JTB

Journal of Tropical Biosciences
ISSN:0795-3089

Volume 10: 45- 56 (December, 2015)

Phenetic relationships on the basis of leaf, fruit and seed morphology of *Adansonia digitata* L. (Bombaceae)

Zhigila, D.A.[1]; Ajiya, B.C[1] Oladele, F.A.[2]; Abdulrahaman, A.A. [2]and Abba, H.M[1]

[1]Botany Programme, Department of Biological Sciences,
Gombe State University, Gombe, Gombe State, Nigeria
[2]Applied Plant Anatomy and Wood Technology Laboratory,
Department of Plant Biology, University Of Ilorin, Ilorin, Nigeria

Abstract

Morphological features of *Adansonia digitata* L. were studied, for the possible delimitation of the taxon at below the species level. The wide range of uses of these naturalised trees in the world have in recent times witnessed increasing demand of their foliar, bark, root, fruit and seed products in nutritional, fibre and medical applications. The upsurge demand for these products needs to be balanced with new varieties of improved performance to meet the supply chain. To achieve this, the present study was aimed at setting the foundation of variability analysis based on morphological features to detect promising varieties for mapping out of future breeding schemes of this multi-purpose tree. Both qualitative and quantitative characters studied were coded and subjected to Cluster and Principal Component Analysis (PCA).Some morphological characters indicated close affinity amongst the Operational Taxonomic Units (OTUs) of *A. digitata*. Results from the PCA and Cluster analyses showed that habits, leaf architecture, fruit characters as well as the seed characters were important tools for the classification and delimitation in the species. The analyses delimited all the OTUs into four varieties hence, infra specific classification of *A. digitata* is hereby proposed.

Keywords: Delimitation; Taximetrics; Varieties; Cluster Analysis and Morphometric.
*Corresponding author: dandrawuszhigila@gmail.com; +23480 6558 8811

Introduction

Numerical taxonomy aids in the collection of data and gives objective not subjective taxonomic conclusion. It has received a great impetus with the development and advancement in computers (Zhigila and Oladele, 2014). Numerical taxonomy in itself neither produces new data nor a new system of classification, but rather a new method of organising data that may prove helpful in better understanding of relationships. Being mathematical and quantitative, it provides a more exact basis for classification and permits classifications to be built on wide range of characters.

Adansonia digitata belongs to the family Bombacaceae. The family includes about 30 genera, six tribes and about 250 species (Assogbadjo *et al.*, 2006). Common names include Boab, baobab, bottle tree, upside-down tree, monkey bread tree, Bambuu, kukka, gullutu (Hausa), ose, igi-ose (Igbo)(Baum *et al.*,1998) among others. Baobab is a multi-purpose tree with medicinal properties, beverages and numerous food uses of various plant parts, and bark fibres that are used for a variety of applications (Sidibé and Williams, 2002; Codjia *et al*., 2003).Available studies so far indicate that baobab leaf and fruit pulp have high nutritional value in terms of vitamins and minerals (Nordeide *et al.*, 1996; Baobab Fruit Company, 2003; Phyto-trade Africa, 2006; Wickens and Lowe, 2008). Apart from food, the species supply livestock fodder, fibre for clothing, material for

