ABUNDANCE OF *Parkia biglobosa* AND WOODY SPECIES COMPOSITION IN PROTECTED AND UNPROTECTED FOREST OF SOUTHERN KANO STATE NIGERIA

by

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LIST OF ABBREVIATIONS

FGR	Falgore Game Reserve
MDF	Massu Dagora Forest
OM	Soil Organic Matter Content
TEMP	Temperature
N	Nitrogen
Na	Sodium
K	Potassium
Ca	Calcium
CEC	Cation Exchange Capacity
P	Phosphorus
Mg	Magnesium
RH	Relative Humidity
SLP	Slope
ELE	Elevation
BLK	Block

KELIMPAHAN *Parkia biglobosa* DAN KOMPOSISI SPESIES BERKAYU DI DALAM HUTAN YANG DILINDUNGI DAN TIDAK DILINDUNGI DI KANO SELATAN NIGERIA

ABSTRAK

Kajian ini bertujuan untuk mengenal pasti kelimpahan *Parkia biglobosa* dan komposisi spesies berkayu di antara hutan Falgore Game Reserve (FGR) yang dilindungi (hutan simpan yang terganggu) dan Hutan Massu-Dagora (MDF) yang tidak dilindungi di Kano Selatan, Nigeria. Objektif utama kajian ini adalah untuk menganggarkan kelimpahan *P. biglobosa*; membandingkan kepelbagaian dan komposisi tumbuhan berkayu di kawasan kajian serta mengkaji korelasi faktor-faktor fizikal dengan kelimpahan *P. biglobosa* dua jenis hutan tersebut. Sebanyak 30 plot enumerasi rambang bersaiz 20m x 10m persegi telah ditubuhkan secara rawak di lokasi yang berlainan didua hutan tersebut (15 kuadrat setiap satu). Sejumlah 5484 batang pokok berkayu daripada 24 famili telah direkodkan, di mana 55 genus direkodkan di FGR manakala 42 genus dari MDF. Jumlah spesies adalah lebih tinggi di FGR dengan 71 spesies berbanding 50 spesies dari MDF. Spesies yang dominan di FGR adalah *Guiera senegalensis* (236, 6.9%) individu, diikuti oleh *Cassia singueana* (168, 4.9%) dan *Anogeissus leiocarpus* (133, 3.9%). Spesies yang dominan di MDF pula ialah *Combretum glutinosum* (171, 8.2%) diikuti oleh *G. senegalensis* (147, 7.1%) dan *C. sieberiana* (134, 6.5%). Diversiti (Kekayaan spesies) tumbuhan berkayu lebih tinggi di FGR dengan nilai index Shannon (H'= 3.948) berbanding dengan MDF dengan (H'= 3.515). Ini menunjukkan bahawa kedua-dua hutan berbeza dalam kekayaan dan komposisi spesies. Ujian penyelarasan CCA (spesies - pembolehubah alam sekitar) menunjukkan bahawa *P. biglobosa, Vitellaria*

