Population Structure of *Vitelaria paradoxa* Gaertn. F. and *Parkia biglobosa* (Jacq.) Benth. in the Agroforestry Parklands of Nigerian Humid Savanna

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Abstract

The distribution and population of *Vitellaria paradoxa* (shea tree) and *Parkia biglobosa* (locust tree), two savanna parkland priority non-timber forest products, were studied in the cultivated and fallow land uses in three ecozones (moist woodland or derived savanna, dry woodland or southern guinea savanna and northern Guinea savanna) all in the Nigerian humid savanna. Lamina morphology of *Vitellaria* population in the region was also studied for possible varietal delimitation. The overall average densities for *Vitellaria* and *Parkia* in the area studied were 8.4 plants/ha and 6.6 plants/ha, respectively. The two species were equally dominant in the cultivated land use. In the fallow land use *Vitellaria* was more dominant than *Parkia* with a stand ratio of 1: 0.6. In the southerly study location (Lanlate) there was preponderance of *Parkia* (12 plants/ha). However, Kontagora in the northerly study area had a preponderance of *Vitellaria* (11.5 plants/ha) in the vegetation. Saplings of the two species were absent in all the agro-ecozones studied. Large trees (>168 cm GBH) of *Vitellaria* were absent in the southerly moist woodland savanna, but present in the dry woodland (15.4%) and northern Guinea savanna (13.5%). All size classes, except saplings, were represented in the *Parkia* population in the ecozones. While the large trees of *Parkia* accounted for 39% and 38% of the population in cultivated and fallow land uses, respectively, the large trees of *Vitellaria* accounted for 20% and 4% of the population in the cultivated and fallow land uses, respectively. Same species replacement and regeneration of *V. paradoxa* and *P. biglobosa* are low. With respect to lamina morphology, especially vestiture of the abaxial surface/petiole and petiole length, two variants may be identified within the *Vitellaria* population in Nigerian humid savanna. Concerted effort should be directed at domestication and plantation establishment of the two species to enhance their productivity and curb the threat of extinction.

Introduction

A number of tree species in the savanna, which include *Vitellaria paradoxa, Parkia biglobosa, Prosopis africana, Moringa oleifera, Jatropha curcas, Adansonia digitata, Termarindus indica, Vitex doniana,* etc. provide a range of forest products and play vital roles in the rural economy (Okafor, 1980; Kio *et al.*, 1989). These trees/shrubs are neither domesticated nor established in organized plantations as the timber species and exotic fruit trees. Rather, the species are endangered and are facing threat of extinction due to continued exploitation without replacement, and pressure on the land and forest resources as a result of ever-increasing population and faulty farm practices that hamper their regeneration. Incidentally, the modifications in the focus of the system improvement programme of ICRAF to prioritize farmers' needs has encouraged investigations into the potentials of indigenous tree species with better nutrition and cash values for inclusion in agroforestry parklands. This re-focusing has made relevant the trees listed above in the establishment of forest plantations (afforestation) and in the growing of trees on the farms where food production is on-going (agroforestry).

Bonkoungou *et al.* (1994) described agroforestry parklands as land-use systems in which woody perennials are deliberately preserved in association with crops and/or animals in a spatially dispersed arrangement and where there is both ecological and economic interaction between trees and other components of the system. Some of the peculiarities of the concept of agroforestry as reported by Berry & Phil (1995) include production of multiple outputs, protection of the resources base and utilization of indigenous multipurpose trees and shrubs. This system is useful in Nigeria to salvage the declining land productivity and in the conservation of endangered plant species.