hunting and fishing, shade and medicine for local people (Codjia *et al*., 2003; Sidibé and Williams, 2002). Baobab products are sold in markets and are important sources of income for people (Chicamai *et al*., 2004; Diop *et al*., 2005). Due to its importance for non-wood forest products, baobab tree has been identified as one of the most important edible savannah trees to be conserved, domesticated and valorized in West Africa (Eyog *et al*., 2002). Research efforts, especially in West Africa, have provided relatively recent data on: ethno-botanical knowledge, agronomy, processing techniques, chemical properties, ecology, distribution, propagation and genetic diversity of baobab (Assogbadjo *et al*., 2008, 2009; Chadare *et al*., 2008; Chia *et al*., 2008). Despite its potentials, which are well recognized, very little is known about the tree's morphology, phenology, floral biology, husbandry or genetic diversity. Traditionally, plant taxonomy has dependent mainly upon comparative morphological features because these are easily observable in the living plants as well as in the herbarium specimens, requiring only keen observation, a hand lens or, at the most, a dissecting microscope as equipment Zhigila and Oladele (2014). These external features show a wide degree of variation which helps in delimitation and identification of taxa. Morphology continues to be mainstay for plant identification, nomenclature and classification. In recent years, certain new trends have emerged in morpho-taxonomic research. One of them is to exploit unexplored characters or the characters which have been neglected in the past. Until now, quantitative information related to the genetic and morphological diversity of baobab is poorly documented (Sidibé and Williams, 2002; Zhigila and Oladele, 2014). Although the biogeography and floral evolution of *Adansonia* species and their systematic relationship with other taxa of Bombacaceae were studied by Baum *et al*. (1998), additional studies are needed to consider patterns of diversity in relation to distribution and morphological variability found in the species.

In the light of the above facts, the present study was conducted to examine, analyze and establish the phenetic relationship among the OTUs of *A. digitata* on the basis of leaf, fruits and seed morphometric features and the ordering of the species into higher ranking taxa based on the observed similarities and differences with the view of delimiting the species and setting the foundation for the improvement of these multi-purpose plants for improved yield.

Materials and Methods

Collection of Plant Materials

The leaves, fruits and seeds of *Adansonia digitata* were obtained during field trips to various locations such as open vegetation, plantations, houses and bushy areas from mature plant standsall in Sudan and Guinea Savanna of Nigeria between December, 2012 and August, 2014. In line with taxonomic practice, individual specimens were used for this study. Sickle of 10m tall was used to remove fruit pods and leaves. Photographs of all the specimens collected were taken with digital camera for study database.

.

Morphological Studies

The leaves were carefully observed for qualitative characters such as leaf type, leaflet shape, leaflet apex, leaflet arrangement, leaflet surface, leaflet base, leaflet margin, leaflet venation, leaf attachment and quantitative features such as the whole leaf length; leaflet length, leaflet width and petiole length were measured and determined respectively using standardized metric plastic rule and Electronic Digital calliper. The fruit and seed morphological characters including pod shape, pod length, pod width, stalk length, stalk width, pod surface, pod index $\left(= \frac{pod\ length + stalk\ length}{pod\ length}\ X\ 100\right)$, seed type, number of seeds in a pod, seed colour, seed width and fruit colour were observed, measured, recorded and range of variation of these characters among the OTUs were noted

Morphometric Analyses

Both qualitative and quantitative characters were used on randomly selected foliar and pod materials of 25 plant stands in a population as OTUs as suggested by Radford *et al.* (1976). Mean values and the corresponding standard

errors of the morphological characters measured were calculated and determined using SPSS version 20. The ranges of variations of these characters among the Operational Taxonomic Units were also noted. Terminologies used were those of Olorode (1984) and Pandey and Misra (2009). The steps taken for cluster analysis and principal component analysis followed those of Sneath and Sokal (1973), Hill (1980) as amended by Zhigila and Oladele (2014).

RESULTS

Table 1 gives the summaries of the qualitative morphological studies of leaves of *A. Digitata*. In all the OTUs studied, the leaf surface was either glossy or scarbid, the leaf stalk colour was green or tan and leaf stalk surface was smooth or hairy. All the OTUs had the same phyllotaxy (ramal), leaf type (multifoliate), leaf shape (palmate or digitate), leaflet base (pulvinus), leaflet margin (entire), leaflet apex (acuminate), leaflet venation (unicostate) and leaf arrangement (alternate).

