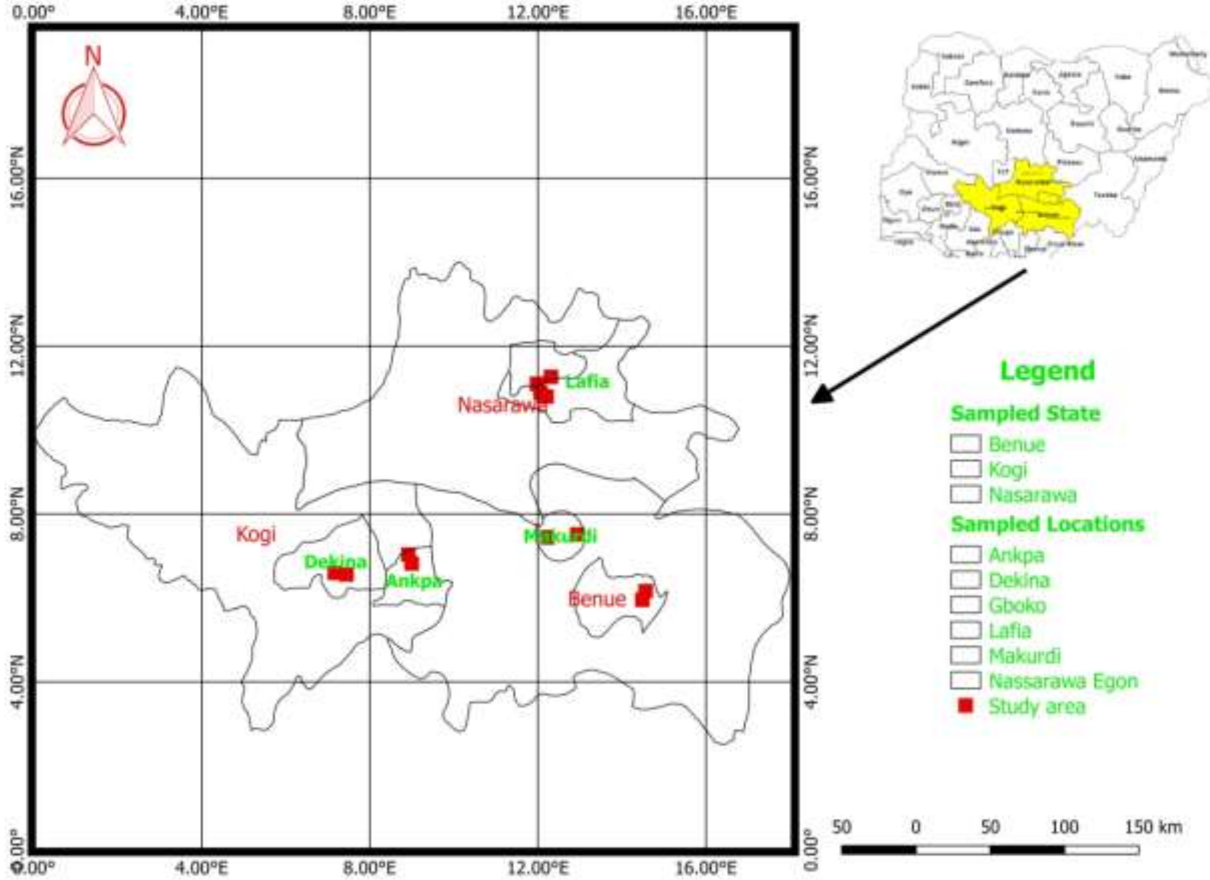


Figure 1: Map of central Nigeria showing parts of the Derived and Guinea ecological zones of Nigeria and the selected states.

Table 1: Locations of the 12 sampling sites for *Parkia biglobosa* populations in the Derived and Guinea savanna zones

States /population	L.G.A	Sampling Locations	Types of savanna	Latitudes	Longitude
Benue	Makurdi	Fiidi	Guinea savanna	N07º42.863’	E08º38.264’
		Adaka	Guinea savanna	N07º41.798’	E08º27.414’
	Gboko	Yandev	Derived savanna	N07º22.244’	E09º03.098’
		Ipyav	Derived savanna	N07º19.070’	E07º01.891’
Kogi	Ankpa	Ojede	Guinea savanna	N07º23.539	E07º36.976’
		Ofugo	Guinea savanna	N07º32.295’	E07º38.174’
	Dekina	Egume	Derived savanna	N07º28.288’	E07º14.534’
		Anyigba	Derived savanna	N07º28.844’	E07º10.266’

Nassarawa	Nasarawa eggon	Ogbagi	Guinea savanna	N08°40.078’	E08°28.739’
		Wata	Guinea savanna	N08°37.571’	E08°23.667’
	Lafia	Keffi wambai	Derived savanna	N08°32.946’	E08°27.133’
		Aridi	Derived savanna	N08 °34.308’	E08°24. 985’

Data Collection

A ground-based inventory was used to collect information on the growth characteristics of *P. biglobosa* trees. Key informants and farmers, who are conversant with each sampling location, were used to locate all *P. biglobosa* trees. The following measurements were made on all trees: diameter at breast height (DBH), diameter at the base ($D_{b)}$, diameter at the middle ($D_{m)}$, diameter at the top ($D_{t)}$ and total height (m)(TH). These parameters were used to compute basal area (m^2) and volume (m^3) of each tree. All diameter measurements were made with diameter tape, while the tree total height was measured with Speigel relascope. Measurements were made only on trees whose DBH is greater than or equal to 10 cm.

Data Computation and Analysis

Preliminary analyses were carried out to obtain descriptive statistics of all measured growth variables of *P. biglobosa* trees. Frequency distribution graphs and tables were generated to show the distribution of measured variables of the sampled trees. The following computations were undertaken.