The shea butter tree (*Vitellaria paradoxa* Gaertn. F.) and locust bean tree (*Parkia biglobosa* (Jacq.) Benth.) are the most prioritized woody component of the Nigerian savanna parkland system because of their drought/fire resistance, and their culinary, therapeutic and industrial raw material values (Kio *et al.*, 1989). The two species form the major woody component of the Southern Mali savanna vegetation (Kater *et al.*, 1992). In Nigeria, they are encounterd in many savanna land uses, including improved fallow, shelterbelt, agrosilvipastoral system, homestead woodlots and fringe plantings (Popoola & Tee, 2001). The agroforestry extension practitioners in the region where these plants are encountered in Nigeria, in terms of preference for conservation, rated shea butter higher than the locust bean because the latter has a substitute in *Prosopis africana,* and its uses are fewer and localized (Awodoyin *et al.*, 1997).

As part of INCO-DC project on *Vitellaria paradoxa* these two most prioritized tree species of the humid savanna, *V. paradoxa* and *P. biglobosa*, were studied with the aim of increasing knowledge of the management of the plants. In this report the population structure of the two plants is discussed with the view of understanding their sustainability in the parklands and to justify the need for their conservation.

Material and methods

The survey was conducted in July/August 2000 and August 2001. The study was conducted in the cultivated and fallow land uses in the moist woodland or derived savanna (Lanlate and Ogbomosho), dry woodland or southern guinea savanna (Saki and Ilorin) and northern guinea savanna (Mokwa and Kontagora), to have a total of six locations and 12 study sites (Fig. 1). The summary of the agroclimatic characteristics of the study sites are given in Table 1. In each site one hectare area that has *Vitellaria* and *Parkia* in its tree stock was carefully located with the help of States Forestry Department Officers. The numbers of stands of the two species present on the marked plots were counted to determine the density. Each stand of the two species were assessed for height (using altimeter) and girth at breast height (GBH) (using tape rule) to determine the population structure. Percentage relative abundance for the two species in the two land uses was calculated using the formula:

[Number of stands in the size-class × 100]/Total number of stands

For possible variation in the *Vitellaria*

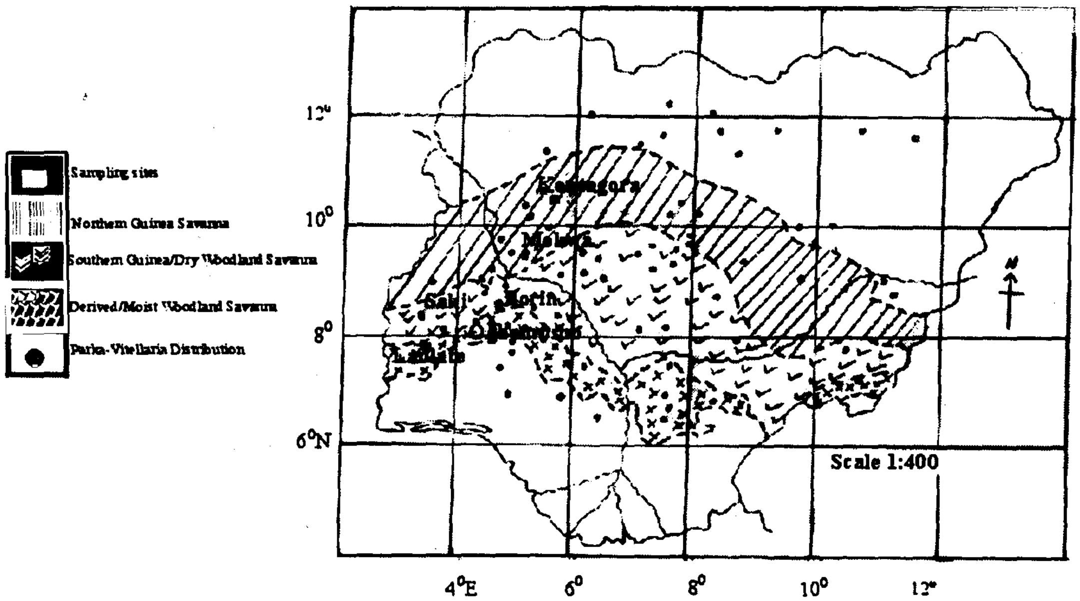

Fig. 1. *Vitellaria-Parkia* distribution in Nigeria and the sampling sites

TABLE 1

Characteristics of the three agroecological zones surveyed for Vitellaria paradoxa *and* Parkia biglobosa *in Nigerian humid savanna*