paradoxum, A. albida, A. leiocarpus, Bridelia ferruginea boleh bertoleransi dengan organik karbon, ketinggian dan kelembapan relatif. *C. arereh, Ficus thonnongii, Annona senegalensis* dan *Entada africana* dikaitkan dengan suhu tinggi. *A. seyel, Lannea barteri, Azadirachta indica, F. glumosa* dan *Adansonia digitata* bertoleransi dengan kelembapan relatif yang lebih tinggi. *Albizia chevalieri, A. nilotica* dan *C. molle* bertoleransi dengan nitrogen tinggi dan akhir sekali *C. singueana* dan *Daniellia oliveri* lebih menyukai pH tinggi dan kawasan bercerun. Kajian ini mendapati bahawa kelimpahan *P. biglobosa* adalah lebih tinggi dalam FGR berbanding MDF yang terdapat bukti gangguan dan ia juga menunjukkan bahawa tumbuhan berkayu lebih meminati kawasan tanah rata yang tinggi. Ujian t-bebas menunjukkan min kelimpahan *P. biglobosa* FGR adalah lebih tinggi (M = 1.77, SD = 0.97) berbanding MDF (M = 0.90, SD = 0.76) dan perbezaaan adalah signifikan pada nilai t (58) = -3.851, P < 0.001. Seterusnya, ujian korelasi Pearson yang dijalankan menunjukkan ketinggian mempengaruhi kelimpahan *P. biglobosa* di mana pada FGR terdapat korelasi positif yang sederhana (r (28) = 0.397, P = 0.030) yang signifikan sedangkan di MDF korelasi adalah positif lemah (r (28) = 0.167, P = 0.378) dan tidak signifikan. Pembolehubah persekitaran yang berbeza mempunyai pengaruh yang berbeza terhadap taburan spesies berkayu dalam kedua-dua jenis hutan. Umumnya, hasil kajian ini menunjukkan bahawa kedua-dua hutan itu kaya dengan spesies berkayu, tetapi memerlukan pelan pemuliharaan dan perlindungan yang baik untuk memanfaatkan potensi hutan yang besar ini kepada komuniti negeri Kano.

ABUNDANCE OF *Parkia biglobosa* AND WOODY SPECIES COMPOSITION IN PROTECTED AND UNPROTECTED FOREST OF SOUTHERN KANO STATE, NIGERIA

ABSTRACT

This research aimed to determine the abundance of *Parkia biglobosa* and woody plants composition between protected Falgore Game Reserve (FGR) and unprotected Massu-Dagora Forest (MDF) in Southern Kano, Nigeria. The main objectives of the research were to estimate the abundance of *P. biglobosa* between the two forest types; to compare the woody plants diversity and composition between the two forest types and to study the correlation between environmental factors of the study areas with abundance of *P. biglobosa*. A total of 30 randomly stratified enumeration plots with quadrat size 20m x 10m square each were established in different location from each forest. A total of 5484 stems of woody plants belonging to 24 families were recorded, where 55 genera were found in FGR while 42 genera were recorded from MDF. Higher species number were recorded from FGR with 71 species while 50 species from MDF. The dominant species in FGR were *Guiera senegalensis* with (236, 6.9%) individual, followed by *Cassia singueana* (168, 4.9%) and *Anogeissus leiocarpus* (133, 3.9%). Dominant species in MDF was *Combretum glutinosum* with (171, 8.2%) total number of individuals followed by *G. senegalensis* with (147, 7.1%) and *C. sieberiana* (134, 6.5%). The diversity (species richness) of woody plants was higher in FGR with Shannon index value of (H'= 3.948) when compared with MDF with (H'= 3.515) this showed that the two forest types differed in species richness and composition. The CCA (species-environmental variables)

ordination showed that *P. biglobosa, Vitellaria paradoxum, Acacia albida, A. leiocarpus, Bridelia ferruginea* can tolerate high organic carbon, elevation and relative humidity; *C. arereh, Ficus thonnongii, Annona senegalensis, Entada africana* were associated with higher temperature; *A. seyel, Lannea barteri, Azadirachta indica* and *F. glumosa, Adansonia digitata* tolerate higher relative humidity; *Albizia chevalieri, A. nilotica* and *C. molle* tolerate high nitrogen and *C. singueana and Daniellia oliveri* prefer high pH and slope area. This study showed that *P. biglobosa* abundance was higher in FGR when compared with MDF which shows evidence of disturbance and it also showed that this species prefers high elevated area. An independent t-test showed that the mean abundance of *P. biglobosa* in FGR (M = 1.77, SD = 0.97) was higher compared to MDF (M = 0.90, SD = 0.76) and the difference was significant t (58) = -3.851, $P < 0.001$. Pearson's correlation test conducted revealed the influence of altitude on abundance of *P. biglobosa*. The correlation test was significant in FGR (r (28) = 0.397, P= 0.030) and not significant in MDF (r (28) = 0.167, P= 0.378). Different environmental variables have a different influence on the woody plant's distribution in both forest types. The findings revealed that both forests are rich in woody species hence needs good management and protection plan to utilize the vast potential benefits of those forest to Kano state community.