Basal area Estimation

Basal area of each tree was calculated using the equation 1.

$$BA = \frac{\pi D2}{4} \qquad \text{(eqn. 1)}$$

Where BA = basal (m^2); D = diameter at breast height (cm); π = 3.142

Volume Estimation

The volume of each tree was estimated using Newton’s equation (Husch *et al.*, 2003) (equation 2).

$$V= \frac{\pi h}{24}(Db^2 + 4Dm^2 + Dt^2) \qquad \text{(eqn. 2)}$$

Where: V = volume (m^3), Db = Diameter at the base (cm), Dm = Diameter at the middle (cm), Dt = Diameter at the top (cm), h = total height (m); π = 3.142.

Tree slenderness coefficient

Tree slenderness coefficient was estimated for each tree using this formula

$$TSC= \frac{TH}{Dbh} \qquad \text{(eqn. 3)}$$

Where TSC = tree slenderness coefficient.
TH =Total height
DBH = diameter at breast height
TSC=TH (cm)/DBH (cm (eqn.3)

The SLCs of all individual trees were classified into three coefficient classes following the recommendation of (Onilude and Adesoye (2007)

a. Slenderness coefficient Class 1: SLC values > 99………… High slenderness coefficient
b. Slenderness coefficient Class 2: 70 < SLC values < 99…......Moderate slenderness coefficient
c. Slenderness coefficient Class 3: SLC values < 70..................Low slenderness coefficient.

Student t-test was used to compare the growth characteristics of the trees in the two ecological zones (i.e. Derived and Guinea savanna) in this study. One-way Analysis of Variance (ANOVA) was used to compare the growth characteristics of *P. biglobosa* trees within the three states (i.e. Benue, Kogi and Nasarawa). Means found to differ significantly were separated using least significant difference (LSD) at 5% probability level.

RESULTS

Parkia biglobosa tree growth characteristics in the Savanna ecological zones of Nigeria

With respect to ecological zones, the results revealed that the mean DBH of *Pakia biglobosa* trees was higher in the derived savanna (59.31 cm) than in the guinea savanna (51.02 cm). Likewise, the derived ecological zone had a higher mean total height value of 7.57 m, compared to the 7.07 m recorded for trees of the species in the guinea savanna. A similar trend was observed for mean basal area and volume of individual trees, which were 0.31m^2 and 0.25 m^2 for derived savanna and guinea savanna, respectively, while volume was 2.01 m^3 and 1.41 m^3 for derived and guinea savanna, respectively (Table 2). The results of analysis of variance indicated that *P. biglobosa* trees in the derived ecological zone had significantly higher mean growth characteristics than those growing within guinea savanna (Table 2). For example, mean individual tree volume production of 2.01 m^3 in the derived savanna was significantly higher than that of the trees in the guinea savanna (1.41 m^3).

Table 2: Mean growth characteristics of *Parkia biglobosa* trees in the derived and the guinea savanna ecological zone

Ecological zone	Mean DBH (cm)	Mean TH (m)	Mean BA (m^2)	Mean Volume (m^3)
Derived Savanna	59.31±21.72 ^{a}	7.57±2.03 ^{a}	0.31±0.23 ^{b}	2.01±1.92 ^{a}
Guinea Savanna	51.02±23.40 ^{b}	7.07±1.99 ^{b}	0.25±0.23 ^{a}	1.41±1.65 ^{b}
P-value	0.000	0.017	0.006	0.001

DBH = Diameter at breast height; TH = total height; BA = Basal area. Mean in the same column with the same alphabet are not significantly different (p≤ 0.05)

A total of 168 and 205 *P. biglobosa* trees were sampled within the derived and guinea savanna zones, respectively (Table 3). Across the States, the maximum DBH ranged from 89.00 to 116.80 in derived savanna zones and 82.50 to 116.90 in guinea savanna zones, while the minimum DBH ranged from 25.40 to 227.50 in derived savanna zones and 14.80 to 25.50 in guinea savanna zones (Table 3). In the derived savanna zone, the highest mean DBH of 65.0 cm was obtained from the Nasarawa State population, which was followed by the Benue State population (62.8cm), while the lowest value (48.7cm) was from the Kogi State population (Table 3). A similar trend was observed in the guinea savanna, where the Nasarawa State *P. biglobosa* population had the mean highest DBH of 72.7cm, which was followed by the Benue State population (45.7cm) and the Kogi State population (39.7cm).

Similar trend was also observed in the mean height growth of the species in the study areas, with Nasarawa population having the highest mean height of 7.87m and 8.80m for derived and guinea savanna ecosystems, respectively, followed by Benue population with respective means of 7.63 m and 6.22m and Kogi population with respective mean heights of 7.21 m and 6.64m for the two ecological zones (Table 3). Across the States, the mean basal area of individual trees ranged from 0.20 m^2 to 0.4 m^2 for the derived savanna and from 0.1 m^2 to 0.5 m^2 in the guinea savanna zone, while the mean volume ranged from 1.1 m^3 to 2.4 m^3 in the derived savanna and 0.2 m^3 to 2.6 m^3 in the guinea ecological zone (Table 3). The results of analysis of variance indicated that *P. biglobosa* trees in Nasarawa and Benue States had significantly higher mean DBH, BA and volume than in Kogi State, while the TH shows no significant differences among the states in the derived savanna. In the guinea savanna, Nasarawa State had significantly higher mean DBH, TH, BA and volume than Benue and Kogi states (Table 3).