Ecozones	*Study locations*	*Latitude (N)*	*Longitude (E)*	*Annual rainfall (mm)*	*Rainfall pattern*	*Rainfall eva-transpiration ratio*
Moist Woodland/	Lanlate	7°36'	3°24'	1350-1500	Bimodal	0.75-1.00
Derived Savanna	Ogbomosho	8°08'	4°14'			
Dry Woodland/	Saki	8°11'	3°23'	1250-1300	Unimodal	0.66-0.80
Southern Guinea Savanna	Ilorin	8°30'	4°32'			
Northern Guinea	Mokwa	9°18'	5°04'	1000-1200	Unimodal	0.40-0.66
Savanna	Kontagora	10°24'	5°29'			

population in the region, 10 trees were selected in each locality for leaf morphological study. On each tree, five mature leaves were plucked from the four cardinal directions to have 20 leaves per tree. Five leaves were randomly selected from the leaflot per tree for detailed study. The leave morphology features studied were lamina length, lamina width (at mid-leaf position), petiole length, petiole thickness, leaf apex, leaf base, leaf margin and vestiture of adaxial and abaxial surfaces. One-way analysis of variance was used to compare means of the leaf empirical parameters.

Results and discussion

Species distribution and density

The overall average densities for the two species were 8.4 stands/ha and 6.6 stands/ha for *Vitellaria* and *Parkia,* respectively. The *Vitellaria* averaged 7.8 and 9.0 stands/ha, and *Parkia* averaged 8.2 and 5.2 stands/ha in the cultivated and fallow land uses, respectively (Table 2). The mean densities of *Vitellaria* and *Parkia* were 3.8 and 4.7 stands/ha, respectively, in the moist woodland, 4.3 stands/ha and 4.2 stands/ha in the dry woodland, and 8.7 and 4.5 stands/ha in the northern guinea savanna ecozones. The results compared with the density of *Vitellaria* reported for other locations within the same ecozone by Awodoyin *et al.* (1997). Conversely, Popoola & Tee (2001), surveying *Vitellaria* distribution in Benue State, Nigeria, reported a density of 23-105 stands/ha. In Uganda, the density of *Vitellaria* in the vegetation ranged from 0.3 tree/ha in wetlands to 12.0 trees/ha in near-compound land use (Nkuutu, 2000).

Vitellaria:Parkia stand ratio on the field was 1:2.4 in Lanlate, 1:0.8 in Igangan, 1:0.9 in Ogbomoso, 1:0.8 in Saki, 1:1.2 in Ilorin, 1:0.4 in Mokwa and 1:0.6 in Kontagora. With respect to land use types, the stand ratios were 1:1 and 1:0.6 for cultivated and fallow areas, respectively. These results imply that there was preponderance of *V.*

TABLE 2

Density [plant/ha] by locality, ecological zone and land use of Vitellaria paradoxa *and* Parkia biglobosa *in Nigerian humid savanna*

Ecozones	*Study locations*	*Study locations land use*	*Density (plant/ha)* Vitellaria paradoxa	Parkia biglobosa	Vitellaria: Parker *stand*
Moist Woodland/		Lanlate (Cultivated)	5	12	1:2.4
Derived Savanna		(Fallow)	6	5	1:0.8
		Ogbomosho (Cultivated)	5	6	1:2
		(Fallow)	7	5	1:0.7
Dry woodland/ Southerns		Saki (Cultivated)	9	9	1:1
Guinea Savanna		(Fallow)	8	5	1:0.6
		Ilorin (Cultivated)	4	6	1:1.6
		(Fallow)	5	5	1:1
Northern Guinea		Mokwa (Cultivated)	11	8	1:0.7
Savanna		(Fallow)	18	5	1:0.3
		Kontagora (Cultivated)	13	8	1:0.6
		(Fallow)	10	6	1:0.6
Total (Agroecological zone)					
Moist Woodland/Derived Savanna			3.8	4.7	
Dry Woodland Savanna/Southern Guinea Savanna			4.3	4.2	
Northern Guinea Savanna			8.7	4.5	
Total (Land use)					
Cultivated			7.8	8.2	
Fallow			9.0	5.2	
Total			8.4	6.6	