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Forest in West Africa is currently under threat, destruction is continuously going on and many forest cover have been changed into agricultural fields through land-use and related disturbances such as woodcutting, browsing and fire which greatly affecting growing conditions for savanna trees (Green *et al*., 2013, Sulaiman *et al*., 2017, Adedayo, 2018). Remaining forest is reduced by poaching, illegal cutting and agricultural farming, but the major two factors affecting the sustainable management of the region's dry forest are collection and consumption of wood fuels coupled with poor institutional quality (Sulaiman *et al*., 2017, Green *et al*., 2013, Mohammed *et al*., 2015).

Savanna ecosystem is characterized by the co-dominance of two different life forms: grasses and trees (Higgins *et al*., 2000, Sulaiman *et al*., 2017, Mohammed *et al*., 2015). However, human disturbances threaten the structure and persistence of trees and shrubs populations on local and regional scales (Ouédraogo *et al*., 2015a, Green *et al*., 2013, Mohammed *et al*., 2015) during recent decades increasing land use pressure have aroused a considerable declination of Africa's woody savanna vegetation (Jurisch *et al*., 2013, Sulaiman *et al*., 2017, Mohammed *et al*., 2015). This has great consequences to the services human derive from these ecosystems, as woody plants are the primary source of energy and non-timber forest products for rural populations of Africa (Schumann *et al*., 2011, Linstädter *et al*., 2014).

In 2001 Federal Government of Nigeria, in its first national biodiversity report, quoted that there are about 7,895 plants species spread across the 4 major biomes of

the country (Adedayo, 2018, Sulaiman *et al*., 2017). Nigeria as a unified nation has no woods domain of its own. It was reported that in 14 years from 2001 to 2014 Nigeria lost 378,680 hectares across its 36 states including Federal Capital Territory. Unfortunately, Nigeria and Ivory-cost were the countries with highest rate of annual forest loss 5.7% compared to the world average of 3.3% per annum (Agbeja, 2016, FAO, 2001).

Lack of routine measurement of floristic composition of individual species can subject the specie to an extinction especially rare species (Badamasi *et al*., 2010). Protected forest was believed to be a conservation area of all types of flora and fauna in any location around the world, while the unprotected forest was believed to be left for other human needs (Gilman, 1997).

In Nigeria species diversity is greatly diminishing in all parts of the country, but more disturbing in northern part, exposing the species to depletion and regeneration problems (Abdulhamid *et al*., 2017). Badamasi *et al*. (2010) reported that the protected forest or Game reserves hotspot known as Falgore Game reserve is continuously destroyed due to poor management and lack of policy. The waning woodland cover in Nigeria is unfriendly to ranger service advancement and its outcomes represent a genuine peril to Nigerian condition in the prompt future. However, *P. biglobosa* woods contributes over 90% of the firewood supplied to Kano (Council, 2006). Unfortunately, for a such useful tree and most consumed wood, to date there is no documentation of its abundance in Nigeria forests. (Abdulhamid *et al*., 2017).

Previous studies on *P. biglobosa* paid attentions to morphological, genetic variability and biochemical analysis or proximate analysis of its parts, such as:

phytochemical screening and anti-bacterial properties of *P. biglobosa* crude stem bark extract (Abioye *et al*., 2013); studies of phenotypic and anatomical diversity of *P. biglobosa* (Amusa *et al*., 2014); studies of genetic diversity of *P. biglobosa* (Ouedraogo *et al*., 2012).

Moreover, the previous studies did not capture the information about distribution pattern and population density (stem number per hectare) of the *P. biglobosa* and other woody species. Therefore, there is need to carry out a research on the abundance and composition of individual species. The research will serve as a stepping stone and guide to protect the woody species against extinction through comparing of the stem number of each species in the two forest types. Therefore, this research aimed to study the abundance of *P. biglobosa* and woody plant composition in protected and unprotected forests of Kano State, Nigeria.