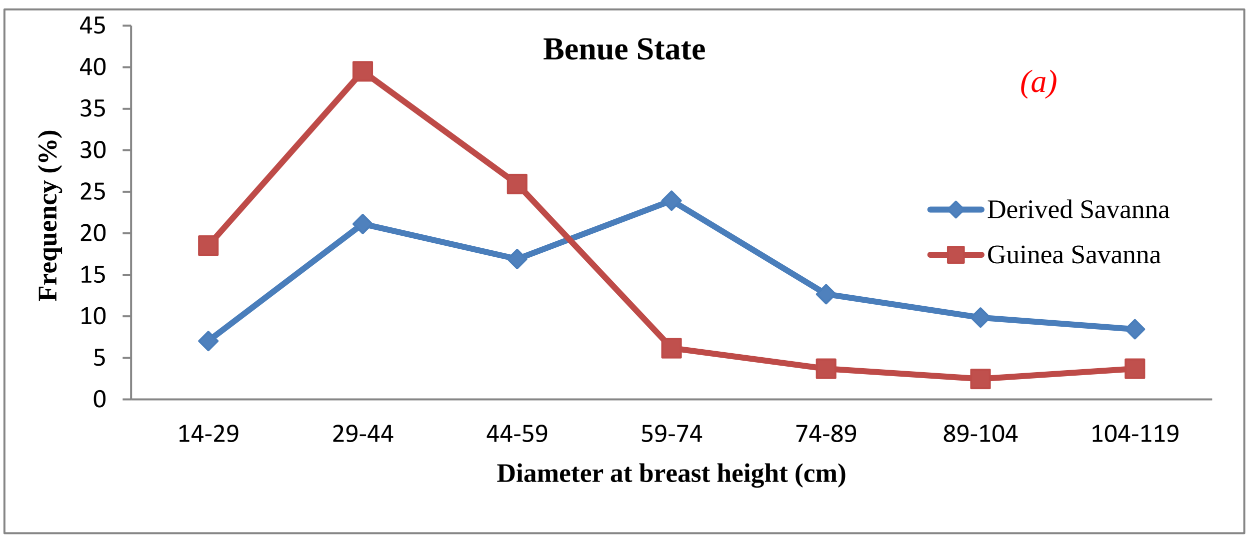
Table 3: Mean growth characteristics of *Parkia biglobosa* trees in three states within the derived and guinea ecological zones of Nigeria

Ecological zone	Population	Number of trees	Max. DBH	Min. DBH	Mean DBH (cm)	Mean TH (m)	Mean BA (m^2)	Mean Vol (m^3)
Derived Savanna	Nasarawa	48	103.20	27.50	65.0±17.7 ^{a}	7.87±1.86 ^{a}	0.4±0.2 ^{a}	2.3±1.4 ^{a}
	Benue	71	116.80	26.90	62.8±24.6 ^{a}	7.63±2.45 ^{a}	0.4±0.3 ^{a}	2.4±2.5 ^{a}
	Kogi	49	89.00	25.40	48.7±16.9^b	7.21±1.4 ^{a}	0.2±0.1 ^{b}	1.1±0.8 ^{b}
	Total	168						
		P-value			0.000	0.256	0.000	0.001

Guinea Savanna	Nasarawa	57	116.00	20.50	72.7±21.4 ^{a}	8.80±2.14 ^{a}	0.5±0.2 ^{a}	0.2±0.2 ^{a}
	Benue	81	116.90	14.80	45.2±21.8 ^{b}	6.22±1.72 ^{b}	0.2±0.2 ^{b}	2.6±1.6 ^{b}
	Kogi	67	82.50	25.50	39.7±12.2 ^{b}	6.64±1.07 ^{b}	0.1±0.1 ^{b}	1.2±1.9 ^{b}
	Total	205						
		P-value			0.000	0.000	0.000	0.000

Mean in the same column carrying the same alphabet are not significantly different (p≤ 0.05)
DBH=Diameter at breast height, TH=Total height, BA=Basal area, Vol=Volume

Diameter class distribution pattern is considered an important factor in understanding changes occurring in a forest stand, and in appreciating differences in the structural pattern (structural heterogeneity) and tree size structure (Akinyemi and Oke 2014; Adio *et al*. 2019; Sharma *et al*. 2020). The diameter class distribution pattern of *P. biglobosa* trees in the derived and guinea savanna ecosystems in the three states is presented in Figure 2. The diameter distribution pattern of trees in the ecological zones ranged from an inverse J distribution pattern (Figures 2a & b) to a normal distribution pattern (Figure 2c). The diameter class with the highest frequency of trees in the two ecological zones was 29 - 44 cm in Benue and Kogi states (Figures 2a & 2b) and 59 - 74 cm in Nasarawa state for trees in the derived savanna and 74 - 89 cm for trees in the guinea savanna (Figure 2c). A high proportion of the trees in the two ecological zones were within the diameter classes of 29 - 44 cm and 44 - 59 cm in Benue and Kogi states (Figures 2a & 2b). For Nasarawa state, a high proportion of the trees were found within the diameter classes of 44 - 59 cm, 59 - 74 cm and 74 - 89 cm (Figure 2c), indicating that *P. biglobosa* trees in Nasarawa state were generally bigger than those in Benue and Kogi states. Large diameter trees (100 cm and above) were absent in the two ecological zones in Kogi state and in the derived savanna in Nasarawa state.