paradoxa in northerly axes (Mokwa and Kontagora) relative to southerly axes (Lanlate). However, the two species were almost equally dominant in the flora at Igangan, Ogbomosho, Saki and Ilorin. In the southerly axis there is alternative to *V. paradoxa* in *Elaeis guineensis* as a source of vegetable oil, while there is alternative to *P. biglobosa* in *Prosopis africana* as a source of condiment (Dadawa) in the northerly axis. Therefore, while *V. paradoxa* enjoys certain degrees of protection in the North, *P. biglobosa* is well protected in the South.

Population structure

In all the agro-ecozones surveyed, saplings of the *Vitellaria* and *Parkia* were absent. This may be the result of uncontrolled incessant bush burning, which may aggravate the threat of extinction that the two species are subjected to, more so that they are not domesticated at present and the large trees, especially *Vitellaria*, are being exploited in one way or the another, and wantonly destroyed for agronomic crops.

In both cultivated and fallow land uses in the southerly moist woodland/derived savanna ecozone, large trees (>168 cm GBH) of *Vitellaria* were absent in the flora. (Table 3). *Vitellaria* are not particularly protected in this zone because of its low product value (probably owing to the oil-palm substitute), urban demand for charcoal, preferential utilization for fuel (owing to its high calorific value) and removal for farming activities. Conversely, large trees of *Vitellaria* were encountered in the flora at dry woodland and northern Guinea savanna ecozones, accounting for 15.4%

TABLE 3

Distribution of trees of Vitellaria paradoxa *and* Parkia biglobosa *in various girth size classes in the land uses in Nigeria humid savanna. Percent relative abundance in parentheses*

Girth size classes GBH (cm)	*Total in land use (6 ha)*			
	Vitellaria		Parkia	
	Cultivated	*Fallow*	*Cultivated*	*Fallow*
<55	6(14)	1(2)	2(4)	0
56-69	3(7)	1(2)	3(7)	0
70-83	2(5)	6(11)	3(7)	1(3)
84-97	2(7)	4(7)	3(7)	2(6)
98-111	2(5)	7(12)	2(4)	3(9)
112-125	4(9)	17(30)	1(2)	3(9)
126-139	10(23)	9(16)	3(7)	5(14)
140-153	2(5)	5(9)	4(9)	6(17)
154-167	3(7)	5(9)	6(13)	2(6)
168-181	1(2)	1(2)	1(2)	3(9)
182-195	2(5)	0	2(4)	3(9)
196-209	1(2)	0	3(7)	1(3)
210-223	1(2)	1(2)	4(9)	2(6)
224-237	2(5)	0	2(4)	0
238-251	1(2)	0	1(2)	0
>251	1(2)	0	5(11)	4(11)

and 13.5% of the stand populations, respectively.

In the Nigerian humid savanna *Parkia* is more protected than *Vitellaria* as all size classes, except saplings were encountered (Fig. 2). Generally, all size classes of *Parkia* were relatively equally represented in the two land use systems. The large trees of *Vitellaria* were more abundant in the cultivated than in the fallow land use, especially in the northerly axis (Table 3). The relative abundance values of large trees of Vitellaria in cultivated and fallow land uses were 20% and 4%, respectively, while those of *Parkia* were 39% and 38%, respectively.