1.2 Justification

P. biglobosa (Jacq.) is one of the multipurpose tree native Africa, useful to rural communities (Teklehaimanot, 2004, Abdulhamid *et al*., 2017) such as: food and fodder (Amusa *et al*., 2014), wood energy (fuel wood and charcoal) and non-timber forest products (Abdulhamid *et al*., 2017, Heuzé 2018).

P. biglobosa occur in diverse agroecological zones in Nigeria across tropical rain forests to arid zones, covering the savanna zones including lowland forest zones (Adesoye *et al*., 2013, Heuzé 2018). Local population deliberately left this species in their farms or homes because of its socio-economic and cultural values (Wala *et al*., 2005). Unfortunately the value of its wood couple with increase in agricultural expansion reduces the trees density in the environment (Abdulhamid *et al*., 2017).

Moreover, rapid population growth in Nigeria, especially in the northern part, has contributed to an increasing need for space (housing), nutrients (agricultural space) and recreational space (infrastructure) which decreased forest land cover.

But lack of electricity coupled with high cost of domestic energy source (fuel) led the population to rely on woody plants as a substitute source of energy for domestic use (FGN, 2009). Unsustainable harvest practice of woody plants in African countries was enormous (Ouédraogo *et al*., 2015a). Indiscriminate wood logging could probably subject some species to extinction, especially *P. biglobosa* which is under overexploitation in west African countries (Padakale *et al*., 2015). The basic information regarding the floristic composition of northern Nigerian forest remain undocumented, scarce or unpublished (Zhigila *et al*., 2016) the information will serve as a stepping stone to decision makers, to set routine monitoring as a critical step for adequate long-term *in situ* conservation of woody plants.

Study questions

Based on the literature searched the following study questions were developed to address the research problems as follows:

Does *P. biglobosa* abundance vary between two forest types?

Does woody plants diversity and composition vary between the two forest types?

Which environmental factors influence *P. biglobosa* abundance between the forest types?

1.3 Aim and Objectives

The aim of this research was to study the abundance of *P. biglobosa* and woody species composition in protected and unprotected forest of southern Kano, Nigeria.

The following research objectives were developed:

1. To estimate the abundance of *P. biglobosa* between the two forest types.

2. To compare the diversity and composition of woody plants of the two forest types.

3. To study the correlation of physical factors of the study areas with abundance of *P. biglobosa*.

Hypothesis statements

The following hypothesis was developed to achieve the aim of the research.

Hypothesis 1:

H_0= There is no difference in abundance of *P. biglobosa* between the two forest types.

H_1=There is a difference in abundance of *P. biglobosa* between the two forest types.

Hypothesis 2:

H_0=There are no differences in diversity and composition of woody plants in the two forest types.

H_1=There are differences in diversity and composition of woody plants in the two forest types.

Hypothesis 3:

H_0=There is no correlation between physical factors of the study areas with the abundance of *P. biglobosa.*

H_1=There is correlation between physical factors of the study areas with the abundance of *P. biglobosa.*

CHAPTER 2

LITERATURE REVIEW

2.1 Discovery of *P. biglobosa*

2.1.1 Origin and exploration of *P. biglobosa*

Mungo Park was a Scottish surgeon who discovered western Africa in 1790s, Park was one of the first Europeans to record *Parkia* tree and named it "nitta". *Parkia* believed to have originated from South America presumably introduced to West Africa during the transatlantic slave trade as described by a French naturalist called Palisot de Beauvois in 1816 that studied the link and name the species as *Inga biglobosa* (Shao, 2002). In 1826 Robert Brown proposed a new name and reclassifying them under genus "Parkia" in honor of Mungo Park (Hopkins, 1981) from which the name "Parkia" was derived. Series of scientific writing regarding historical background of *P. biglobosa* consist of confusing names in describing it.