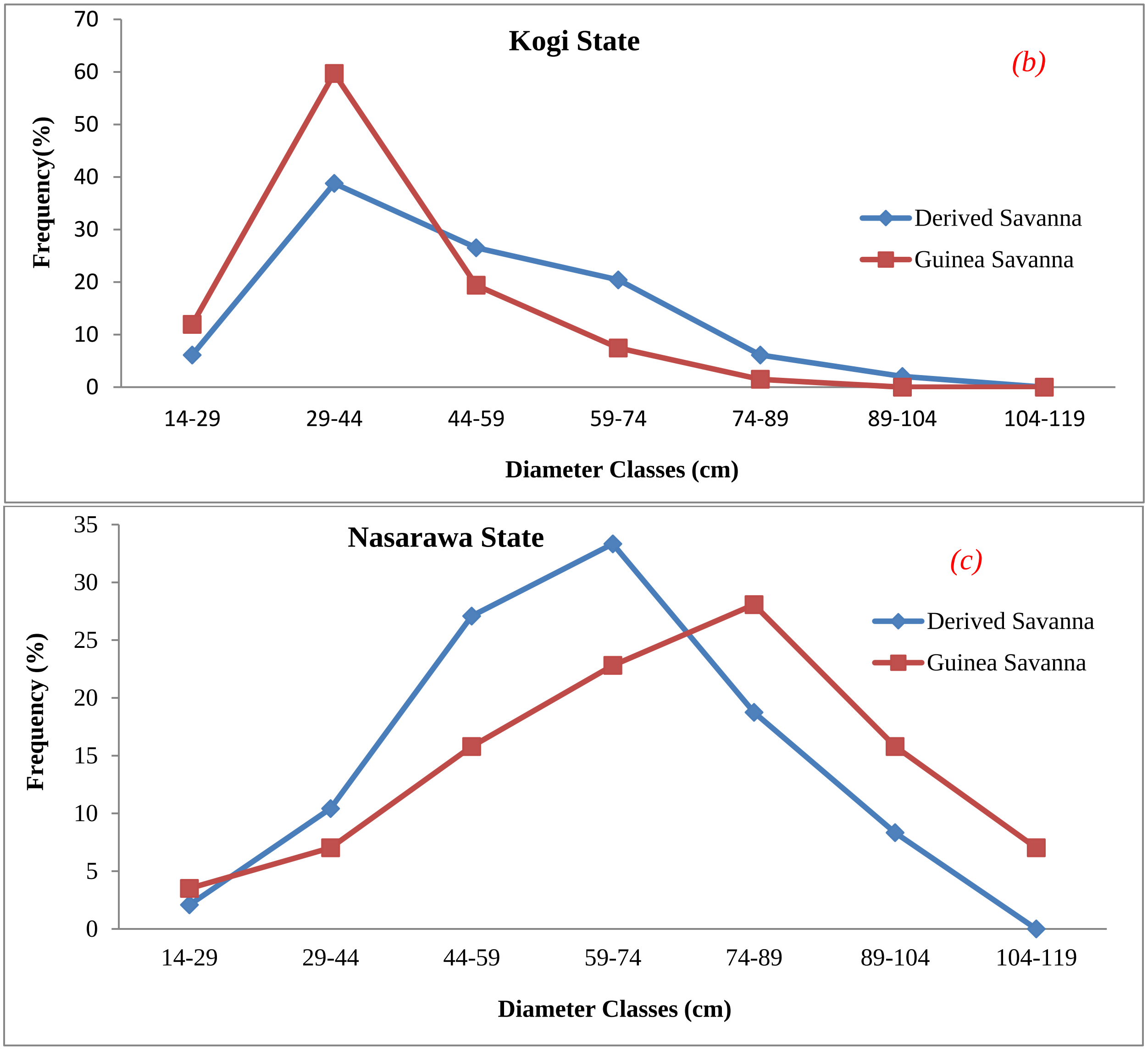


Figure 2: Diameter (cm) distribution pattern of *Parkia biglobosa* trees in the derived and guinea savanna ecological zones of (a) Benue, (b) Kogi and (c) Nasarawa states

The total height (m) distribution patterns of individual *P. biglobosa* trees in derived and guinea savanna ecological zones of Benue, Kogi and Nasarawa states are shown in Figures 3 a-c. Generally, *P. biglobosa* trees in the study area have short heights, with only a small proportion of the trees exceeding total height growth of 12 m (Figures 3a-c). In Benue and Kogi states, most of the trees were found in the height class of 4 - 8 m, followed by 8 - 12 m while in Nasarawa states, most of the trees were found in the height class of 8 - 12 m, which was closely followed by 4 - 8 m height class. In Kogi state, no tree was found in the height class of above 12 m (Figure 3b).