The leaflets in the OTUs show some variations in percentage occurrence and numbers (Table 2 and Figs 1 – 5) but generally the leaves are multifoliate with 5 and 6 numbers of leaflets occurring in all the OTUs studied. Leaves with 5 leaflets recorded the highest frequency, for instance in OTUs 15 and 17 with 73.5 and 67.4% respectively. In OTUs 7 and 8, the highest occurrence of number of leaflet is 7 (54.17%) and (40.12%) respectively. OTU 14 has 4 leaflets with the highest frequency (28.80 %). It was noticed that OTUs 4, 6 and 10 recorded no leaves with 3 leaflets; OTUs 1, 4, 6 and 8 have no leaves with 4 leaflets and leaves with 8 leaflets recorded the least as it occurs only in OTUs 4, 6, 8 and only with the least frequency (3.51%) in OTU 9. The average leaf length in OTU 10 has the highest record (32.91 cm) while the highest mean leaf width was observed in OTU 3 (28.26 cm). The lowest mean leaf length (15.16 cm) and leaf width (13.38 cm) were recorded by OTUs 16 and 17 respectively (Table 3). The longest terminal leaflet length (15.88 cm) and width (6.24 cm) was observed in OTUs 23 and 2 respectively. The shortest terminal leaflet length was recorded in OTU 16 with (8.18 cm). The result for the quantitative features of fruit pod and stalk is presented on Table 4. The OTU with the highest mean pod length (301.31 mm) was 21, while OTU 23 has the highest mean stalk length (576.78 mm) and stalk width (22.56 mm) with the lowest stalk length and stalk width ranging from 49.06 – 52.28 mm and 4.11 – 4.66 mm in OTUs 14 and 15 respectively. The average pod width (142.31 mm) was recorded the highest in OTU 3 and the highest average number of seed per pod was recorded in OTU 20 (337.60). The results also show that the average seed length and seed width in OTU 7 were the highest (15.91 mm) and (13.60 mm) respectively and the lowest seed length was observed in OTU 10 (10.61 mm). Seed colour in OTUs 10, 11, 18 and 19 were coffee brown (Table 1 and Fig. 10), other OTUs have brown seed colour. Other qualitative morphological studies showed a very close relationship between the 25 OTUs. All the OTUs have green immature fruit pods, pale green or brown mature fruit pod and hairy. The pulp is fibrous and creamy white in colour (Fig. 12) and the seeds are bean-shaped in the entire OTUs studied (Fig. 10).

The analysis of the values of morphological features of *A. Digitata* based on Complete Linkage Cluster Analysis indicated four cluster groupings (Fig. 13). Table 5 shows the cluster membership using four methods of cluster analysis. Cluster I is comprised of OTUs 1, 2, 3, 6, 11, 13, 14, 15, 17, 18, 19, 20, 22, 21, 23, 24 and 25. Cluster I constitute the group with the highest number of OTUs totalling 17; cluster II constitute OTUs 4 and 5; cluster III constitute OTUs 7, 8, 9, 12 and 16 while OTU 10 makes up cluster V. It was observed that the grouping does not take into account the variations in area of collection of the samples studied. The scree plot from a principal component analysis of the features in *A. digitata* (Fig. 14) shows that there is a break in the plot that separates the meaningful components from the trivial components. Components – 5, 6 – 9, 10 and 11 – 13, are probably more meaningful with large eigenvalues while components 14 – 24 with small eigenvalues. Generally, the scree plot had displayed several brakes.