2.1.2 Synonyms

P. biglobosa Jacq. has numerous synonyms like *P. africana, P.intermedia, P. oliver*i and, *P. clappertoniana* other common English's names are African Locust Bean, fern leaf, monkey cutlass tree, two-ball nitta-tree, French name arbre à farine. In West Africa it is commonly known as *nitta, nete, nere* while in Nigeria kwon as *narghi* (Fulani) *dawa-dawa, dawadawa, daddawa* (Hausa), *ogiri* (Igbo), (Heuzé 2018, Council, 2006)

2.2 Taxonomy and classification of *P. biglobosa*

P. biglobosa belongs to the family Leguminaceae under genus *Parkia*. The genus *Parkia* comprises of 24 species (Hall *et al*., 1997) or 31 species (Thiombiano

et al., 2012); 10 species found in tropical South America, 10 species occur in tropical Asia, and 4 species in Africa and Madagascar (Hall *et al*., 1997). The four African species were *P. biglobosa, P. clappertonia, P. filicoidea* and *P. bicolor*.

According to Chevalier (1910) *P. biglobosa* and *P. filicoidea* were similar and should be placed into subgenus "Euparkia" based on their endocarp which entirely fills the space between the seeds and pod. Similarly, it was further suggested that *P. clappertonia* was described as similar and use as a synonym to *P. biglobosa* (FAO, 1988).

The tree has various synonyms and confusing provenance across African countries, (Burkill, 1995) reported that *P. biglobosa* to have occurred from Senegal across southern Sudan while *P. bicolor* occurs mostly in Guinea across eastern Zaire and *P. filicoidea* occurred in central to eastern Africa and rarely in Ivory Coast, Ghana and Togo. Until recently when Hall *et al*. (1997) reported that *P. biglobosa* and *P. filicoidea* are taxonomically described as different species unlike what Chevalier (1910) suggested, after close observation of their leaves morphology, hence reported two species *P. biglobosa* and *P. bicolor*.

2.3 Botanical description of *P. biglobosa*

2.3.1 Size

P. biglobosa it is a perennial, deciduous tree reaching 7 – 20 m in height (Shao, 2002) it often grows more than 20 meters tall (Council, 2006), 20-30m high (Heuzé 2018).

2.3.2 Crown

Locust beans are beautiful savanna trees, with a dense, wide spreading crowns of umbrella-shaped (Figure 2.1), the tree consist of spherical bright red flowers hanging like holiday ribbons on long stalks (Council, 2006, Heuzé 2018).

Figure 2.1: A typical *P. biglobosa* matured tree showing crown.

2.3.3 Bole (trunk)

P. biglobosa is a medium-sized legume tree bole is usually short, straight and cylinder (Figure 2.2) girth up to 130cm in diameter (Heuzé 2018), low branches on a stout bole (Shao, 2002), consisting of heavy branches spread out forming an umbrella-like crown, a slash orange colour ash-grey scaly thick bark formed as a result of longitudinal fissured covered the trunk which is rough in texture as a result of crevices of the scales (see Figure 2.2), it also produces an exudes of amber gum when cut (Heuzé 2018).

Figure 2.2: Typical *P. biglobosa* trunk.

2.3.4 Root

P. biglobosa has a deeply tap-rooted system spread over a wide range of area, minimum of 10 meters away from the trunk, it occupies twice of the crown area and denser at depth of 10-20 cm in the ground. It occupies rocky slope of arid zones with

minimum rainfall < 400 mm per annum and adapted to various alluvial soils types and can grow on shallow-drift sands or deep-heavy sand, this deep tap root systems was recognize as adaptation mechanism to withstand drought conditions (Heuzé 2018, Padakale *et al*., 2015, Shao, 2002).

2.3.5 Leaves

P. biglobosa has alternate dark green bi-pinnate leaves; the lamina of the leaflet is darker in green than the leaves but turn into pinkish or yellowish green before shedding (Figure 2.3). The petiole ranges between 9-10 cm long, having a base of single rounded gland with no spines (Hopkins, 1981, Orwa *et al*., 2015). The rachis ranged between 20 to 40 cm long, consist of 8 to 30 pairs of alternate pinnae (Council, 2006, Heuzé 2018). The leaflets are about 12 mm long and 8 mm wide, glabrous, linear-oblong and slightly pointed at the apex, with more or less parallel margins (Shao, 2002, Heuzé 2018). Usually the middle leaflets are larger and longer than the basal and terminal leaflets (Orwa *et al*., 2015, Shao, 2002). It has no spines attached with drooping leaves and is often leafless when flowering commences (Sacande and Clethero, 2007).