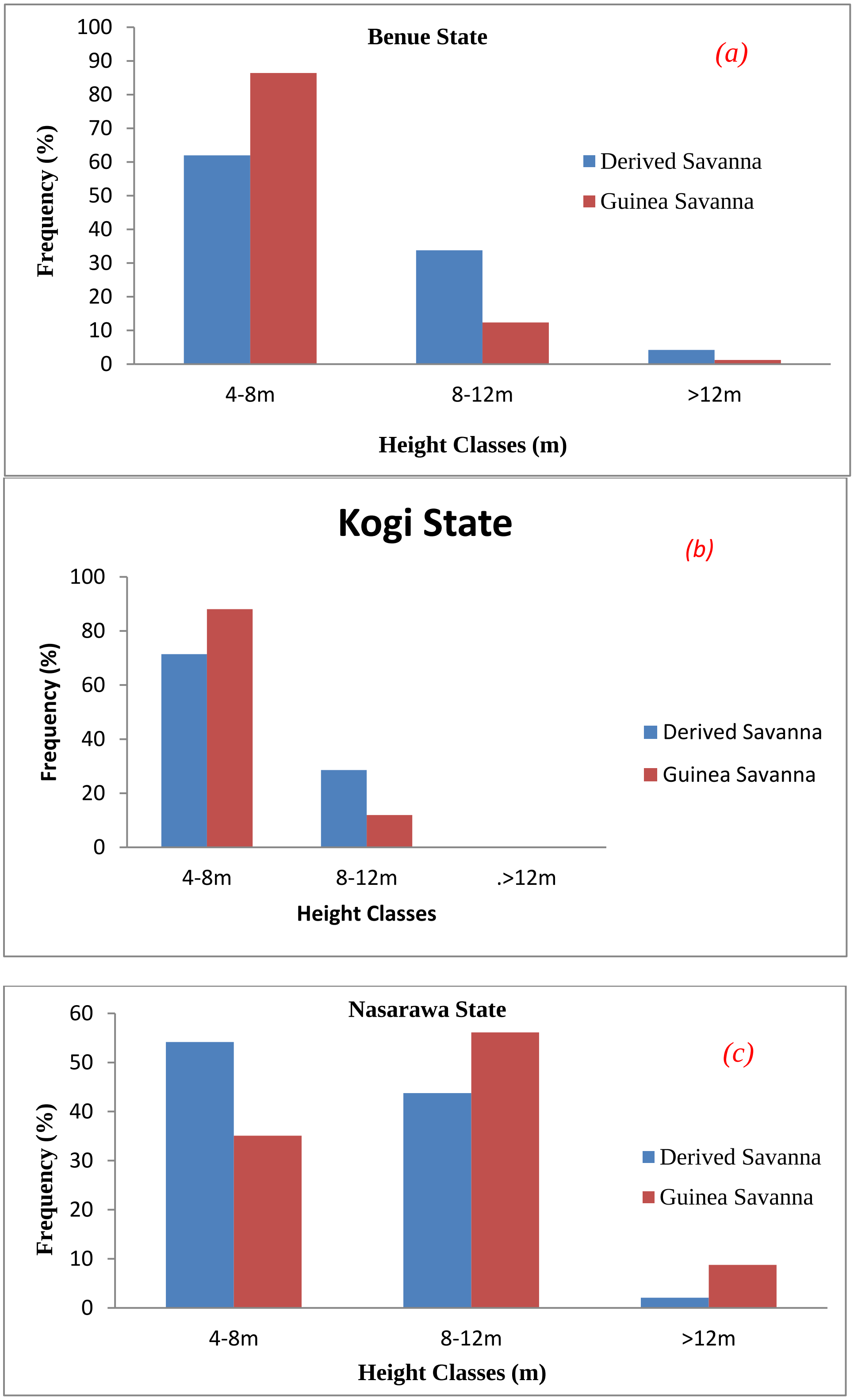


Figure 3: Total height (m) distribution pattern of *Parkia biglobosa* trees in the derived and guinea savanna ecological zones of (a) Benue, (b) Kogi and (c) Nasarawa states

The slenderness coefficient value across the States in the two savanna ecological zones was between 11.30 to 17.00. *P. biglobosa* in the study locations had a low slenderness coefficient (SC), indicating their suitability against wind throw.

Table 4: Slenderness Coefficient of *P.biglobosa*

Ecological zones	Population	DBH	Total height	Slenderness coefficient(SC)	Remark
	Benue				
Derived Savanna		0.62	7.63	12.31	Low slenderness
Guinea Savanna		0.45	6.22	13.82	Low slenderness
	Kogi				
Derived Savanna		0.49	7.02	14.33	Low slenderness
Guinea Savanna		0.39	6.63	17.00	Low slenderness
	Nasarawa				
Derived Savanna		0.64	7.87	11.30	Low slenderness
Guinea Savanna		0.73	8.80	12.50	Low slenderness

The results of the correlation analysis are presented in Table 4. All tree growth variables (DBH, BA, TH and Vol.) were positively correlated at 5% probability level (Table 4). The DBH of trees had a high positive correlation with volume (0.88) and a low positive correlation with total height (0.126). The correlation between basal area and tree volume was high and positive (0.92), while basal area and total height had a low positive correlation (0.14). There was a weak positive relationship between total height and volume (0.177). There was a weak negative relationship between most of the growth variables and ecological zones, except total height, that had a weak positive correlation (0.122) with ecological zones (Table 4).

Table 4: Pearson Correlation matrix of *Parkia biglobosa*

Variables	Ecological zones	DBH (cm)	Basal Area (m^2)	Volume (m^3)	Total tree height (m)
DBH	-0.180**	1	-	-	-
BA	-0.142**	0.979**	1	-	-
Vol	-0.167**	0.882**	0.924**	1	-
Total tree height	0.122*	0.126*	0.141**	0.177**	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed)

DISCUSSION

Studies on structure and knowledge of floristic compositions are very vital in forest management and sustainability as they play a major role in the conservation of plant species and the sustainable management of ecosystems (Akinyemi and Oke, 2014). The mean DBH values reported for the study area in this study were higher than those (25.8 cm) reported for *P. biglobosa* trees in southern Mali by

Diarra (2017), as well as the value reported for *Triplochiton scleroxylon* (18.7 cm) by Akintude *et al*. (2024) and values for *Pinus roxburghii* trees (34.9 cm) in Nepal by Sharma *et al*. (22020). The difference observed in the DBH might be due to differences in ecological conditions, anthropogenic activities and tree management regimes. The DBH results obtained by Moksia *et al*. (2019) (79.14 cm) and Kelly *et al*. (2022) (range: 59.23-62.29 cm) for *P. biglobosa* in Cameroon and Southern Mali were in line with our results. In another study, Kelly *et al*. (2021) reported a mean DBH range of 45.46 - 66.26 cm for *P. biglobosa* trees in southern Mali, which is also in agreement with our results.

The DBH values (62.97 -73.92) reported by Avana-Tientcheu *et al*. (2019) for *P. biglobosa* trees in Chad are within the range for the tree species in the study area. In the south-western Nigeria, Oyerinde *et al.* (2018) observed a mean DBH range of 147 - 161 cm for P. *biglobosa* in Ekiti, Osun and Ondo States, which was higher than what was obtained in this study. This disparity may be attributed to differences in the climatic conditions in ecological zones. Given that southwestern Nigeria is predominantly a tropical rainforest ecosystem, its better climatic (rainfall, temperature) and soil conditions could account for the higher DBH of the species in this ecosystem compared to the study area, which is in a savannah ecosystem.

Observations have been noted in studies on other forest tree species. For instance, Olajiire *et al.* (2024) reported a mean DBH of 58.70 cm and 26.11 cm for *Nauclea diderrichii* and *Terminalia ivorensis*, respectively. Kelly *et al*. (2018) found the mean DBH range of 26.05 -31.35 cm for *Vitelleria. paradoxa* in southern Mali, which is lower than the values noted in this study. The results of this study and reports in available literature seem to suggest that *P. biglobosa* trees in Nigeria are inherently short. The mean total height of 8.4 m for *P. biglobosa* in the southwestern region of Nigeria recorded by Ogidan *et al.* (2023) aligns with the the m recorded for trees of the species in this study. Similarly, the mean total heights in this study agree with the findings of Oyerinde *et al*. (2018), who reported mean heights of 6.92, 7.11 and 7.43 m for *P. biglobosa* trees in three sites in southwestern Nigeria. A similar mean height (8.14m), in line with the findings of this study was also given by Akintude *et al*. (2024). Contrary to the above results from Nigeria, researchers have generally reported higher height growth for *P. biglobosa* trees outside Nigeria.