Analysis of the tree population structure shows that;

1. Concern for the conservation of the two species is justified by the complete lack of trees that are less than 51 cm GBH (saplings). This indicates that same

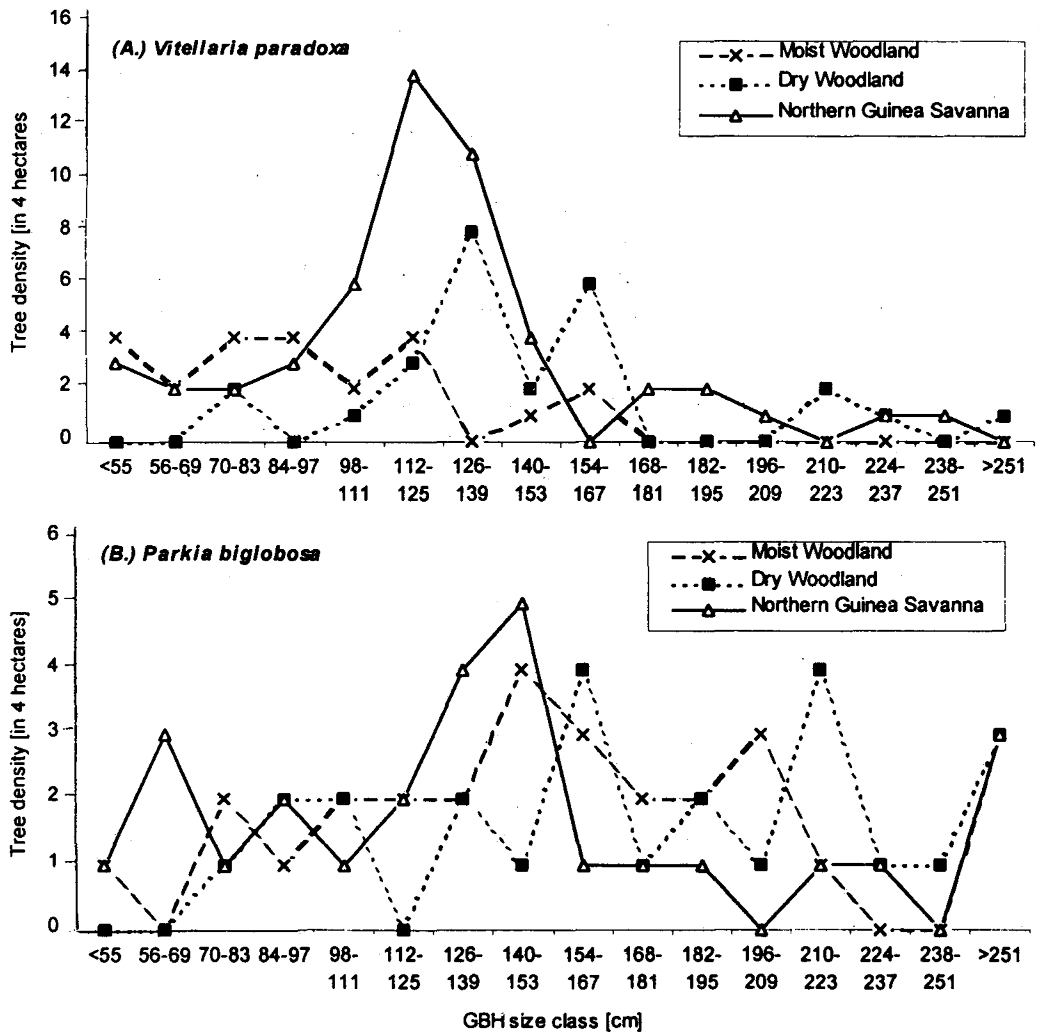

Fig. 2. Population structure of *V. paradoxa* and *P. biglobosa* in three agroecological zones in the Nigeria moist savanna

species replacement and regeneration are poor.