Figure 2.3: A typical *P. biglobosa* leaf.

2.3.6 The flower

P. biglobosa flowers are seen blooming from December to February (Shao, 2002, Orwa *et al*., 2015).The flowers are borne in pendent capitula set at the end of a branches (Figure 2.4) up to 30-50 cm long peduncle, in pink, orange or red balls (Heuzé 2018). A red, club-shaped flower heads about 5 cm in diameter appears in cluster of capitula (Sacande and Clethero, 2007, Orwa *et al*., 2015), the bisexual flowers are tightly packed together to form the globular head resemble "Christmas Tree ornaments" (Heuzé 2018, Orwa *et al*., 2015)

Each globular-bud composed of 1500-2000 flowers.(Sacande and Clethero, 2007) up to 2500 individual flowers organized around a globular bud (Shao, 2002, Orwa *et al*., 2015). The flower is divided into two distinct sections, a thick long cylindrical stalk of about 2 cm long and a rounded globular shaped bunch of staminodial flowers about 6 cm diameter (Heuzé 2018, Orwa *et al*., 2015).

Figure 2.4: Typical flower of *P. biglobosa*.

2.3.7 Pod and seed

Immature pod appeared to be light to dark green in colour hanging in clusters or bunches (Figure 2.5) at the tip of the rounded peduncle head (Orwa *et al*., 2015). Pod are usually identical 10-30 cm in length (Figure 2.6) and 1.5-2.7 cm in diameter, pod numbers per peduncle range from 1-20 up to 25 dangling on a long stalk (Orwa *et al*., 2015), the pod later changed gradually from light pink brown to dark brown (Figure 2.6) when matured/ripen (Heuzé 2018).

The seeds are found enclosed in a mealy yellow pulp (mesocarp) clinged to each seed, which is sweet tasting and edible. When dry, the yellow pulp is powdery and, fill up the space between the seeds and pod shell (Orwa *et al*., 2015).The seeds are rounded or oval in shape and small in size ranging between 0.6-1.5 mm by 0.6-1.00 mm. The seed colour is distinctively of two types reddish-brown and dark-brown in newly

matured non dried seeds, while dark drown to black in dried matured seeds, with the hard testa stick closely to the cotyledons (Orwa *et al*., 2015). Larger seed tend to be bigger than the seeds towards the two ends. Seed numbers per pod may vary because they are highly related to pod length (Orwa *et al*., 2015). The common range is 15-20 seeds per pod occasionally in some up to 30 (Heuzé 2018, Orwa *et al*., 2015).

Figure 2.5: *P. biglobosa* pod (young pod).

Figure 2.6: *P. biglobosa* pod (matured).

2.4 Pollination agents

Late in the afternoon and evening a strong fruity odour smell is produced together with nectar from the flower of about 5-10 ml (Council, 2006, Heuzé 2018). The nectar attracts bats that facilitate the pollination (Orwa *et al*., 2015); but it was also reported

that it can be pollinated by wind, honey-bees, some species of beetles and bugs (Heuzé 2018, Orwa *et al*., 2015) wasps, ants, and some flies (Shao, 2002).

2.4.1 Environmental factors influencing abundance of *P. biglobosa* and woody plants diversity.

Environmental factors have been considered as essential drivers of global biodiversity pattern, (Qian, 2013). woody plants (species richness) was greatly controlled by environmental factors (Cui and Zheng, 2016). According to Aguilar et al. (2013) diversity of woody plants increases with topographic heterogeneity and disturbance. Presence and abundance of the woody species were closely related to topographic factors (Nguyen *et al*., 2015). Soil been the most important topographical factors (Qian, 2013). In addition to that, rainfall plays major role on woody species abundance (Hopkins and White, 1984).