For example, Moksia *et al.* (2019) recorded a height range of 12.15 to 14.76 m for the *P. biglobosa* tree in Cameroon, while Kelly *et al*. (2021) reported a range of 10.68 to 12.59 m for the species in Southern Mali. Similarly, Avana-Tientcheu *et al.* (2019) total height range of 12.5 to 14.68 m for *P. biglobosa* trees in Chad. All these are higher than the values reported for the species in this study and in Nigeria. This difference could potentially be attributed to variances in the agroclimatic conditions, genetic variation and environmental and management influence on tree growth (Avana-Tientcheu *et al.* 2019; Kelly *et al*., 2021). Generally, *P. biglobosa* trees have lower mean height growth than many tropical forest tree species based on some published results. Onilude *et al*. (2020) and Olajiire *et al*. (2024) reported mean total height of 17.07 m and 12.4 m, respectively, for *Terminalia ivorensis.* Onyekwelu (2007) reported a total height range of 9.0 - 23.6 m for 5 to 30-year-old *Nauclea diderrichi* plantations, respectively, while the mean total height of 10 to 25-year-old *Gmelin arborea* plantations was 18.4 to 25.3 m (Onyekwelu *et al*. 2006). The mean total height range of 6.0 to 20.5 m was reported for 4 to 22-year-old *Hevea brasiliensis* plantations in Nigeria (Samuel *et al*., 2020).

The mean BA value of 0.38 m^2 reported by Adio *et al*. (2019) for *P. biglobosa* trees is within the range for this study. Also, the BA of 0.2188 m^2 of *P. biglobosa* was reported in the Southern guinea savanna of Kogi, which is like the results of this study. The volumes recorded for *P. biglobosa* trees by Olajiire *et al*. (2024) (0.380m^3), Akintude *et al*. (2024) (0.320 m^3) and Onilude *et al.* (2020)(0.382m^3) were lower than the result obtained in this study. The results of the correlation matrix showed a strong positive correlation between measured variables which corresponds to a high positive correlation between measured variables observed by Adio *et al*. (2019) and Kelly *et al*. (2021). This positive correlation indicates that as diameter increases, the tree develops a stronger supportive structure, which enables vertical growth (height) and crown expansion.

Tree size distribution is an indicator of changes in tree and forest structure (Akinyemi and Oke, 2014). The diameter distribution of *P. biglobosa* trees in the study area followed J-shapedd distribution pattern to a normal distribution pattern with a higher number of individuals in small size classes, a substantial number in middle size diameter classes and fewer trees in large size diameter classes. A similar trend has been reported in the Opara Forest Reserve of Oyo State (Ogidan *et al*., 2023). Fewer individual trees in the larger diameter classes show a population under pressure from anthropogenic activities, such as overexploitation of its natural resources, as opined by Ogidan *et al*. (2023).

The higher number of individuals in the lower diameter classes than the higher DBH classes might be due to less disturbance from natural and anthropogenic activities. Similar trends were reported by Bhatta and Devokta (2020) and Sharma *et al*. (2020). The diameter class distribution of trees in this study has shown that Benue, Kogi and Nasarawa *P. biglobosa* populations were characterized by small (29-44 cm) and medium (44-59 cm) sized trees, with a gradual decrease in tree frequencies as the diameter class increases (e.g. 74-89, 89-104 and 104-119). The highest number of individual trees occurred in DBH classes of 29-44 cm and 44-59 cm for *P. biglobosa* trees in the derived savanna and guinea, respectively. Fewer individuals were observed in the small diameter class of 14-29 cm, indicates low or poor natural regeneration of *P. Parkia biglobosa* trees in the study area as noted by Raebild *et al.* (2012), Padakale *et al.* (2015) and Moksia *et al*., (2019). Low frequency of individuals in the low diameter class of 14 -29 cm in this study agrees with a low frequency in the diameter class of 10-30cm reported by Koura *et al*. (2013) for *P. biglobosa* trees. Lawal *et al.* (2024) reported higher number of individual *Chrysophylum albidum* trees in 10-30cm DBH class.

The individual trees height distribution results obtained in this study are in agreement with those of Ogidan *et al.* (2023), who found a greater number of trees in the height class of 6-10 m. The height range of the species confirms the established fact that *P. biblobosa* trees generally grow to a total height of between 7m to 20 m (Zaku *et al*., 2022). The scarcity of taller trees (>12 m) in the study area shows the general height growth characteristics of *P. biglobosa* trees and could imply the low presence of old-growth individuals, which are crucial for ecological functions such as fruit and seed production, shade, and microhabitat formation. The slenderness coefficient of *P.biglobosa* was low across the studied populations, which implies that *P.biglobosa* has good stability and low susceptibility to wind-induced damage as noted by Adeyemi and Ugo-Mbonu (2017). The slenderness coefficient value over 100 is considered to indicate a high risk of windthrow. Thus, *P. biglobosa* tree species do not belong to this high-risk category for windthrow.

Conclusion

The study found that *Parkia biglobosa* is well distributed across the derived and guinea savanna zones of Benue, Kogi, and Nasarawa States, with trees in the derived savanna showing better growth performance in terms of diameter, height, basal area, and volume. Significant variations existed among states. Benue and Kogi showed an inverse J-shaped diameter distribution, indicating active regeneration, while Nasarawa displayed a more balanced distribution with more mature trees. The species generally had short stature but good structural stability, suggesting resistance to wind damage.

To ensure sustainability, conservation measures are needed to protect mature trees, especially in Kogi and parts of Nasarawa. Forest managers should promote natural regeneration and enrich areas with low recruitment using quality seedlings for genetic improvement. Local communities should be trained on sustainable harvesting practices to reduce overexploitation. Government and forestry agencies should incorporate these findings into forest management and agroforestry programs, particularly in community forest areas where *P. biglobosa* holds significant economic and cultural value.

References

Adio, A.F., Onilude, Q.A., Kareem, A.A and Sulaiman, O.N. (2019). Floristic dynamics and structure of a degraded community forest in Kwara state, Nigeria. *Australian Journal of Science and Technology,* 3(4):195-200.

Akintude A.D., Onilude, Q.A., Ige, P.O. and Adeoti, O.O. (2024). Stand growth, biomass and carbon sequestration potentials of *Parkia biglobosa* (jacq.) Bench plantation in South-Western Nigeria. Journal of Applied Science, Environment and Management 28(4):1297-1304.