Table 1: Qualitative Features in Varieties of *A. digitata*

OTUs	Leaf Surface	Leaf Stalk Surface	Leaf Stalk Colour	Pod Shape	Pod End Form	Pod Colour	Pod Size	Seed Colour
1	Glossy	Smooth	Green	ovate	Round	pale green	Small	Brown
2	Glossy	Hairy	Tan	ovate	Round	pale green	Medium	Brown
3	Glossy	Hairy	Tan	ovate	Round	pale green	Large	Brown
4	Scarbid	Hairy	Tan	orbicular	Acute	pale green	Medium	Brown
5	Scarbid	Smooth	Green	ovate	Round	pale green	Large	Brown
6	Scarbid	Smooth	Tan	ovate	Round	pale green	Medium	Brown
7	Scarbid	Smooth	Green	ovate	Round	pale green	Small	Brown
8	Glossy	Smooth	Green	orbicular	Acute	pale green	Medium	Brown
9	Glossy	Smooth	Green	elongated	Acute	pale green	Large	Brown
10	Glossy	Hairy	Green	ovate	Round	dark green	Medium	Coffee Brown
11	Glossy	Hairy	Green	ovate	Round	dark green	Small	Coffee Brown
12	Glossy	Hairy	Green	ovate	Round	dark green	medium	Brown
13	Glossy	Smooth	Green	ovate	Round	pale green	medium	Brown
14	Glossy	Smooth	Green	cordate	Cordate	pale green	small	Brown
15	Glossy	Smooth	Green	ovate	Round	pale green	small	Brown
16	Glossy	Smooth	Tan	ovate	Round	pale green	small	Brown
17	Scarbid	Smooth	Green	ovate	Round	dark green	small	Brown
18	Scarbid	Smooth	Green	orbicular	Acute	dark green	small	Coffee Brown
19	Scarbid	Smooth	Green	orbicular	Acute	dark green	small	Coffee Brown
20	Glossy	Smooth	Green	orbicular	Acute	dark green	medium	Brown
21	Glossy	Smooth	Green	ovate	Round	dark green	large	Brown
22	Glossy	Smooth	Green	ovate	Round	pale green	small	Brown
23	Scarbid	Hairy	Tan	ovate	Round	pale green	large	Brown
24	Scarbid	Hairy	Tan	ovate	Round	pale green	small	Brown
25	Scarbid	Hairy	Tan	ovate	Round	pale green	medium	Brown

Table 2: Frequency of Number of Leaflets in *A. digitata*

OTUs	Frequency (%)					
	3	**4**	**5**	**6**	**7**	**8**
1	13.86	0	29.7	21.78	7.82	0
2	13.68	13.68	42.06	9.35	18.69	0
3	14.29	5.26	42.11	31.58	7.89	0
4	0	0	52.38	30.33	10.29	6.99
5	8.33	11.11	63.89	16.67	0	0
6	0	0	25	12.25	54.17	12.5
7	16.67	9.68	61.29	12.9	0	0
8	0	0	24.32	31.31	40.12	4.25
9	5.26	2.19	43.86	32.9	12.28	3.51
10	0	7.45	44.21	37.33	11.8	0
11	24.11	12.6	46.71	12.11	0	0
12	12.86	12.86	44.6	16.96	15.33	0
13	15.13	4.36	45.2	31.5	6.78	0
14	12.68	28.8	22.77	8.9	0	0
15	10.17	11.14	73.5	5.1	0	0
16	25.14	7.3	53.11	15.12	0	0
17	8.14	10.21	67.71	21.5	0	0
18	13.21	9.5	41.4	33.6	0	0
19	8.75	15.11	56.14	18.66	0	0
20	14.12	9.25	43.21	27.1	5.6	0
21	9.19	8.88	67.4	17.56	0	0
22	24.41	7.23	52.82	7.8	0	0
23	11.1	5.5	66.32	15.2	5.3	0
24	18.23	12.53	59.5	10.2	10.46	0
25	24.21	9.52	63.93	2.35	0	0