2. Vitellaria germplasm is more threatened in the southerly study area, whereas it enjoys some management regime in the northerly area. This is obvious from the almost lack of trees whose GBH is greater than 168 cm in the southerly area.
3. The current low density and lack of large mature trees in the southerly ecosystem may be attributed to the local utilization of the trees for timber, fuel wood, production of charcoal and removal of stands for agronomic crops because of its dense canopy that limits light inception. These and utilization of seeds for vegetable oil have prevented regeneration and reduced the production status of the species.

Improving the market value of shea butter will increase the product value of the plant and this will stem the destruction of the plant for timber, fuelwood, pestle/mortal and charcoal.

Lamina morphology of V. paradoxa

The leaf form is generally oblong with nearly parallel sides. The leaf apex is retuse, i.e. rounded but slightly notched at mid-vein. The leaf base is rounded, but with the lamina constricting abruptly to the petiole (i.e. obtuse). Though the leaf margin is entire, it is weakly wavy in a vertical plane (undulate).

The adaxial surfaces of the leaves in all localities had no outgrowth and coverings (vestiture is glabrous). However, there are variations in the leaves with regard to the vestiture of abaxial surfaces. While the abaxial surfaces of the leaves collected in Mokwa and Kontagora (northern Guinea savanna) were glabrous, those collected in the moist and dry woodland savannas (Lanlate, Ogbomosho, Saki and Ilorin) had lepidote abaxial surfaces. The undersurfaces and the petioles are covered with rusty brown scales that are easily removed when rubbed between fingers. In Lanlate, however, while most *Vitellaria* trees had leaves with lepidote abaxial surfaces, the leaves of a few trees had glabrous undersurfaces and relatively long petioles that compared with those growing in northern Guinea savanna.

The lamina length ranged between 16.03 cm and 19.56 cm, and the width ranged from 6.00 cm to 7.95 cm (Table 4). The leaves produced by *Vitellaria* trees in the woodland savannas, except a few stands in Lanlate, were significantly ($P < 0.05$) longer than those produced by the trees in the northern Guinea savanna (Table 4). The leaves of *Vitellaria* trees growing in northern Guinea savanna had significantly ($P < 0.05$) longer petioles than those growing in the woodland savanna. The petioles of leaves of *Vitellaria* trees in Ogbomoso and Saki localities were significantly ($P < 0.05$) thicker than those of tress in other localities.

From the study, two variants may be identified within *Vitellaria* population in the Nigerian humid savanna with respect to lamina morphology. The most important lamina parameters in the delimitation are vestiture of the abaxial surface/petiole, and length/thickness of the petiole. Farmers in the surveyed area are only able to do some delimitation based on fruit size and sweetness of pulp, though they do not have preference for any in the butter production. Though Hutchinson & Dalziel (1958) had reported that the genus *Vitellaria* is monospecific, Irvine (1961) reported

TABLE 4

Lamina morphology of Vitellaria paradoxa *in the Nigerian humid savanna*

A. Quantitative parameters

	Length (cm)		Breadth (cm)		Petiole length (cm)		Petiole thickness (cm)		Length/Breadth ratio	
Locations	*Mean*	*SE*	*Mean*	*SE*	*Mean*	*SE*	*Mean*	*SE*	*Mean*	*SE*
Lanlate	17.55	0.36	6.66	0.30	5.72	0.09	0.18	0.01	2.67	0.08
Ogbomosho	19.56	0.25	7.95	0.45	5.69	0.13	0.20	0.003	2.32	0.02
Saki	18.98	0.63	6.72	0.30	5.56	0.14	0.22	0.01	2.86	0.12
Ilorin	18.79	0.22	7.22	0.07	6.21	0.09	0.19	0.003	2.60	0.03
Mokwa	16.03	0.40	6.18	1.90	6.72	0.16	0.18	0.002	2.66	0.12
Kontagora	17.73	0.64	6.00	0.19	7.25	0.37	0.19	0.01	2.97	0.07
LSD (0.05)	1.28	-	0.79	-	0.53	-	0.02	-	0.25	-
CV (%)	7.80	-	12.84	-	9.56	-	10.53	-	10.49	-