Akinyemi, D. S and Oke, S.O. (2014). Floristic Composition and Structural Diversity of Shasha Forest Reserve in Ile-Ife, Southwestern Nigeria. *Not Sci Biol*, 6(4):433-440.

Akinyemi, A.A and Ngo-Mbon, N.A (2017). Tree slenderness coefficients and crown Ratio models for *Gmelina arborea* (ROXB) Stand in Afi River Forest Reserve, Cross River State, Nigeria. Nigeria. *Journal of Agriculfure, Food and Environment*. 13(1):226-237

Amusa, O., Adesoye, A., Ogunkanmi, O., Omoche, O., Olowe, S. and Akinyosoye, T.O. (2014). Genetic Diversity of *Parkia biglobosa* from different agroecological zones of Nigeria using RAPD markers. *International Journal of Biodiversity*,1: 6pp. https://doi.org/10.1155/2014/457309

Avana-Tientcheu, M.L.A., Keouna, S D., Nguemo, D and Mouga, M.B (2019). Structure des peuplements et potentiel de domestication de *Parkia biglobosa* dans la région de Tandjilé-Ouest (Tchad). *International*

Journal of Biological and Chemical Sciences, 13(1): 219-236.

Bharucha, Z. and Pretty, J., 2010. The roles and values of wild foods in agricultural systems. Philos Trans. 365:2913–2926.

Bhatta, S.P and Devkota, A (2020). Community structureand regeneration status of Sal (Shorea robustaGaertn.) forests of Dadeldhura district, Western Nepal. *Community Ecology*, 21(2), 191-201.

Chao, S., 2012. Forest peoples: numbers across the world. United Kingdom: Forest Peoples Programme, 24 pp.

Diarra, I. (2017). Evaluation de la disponibilité des espèces d'arbres et d'arbustes locaux comestibles dans la région de Sikasso. Mémoire d'Ingénieur des Eaux et Forêts. IPR/IFRA de Katibougou. Mali 68 p.

Freigoun, S. A. B., Raddad, E. Y. A and Elagib, T. Y. (2017). Provenance variation in seed morphological traits and early seedling growth of *Balanites aegyptiaca* Del. Sudan. *Journal of Agricultural Research*, 27:93-108.

Heuze, V., Thiollet, H., Tran, G., Edourard, N and Lebas, F. (2019). African Locust bean (*Parkia biglobosa* and *Parkia filicoidea*) Feedipedia, a programme by INRAE CIRAD AFZ and FAO 268, 10:22.

Houndonougbo, J. S. H., Kassa, B., Mensah, S., Salako, V. K., Kaka¨ı, R. G and Assogbadjo, A. E. (2020). A global systematic review on conservation nd domestication of *Parkia biglobosa* (Jacq.) R. Br. ex G. Don, an indigenous fruit tree species in Sub-Saharan African traditional parklands: current knowledge and future directions. *Genetic Resources and Crop Evolution* 67(4):1051–1066.

Husch, B., Beers, T.W and Kershaw Jr., J.A (2003): Forest Mensuration, 4th ed. John Wiley and Sons, Inc., New Jersey, USA, 443 pp.

Ibitoye, S.I. (2012): Assessment of the levels of awareness and use of agricultural insurance scheme among the rural farmers in Kogi State, Nigeria, *International Journal of Agricultural Science, Research and Technology*, 2 (3):143-148.

Ige, P.O (2017). Relationship between the Slenderness Coefficient and tree or stand growth characteristics for Triplochiton scleroxylon (K. Schum) stands in Onigambari forest reserve, Nigeria. Journal of Forest Research and Management 14(2):166-180

Joshi, A.R and Joshi, K. (2009): Plant Diversity and Ethno-botanica.l Notes on tree species of Syabru Village, Langtang National Park, Nepal. *Ethno botanical leaflets* 13: 651-664.

Kelly, B.A., Kouyaté, A.M and Dembélé S.G (2021). Variation of *Parkia biglobosa* morphological traits according to land use and agro-climatic zones in Southern Mali. *African Journal of Plant Science*, (15)1:20-27.

Kelly, B.A., Kouyaté, A.M and Dembélé, S.G. (2022). Leaf and fruit characteristics of *Parkia biglobosa* (Jacq.) Benth. according to agro climatic zones and land use in Southern Mali. *Research in Plant Biology*, 12: 1-9.

Kelly, B.A., Poudyal, M and Bouvet, J. M (2018). Variation of *Vitellaria paradoxa* phenophases along the north-south gradient in Mali. *Research in Plant Biology*, 8:8-16.

Koura, K., Mbaide, Y and Ganglo, J.C. (2014). Caractéristiques phénotypique et structurale de la population de *Parkia biglobosa* (Jacq.) du Nord-Bénin. *International Journal of Biological. Chemical. Science*. 7(6): 2409-2425.

Lamien, N., Ekue, M., Ouedraogo, M and Loo, J (2011). *Parkia biglobosa*, Africa locust bean. In Conservation and sustainable use of genetic resources of priority food tree species in Sub-Saharan Africa. Rome, Italy: *Biovers. Int.* Leaflet pp 1-8.

Lawal, A., Sale, F.A and Arogundade, J.C. (2024). Characterization of *MatK* and *RuBisCO* Genes within the Population of *Chrysophyllum albidum* (G. Don) in Akure Forest Reserve, Ondo State, Nigeria. *Biological and Environmental Sciences Journal for the Tropics*, 21(1):178-188.

Lompo, D., Vinceti, B., Gaisberger, H., Konrad, H., Duminil, J., Ouedraogo, M., Sina, S and Geburek, T. (2017). Genetic conservation in *Parkia biglobosa* (Fabaceae: Mimosoideae)-what do we know? *Silvae Genetica*, 66(1):1-8.

Lompo, D., Vinceti, B., Konrad, H., Gaisberger, H and Geburek, T (2018). Phylogeography of *African* locust bean (*Parkia biglobosa*) reveals genetic divergence and spatially structured populations in West and Central Africa. *Journal of Heredity*, 109: 811.

Moksia, F.T., Hamawa, Y., Souare, K., Todou G and Baye-Niwah, C (2019). Structure and regeneration of *Parkia biglobosa* (Jacq.) R.