Table 3: Leaf Morphometric Features in *A. digitata*

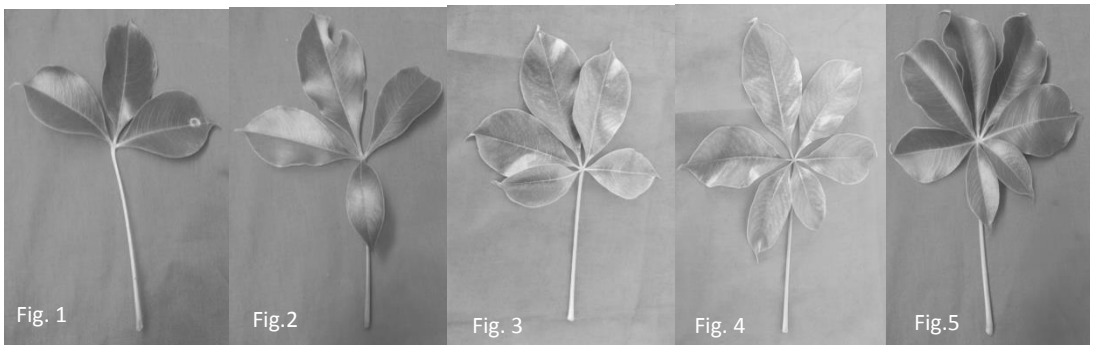
OTUs	Leaf Length (cm)	Leaf Width (cm)	Terminal Leaflet Length (cm)	Terminal Leaflet Width (cm)
1	26.46±4.18	22.48±2.64	14.18±1.98	5.32±0.62
2	23.30±2.19	18.42±1.77	11.74±1.01	6.24±0.36
3	31.50±2.58	28.26±1.73	15.62±1.18	6.18±0.48
4	25.60±1.42	19.32±1.43	13.80±0.93	6.18±0.36
5	24.92±0.67	21.12±0.40	12.78±0.54	5.68±0.07
6	24.68±1.85	18.36±0.93	11.53±0.60	4.96±0.35
7	25.22±2.28	17.94±0.76	11.92±0.27	5.20±0.29
8	28.38±1.01	20.64±0.95	12.92±0.39	5.00±0.16
9	32.42±3.31	21.66±1.89	14.86±0.85	6.98±0.39
10	32.91±2.76	23.72±1.23	14.98±0.69	6.98±0.49
11	29.28±0.81	19.76±1.04	12.50±0.22	5.34±0.27
12	22.40±1.31	13.74±1.16	13.74±1.16	4.96±0.16
13	27.02±1.99	16.02±1.25	14.18±0.53	5.38±0.34
14	32.14±3.51	21.44±1.38	15.16±0.44	6.62±0.29
15	25.38±0.88	21.70±0.81	12.56±0.63	5.38±0.06
16	15.16±0.47	13.50±0.59	8.18±0.43	4.72±0.06
17	15.18±0.36	13.38±0.59	9.22±0.29	5.80±0.75
18	20.40±0.68	14.50±0.30	8.42±0.32	5.06±0.25
19	25.14±1.95	17.74±0.79	11.54±0.27	5.50±0.21
20	21.90±1.26	16.80±0.66	13.98±1.25	5.60±0.16
21	24.12±0.89	18.68±0.77	13.86±0.97	6.18±0.30
22	28.62±1.22	19.23±0.82	14.27±1.20	5.66±0.22
23	30.11±2.75	20.52±0.78	15.88±0.44	4.82±0.65
24	22.58±1.46	15.62±0.55	12.65±0.33	4.21±0.82
25	27.23±1.18	18.75±0.79	14.39±1.54	5.64±0.52
Code:	15 - 23 = 1 24 - 33 = 2	13 - 21 = 1 22 - 29 = 2	8 - 12 = 1 13 - 16 = 2	4 - 5 = 1 6 - 7 = 2