2.4.2 Rainfall

The relationship between *P. biglobosa* and environmental factors was not well documented (Oni, 1997). The tree is adapted to drought and prolonged dry season 2-7 dry months (Orwa *et al*., 2015). Abdulhamid et al. (2017) reported that *P. biglobosa* occur under annual rainfall below 1000mm in Nigeria. In Senegal , Mali and Burkina Faso the tree occurred under a mean annual rainfall between 500-1000mm. likewise in Ghana, Benin and Cameroun under 600-1500 mm whereas, in Guinea-Bissau and Sierra Leone occur under mean annual rainfall between 2200-4500 mm. (Heuzé 2018, Oni, 1997).

2.4.3 Temperature

P. biglobosa prefers regions where mean annual temperature range is about 26-28°C (Heuzé 2018) or between 20-30°C (Oni, 1997), thrive better in semi-arid tropical climates with an average daily maximum temperature above 33.5 °C (Council, 2006).

2.4.4 Soil

The tree preferred a loamy sandy to clay sandy soil and grow better in fine texture or medium to coarse (Hopkins and White, 1984) or on shallow lateritic soils (Heuzé 2018). In Nigeria, it is commonly more frequent in an underlying geology of crystalline basement complex characterized by a well-drained soil with a good moisture holding capacity (Oni, 1997).

P. biglobosa has been reported from areas of sandstone rock and absence or scarce in areas of deeps-deposits-volcanic rocks (Hopkins and White, 1984, Oni, 1997). There was no report regarding its survival under saline soil.

2.4.5 Altitude (Elevation)

P. biglobosa occurred mostly on highly elevated areas up to 1350 m (Heuzé 2018). Between low elevation <400 m and higher elevation >400 m (Oni, 1997). In Nigeria the tree occupies various type of elevation ranging from low 100m to 700m high at southern part and 450m to 1285 at northern part (Oni, 1997).

2.5 Uses of *P. biglobosa*

2.5.1 The flower

In west Africa flower buds were harvested and mixed with salads as a food (Council, 2006). The flower attracts honey bees which made it important tree for bee-farming (Heuzé 2018).

2.5.2 The pod/fruit

The young pod are roasted and eaten as a food in Ghana, Nigeria and Burkina Faso (Shao, 2002). used as a fish poison by fishermen (Heuzé 2018). Matured and young pod were recognized as a favorite food of primates (Shao, 2002). The mature fruit contain sweet pulp used as animal feeds (Oni, 1997). Proximate analysis of the sweet pulp showed that, the pulp contains about 60 percent carbohydrates; 10-24 percent of sucrose; and 291mg of Vitamin C per 100g (Shao, 2002). The pulp powder is mixed with water and flavored with honey to makes valuable baby food which contributes significantly alleviated malnutritional in Africa (Heuzé 2018, Council, 2006, Shao, 2002, Oni, 1997).

The pulp powder mixed with tamarind and water were used as refreshing drink (kunun dorawa) for adults in Nigeria (Council, 2006). While in Ghana the pulp powder are combined with rice baked into cakes (Oni, 1997). However, in Ghana Bayor *et al*. (2015) used the pulp powder as an excipient in drug synthesis aimed to reduce the cost of drug and free side effect drugs. Lastly, the pod husk are soaked overnight and mixed with clay and used as a substitute of cement in non-concrete houses (Council, 2006, Shao, 2002).

2.5.3 The Seed (dawadawa)

The seeds are edible when fermented as a condiment called "dawadawa", "ogiri", "soumbala", or "afinti" is used as seasoning of soup and doughnuts (Council, 2006, Heuzé 2018). The seed can be roasted to make a coffee substitute known as "Sudan coffee" (Heuzé 2018).