B. Descriptive parameters

					Vestiture	
Locations	*Leaf form*	*Apex*	*Base*	*Margin*	*Adaxial*	*Abaxial*
Lanlate	Oblong	Retuse	Obtuse	Undulate	Glabrous	Lepidote/Glabrous
Ogbomosho	"	"	"	"	"	Lepidote
Saki	"	"	"	"	"	Lepidote
Ilorin	"	"	"	"	"	Lepidote
Mokwa	"	"	"	"	"	Glabrous
Kontagora	"	"	"	"	"	Glabrous

occurrence of more than one variety in Ghana. Henry *et al.* (1983) reported that the plant has two subspecies, *V. paradoxa* subspecies *paradoxa* and *V. paradoxa* subspecies *nilotica*. While subspecies *paradoxa* is prevalent in West Africa, subspecies *nilotica* is prevalent in East Africa (Lovett & Haq, 2000). Further taxonomic study will elucidate variation within the population.

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References

Awodoyin R. O., Adelaja B. A. and Denton O. A. (1997). *Vitellaria paradoxa* in the farming systems of Nigeria Humid Savanna. In *Environment and Resource Development* (E. A. Oduwaiye, P. C. Obiaga and J.E. Abu, ed.), pp. 226-233. Forestry Association of Nigeria.

Berry V. G. and O'keefe P. (1995). *The New Forester.* Intermediate Technology Publication (ITP) Limited, 103/105 Southampton, London, WCIB 4HA, UK.

Bonkoungou E. G., Alexandre D. Y., Ayuk E. T., Depormmier D., Morant P. and **Ouadaba J. M.** (1994). *Agroforestry Parklands of the West African semi-arid lands. Conclusions and recommendations of an international symposium.* Ougadougou. 25-27 October 1993. ICRAF/SALWA. 18 pp.

Henry A. N., Chithra V. and **Nair N. C.** (1993). *Vitellaria* versus *Butyrospermum* (Sapotaceae). *Taxon* **32**: 286.

Hutchinson J. and **Dalziel J. M.** (1958). Flora of West Tropical Africa, 2nd revised. Millbank, London: Crown Agents for Overseas Governments and Administration.

Irvine F. R. (1961). *Woody plants of Ghana.* London: Oxford University Press. 868 pp.

Kater L. J. M., Kante S. and **Budelman A.** (1992). Karite (Vitellaria paradoxa) and nere (Parkia biglobosa) associated with crops in South Mali. *Agrofor. Sys.* **18**: 89-105.

Kio P. R. O., Ero I. I., Ola-Adams B. A. and **Ladipo D. O.** (1989). *Forests resources Development and Management in Nigeria 1990-1999.* A consultancy report submitted to United Nations Environmental Programme (UNEP), Nairobi, Kenya. November 1989.

Lovett P. N. and **Haq N.** (2000). Evidence for anthropic selection of the sheanut tree (*Vitellaria paradoxa*). *Agrofor. Sys.* **48**: 273-288.

Nkuutu D. (2000). *Indigenous tree management in the* Butyrospermum *Parklands of Northern Uganda with particular reference to the shea butter tree* (Vitellaria paradoxa). (BSc. Thesis.) University of Makerere, Kampala, Uganda. 82 pp.

Okafor J. C. (1980). Edible indigenous woody plants in the rural economy of the Nigerian Forest Zone. *Forest Ecol. Mgmt.* **3**: 45-55.

Popoola L. and **Tee N. T.** (2001). Potentials of *Vitellaria paradoxa* Gaertn. F. in agroforestry systems in Benue State, Nigeria. *Niger. J. Ecol.* 3: 65-74.