Table 4: Fruit Pods and Seed Morpho-metrics of *A. digitata*

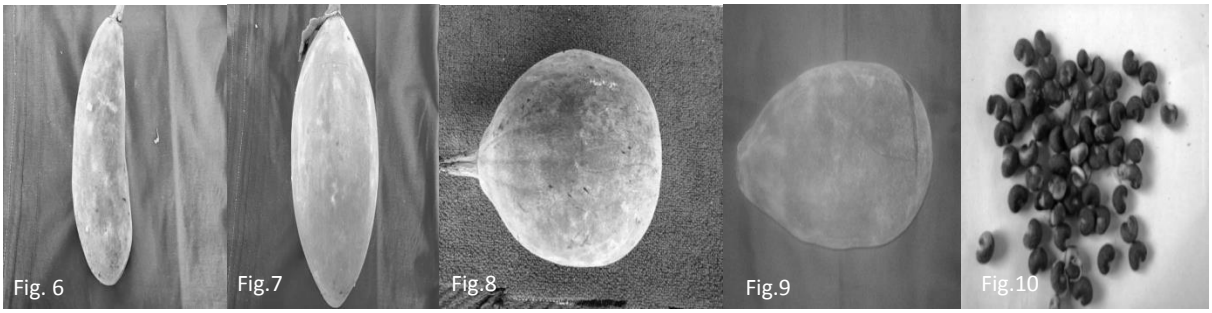
OTUs	Pod Length (mm)	Pod Width (mm)	Stalk Length (mm)	Stalk Width (mm)	No. of Seed /Pod	Pod Index	Seed Length (mm)	Seed Width (mm)
1	138.72±8.01	84.75±2.14	158.57±7.76	5.91±0.56	97.60±2.77	2.17±0.11	12.84±0.24	10.12±0.21
2	244.98±17.75	116.32±6.12	394.47±39.26	12.51±0.63	137.60±9.62	2.62±0.14	11.11±0.30	9.73±0.40
3	296..00±2.80	142.31±11.73	213.64±8.46	13.62±0.41	300.00±3.18	1.71±0.02	11.27±0.28	10.22±0.42
4	197.69±6.49	98.26±3.21	438.90±47.92	6.69±0.45	128.00±7.09	3.26±0.30	12.69±0.30	9.22±0.31
5	261.55±6.77	133.30±14.70	181.28±10.35	7.63±0.27	139.20±8.49	1.69±0.04	13.72±0.54	9.34±0.29
6	176.01±7.29	99.68±7.40	209.67±4.76	6.46±0.41	133.20±20.69	2.20±0.07	13.29±0.23	10.45±0.35
7	135.41±3.66	102.73±2.85	184.82±3.58	4.91±0.21	89.20±7.48	2.37±0.03	15.91±1.21	13.60±1.21
8	214.57±25.37	95.59±4.98	485.08±70.50	7.60±0.59	176.20±53.49	3.44±0.44	14.32±1.32	12.01±1.07
9	244.54±3.80	91.77±2.56	167.81±9.56	7.01±0.25	215.40±3.50	1.69±0.04	11.23±0.47	9.12±0.88
10	177.68±13.66	143.70±26.80	240.74±13.13	11.57±1.14	336.20±18.27	2.43±0.07	10.61±0.50	8.08±0.34
11	137.62±2.83	71.84±2.75	459.24±25.65	4.87±0.12	42.40±0.68	4.33±0.12	12.41±0.32	10.12± 0.41
12	251.27±15.53	108.37±3.67	466.77±14.15	8.76±0.17	168.40±19.45	2.71±0.17	12.26±0.21	10.30 ±0.21
13	186.54±14.41	77.37±0.87	433.67±8.57	6.25±0.98	50.00±1.64	3.38±0.17	11.14±0.33	10.51 ±0.80
14	89.49±5.12	73.87±6.08	52.28±4.27	7.26±0.49	73.00±2.72	1.72±0.11	12.34±0.31	11.01± 0.89
15	74.44±4.92	106.82±7.26	200.28±28.19	4.66±0.44	73.60±2.70	3.65±0.17	13.77±0.30	10.64 ±0.16
16	121.23±6.68	73.08±3.44	265.75±10.14	5.75±0.48	108.00±5.32	3.32±0.19	12.80±0.42	11.23± 0.18
17	94.57±2.63	81.07±5.05	56.93±2.07	7.05±0.48	80.40±1.44	1.61±0.02	12.07±0.18	9.55±0.90
18	133.67±2.21	78.80±0.76	286.33±8.99	7.05±0.15	108.80±3.77	3.14±0.72	14.11±0.22	10.62±0.44
19	79.52±3.18	107.22±2.00	241.14±20.35	5.36±0.34	76.80±2.50	4.32±0.26	13.34±0.21	10.64±0.15
20	206.39±5.37	122.40±3.05	242.85±14.54	10.45±0.17	337.60±17.82	2.43±0.55	11.28 ±0.19	10.28±0.32
21	301.31±5.69	137.21±13.02	194.49±16.37	12.96±0.33	290.80±14.66	1.71±0.02	13.59±0.20	10.63±0.18
22	149.93±2.34	102.68±1.89	451.99±14.44	5.99±0.45	83.20±4.36	4.01±0.45	11.95±0.31	9.59±0.89
23	288.23±4.89	142.24±3.45	576.78±15.28	22.56±1.45	325.40±20.11	2.99±0.23	12.28±0.44	10.32±0.72
24	115.59±2.13	64.63±1.50	476.62±10.11	15.15±0.89	62.10±1.43	5.12±0.98	11.97±0.22	9.29±0.29
25	192.62±8.12	94.75±1.75	513.78±8.91	11.47±1.10	92.80±2.54	3.67±0.54	13.98±0.37	11.11±0.16