The seeds contain a nice balance of protein, fat starch, fibre, vitamins and minerals, about 7% of the proteins is lysine one of the best protein food known, similar with that of the whole egg. Unfortunately, it is deficient in two critical amino acids, methionine and tryptophan (Council, 2006). The seed's fat is approximately 60% unsaturated, containing the important fatty acid called linoleic, a nutritionally useful ingredient rarely found in poor people's diets (Council, 2006).

The seed has tough leathery seed coats, which should be peeled or cooked for about 12 hours prior to consumption; the process consumed a large amount of fuel. The raw seeds were suspected of containing anti-nutritional factors which must be eliminated through the cooking process, once processed to remove anti-nutritional factors, can be included in livestock feed (Heuzé 2018). It was reported that in cooked locust seeds the only factors found to be reduced in the nutritive value is the low levels of methionine and tryptophan (Council, 2006).

Generally, the processed seed is used on daily basis in most of the west African countries. a survey carried out by Mertz *et al.*, (2001) based on the fermented seed consumption per household in Burkina Faso. He reported that the fermented seeds were consumed in 78% to 85% of all meals per day. An average of 17g of fermented seed

consumed per head on daily basis in Burkina Faso 10g, 4g and 2g in Nigeria, Togo and Ghana respectively (Oni, 1997, Mertz *et al*., 2001).

2.5.4 The leaves

The leaves were used as a fodder usually harvested during the dry season when feed is scarce even though their mineral content is too low it was recommended that it should be mixed with other feed (Heuzé 2018). The young leaves are edible can be boiled, mixed with cereal flour and eaten as vegetable (Heuzé 2018, Orwa *et al*., 2015). Leaf fall contributes by adding organic matter to the soil, in Gambia farmers gather the leaves and use it as a green manure (Shao, 2002).

2.5.5 The crown

The crown (umbrella shape) of mature tree, offers an excellent shade to man, animals to escape sun heat (Shao, 2002). It also serves as shelter to many birds and animals, and good for beehive keeping (Heuzé 2018, Shao, 2002, Jurisch *et al*., 2013).

2.5.6 The Bark

The bark is used in west Africa as a remedy such as toothache, ear, fever, *Schistosomiasis*, Rheumatism, and infected wounds (Council, 2006, Bayor *et al*., 2015, Shao, 2002). Use to treat leprosy, skin infections, sores, ulcers, bronchitis, pneumonia and colic (Shao, 2002, Ouédraogo *et al*., 2015b, Dedehou *et al*., 2016).

2.5.7 The Root

Roots are boiled to make a decoction by herbalist to cure diarrhea, dysentery, eye infections and Guinea-worm infection (Shao, 2002, Abioye *et al*., 2013, Dedehou *et al*., 2016).

2.5.8 The Wood

Wood tissues are white-yellow, or in some a dull brown soft wood (Figure 2.7) very easy to cutdown. The wood has poor quality usually used for house posts, mortars, bowls, and some carpentry and provides pulp to make paper (Heuzé 2018). It is mainly used as fuel (Figure 2.7) in Nigeria (Council, 2006). It was estimated that locust bean wood constituted more than 90% of firewood supplied to Kano (Council, 2006). Kano is a Nigerian city with over 9 million peoples as reported by Independent National Electoral Commission (INEC) of Nigeria (Lewis and Kew, 2015).

Locust wood is used by many poor people in Africa as toothbrush, because it contained soapy compounds called saponins which clean teeth (Heuzé 2018).

Figure 2.7 A typical *P. biglobosa* wood cut into pieces as firewood.

2.6 Current challenges affecting distribution of *P. biglobosa* in Nigeria

2.6.1 Regeneration

Although the mature tree is a fire-resistant (heliophyte) that needs little protection or care (Heuzé, 2018), but the seedlings are sensitive to browsing should not be harmed by wandering livestock (Heuzé, 2018, Mohammed *et al*., 2015, Orwa *et al*., 2015). Animal browsing affect the regeneration of young seedlings (Figure 2.7).

Several studies reported *P. biglobosa* regeneration problems such as Sambe et al. (2010) and Ræbild et al. (2012), poor regeneration can lead to extinction over time as