Br. Ex G Don in Mount Mandara, Cameroon, *International Journal of Biodiversity and Conservation*, 11(9):241-251.

Ogidan, O.A., Aderounmu, A.F., Ekaun, A.A., Ogundana, O.A and Afolabi, R.T (2023). Assessment of Growth Characteristics, Diversity and Structure of Tree Species in Opara Forest Reserve, Oyo State, Southwest Nigeria, *J. Appl. Sci. Environ. Manage*., 27 (11): 2591-2596.

Olajiire-Ajayi, B. L., Ogundana, O. A and Adenuga, D. A. (2024). Assessment of Stand Growth and Slenderness Coefficient of *Nauclea Diderrichii* A. Chev and *Terminalia Ivorensis* De Wild and Thur In Forestry Research Institute of Nigeria, (Frin) Arboretum, Oyo State, Nigeria. *Fudma Journal of Sciences*, 8(4):55 - 61.

Olorunmaiye, K. S., Fatoba, P. O., Adeyemi, O. C and Olorunmaiye, P. M. (2011). Fruit and seed characteristics among selected *Parkia biglobosa* (JACQ) G. Don. Population. *Agriculture and Biology Journal of North America*, 2(2):244-249.

Onilude, Q.A., Fajemila, A., Adeleye, I.G., Oduola, M., Osijo, A and Oso, A.O (2017) Stem Taper and Tree Growth Characteristics for *Triplochiton scleroxylon* (K. Schum) Stands in Ibadan Metropolis, Nigeria. *International Journal of BioSciences, Agriculture and Technology*, 8(4):28–35.

Onyekwelu, J.C, Mosandl, R. and Stimm, B (2006). Productivity, site evaluation and state of nutrition of *Gmelina arborea* plantations in tropical rainforest zone in South-western Nigeria. *For. Ecol. and Manage.*, 229: 214–227. doi:10.1016/j.foreco.2006.04.002

Onyekwelu, J.C (2007). Growth, biomass yield and biomass functions for plantation-grown *Nauclea diderrichii* in humid tropical rainforest zone of Nigeria. *Bioresource Technology*, 98: 2679 – 2687. doi:10.1016/j.biortech.2006.09.023

Onyekwelu, J.C., Oyewale, O., Stimm, B. and Mosandl, R., 2015. Antioxidant, nutritional and anti-nutritional composition of *Garcinia kola* and *Chrysophyllum albidum* from rainforest ecosystem of Ondo State, Nigeria. Journal of Forestry Research, 26:417-424. DOI: 10.1007/s11676-015-0068-2

Onyekwelu, J.C., Agbelade, A.D., Tolorunju, M.S., Lawal, A., Stimm, B. and Mosandl, R. (2022): Conservation Potentials, Tree Species Diversity, Distribution and Structure of Sacred Groves in South-Western Nigeria. *Journal of Tropical Forest Science*, 34(3): 333-345.

Oyerinde, O.V., Olusola, J.A and Adebo, A. A (2018). Variation in morphometric traits of trees, pods and seeds of *Parkia biglobosa* (Jacq) G. in southwestern Nigeria. *International Journal of Conservation Science*, 9(1):185-192.

Padakale, E., Atakpama, W., Dourma, K.D., Wala, K., Guelly, K.A and Akpagana, K (20015). Woody Species Diversity and Structure of *Parkia biglobosa* Jacq. Dong Parklands in the Sudanian Zone of Togo (West Africa). *Annual Research and Review in Biology*, 6(2):103-114.

Ræbild, A., Hansen U.B and Kambou, S. (2012) Regeneration of *Vitellaria paradoxa* and *Parkia biglobosa* in a parkland in Southern Burkina Faso. *Agroforestry System*, 85:443-453.

Sacande, M., Sanogo, S and Beentje, H (2016). Guide d'identification des arbres du Mali. Royal Botanic Gardens, Kew; Kew Publishing, 356 pp.

Samuel, O.G., Onyekwelu, J.C. and Omokhafe, K.O. (2020). Growth characteristics and trends of *Hevea brasiliensis* muell. Arg. Plantations in rainforest ecosystem of Edo State. Research Journal of Agriculture and Forestry Sciences, 8(3), 1-9.

Sani, M. H. and Haruna, U. (2010): Planning model for sustainable vegetable crop production in the eastern part of Kogi State, Nigeria. *Journal of Agronomy*, 9 (1):17-22.

Sharma, K.P., Bhatta, S.P., Khatri, G.B., Pajiyar, A and Joshi, D.K. (2020). Estimation of Carbon Stock in the Chir Pine (*Pinus roxburghii* Sarg.) Plantation Forest of Kathmandu Valley, Central Nepal. *J. Forest. Environ. Sci.* 36:37-46.

Shamaki, S.B and Oyelade, D.O (2022). Tree slenderness coefficient and its relationship to diameter at breast height for *Azadiracta indica* stand in Sanyima community plantation, Sokoto state, Nigeria. Proceedings of the 8th Biennial Conference of the Forests and Forest Products Society held at the Forestry Research Institute of Nigeria, Ibadan, Nigeria. 14th -20th August 2022.

Shrestha, S., Shrestha, J and Shah, K (2020). Non-Timber Forest Products and their Role in the Livelihoods of People of Nepal: A Critical

Review. *Grassroots Journal of Natural Resources*, 3(2):42-56.

Talukdar, N.R., Choudhury, P., Barbhuiya, R.A and Singh, B. (2021). Importance of non-timber forest products (NTFPs) in rural livelihood: a study in Patharia Hills Reserve Forest, northeast India. *Trees, For. People*, 3, 100042. https://doi.org/10.1016/j.tfp.2020.100042

Zaku, S.S., Amadi, D.C.A., Maiguru, A.A and Rabo, S (2022). Contributions of *Parkia biglobosa* (Jacq.) Benth to community livelihoods in Jema'a Local Government Area of Kaduna State, Nigeria. *International Journal of Agricultural Research, Sustainability,and Food Sufficiency* (IJARSFS), 9 (01): 552 – 559.

10/25/2025