Table 5: Groups of OTUs according to the method of analysis

Method of Analysis	Cluster Membership			
	group 1	group 2	group 3	group 4
Average Linkage	1, 2, 3, 6, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25	4, 5	7, 8,	10
Complete Linkage	1, 2, 3, 6, 11, 13, 14, 15, 17, 18, 19, 20, 22, 21,23, 24, 25	4, 5	7, 8, 9, 12, 16,	10
Single Linkage	1, 2, 3, 4, 5, 6, 9, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25	7, 8	10	12
Centroid Linkage	1, 2, 3, 4, 5, 6, 9, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25	7, 8	10	12



Figs. 1: leaf with 3 leaflets; 2: leaf with 4 leaflets; 3: leaf with 5 leaflets; 4: leaf with 6 leaflets; 5: leaf with 7 leaflets



Figs 6 – 9 show the sizes and shapes of fruit pods in OTUs of *A. digitata* 6 – elongated; 7 – elongated; 8 – orbicular; 9 – ovate. Fig. 10: Seeds of *A. digitata*

Fig. 11: Surface view of the sizes and shapes of fruit pods in OTUs of *A. digitata* (a:Small; b: Medium and c: Large)

Fig. 12: fruit pulp of *A. digitata* (cream in colour)

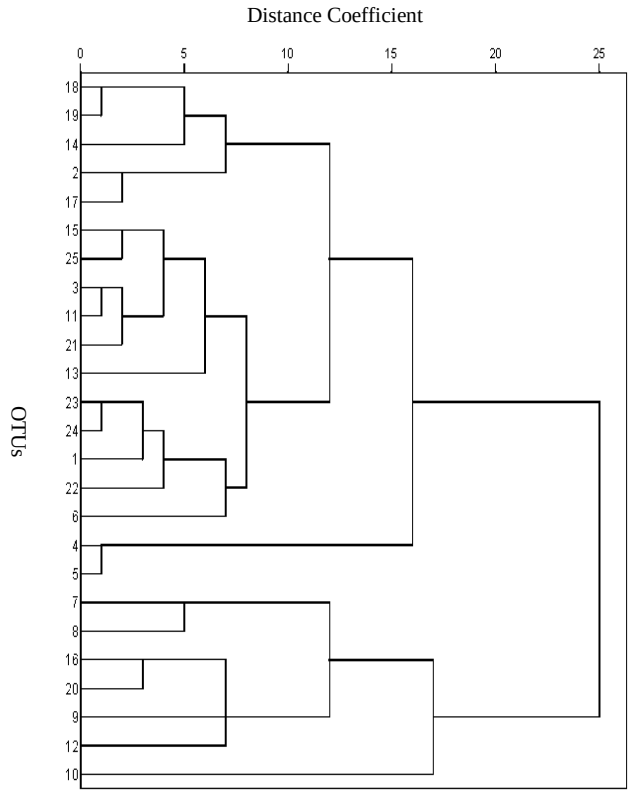


Fig. 13: Dendrogram of the OTUs of *A. digitata* using CompleteLinkage (Among groups)

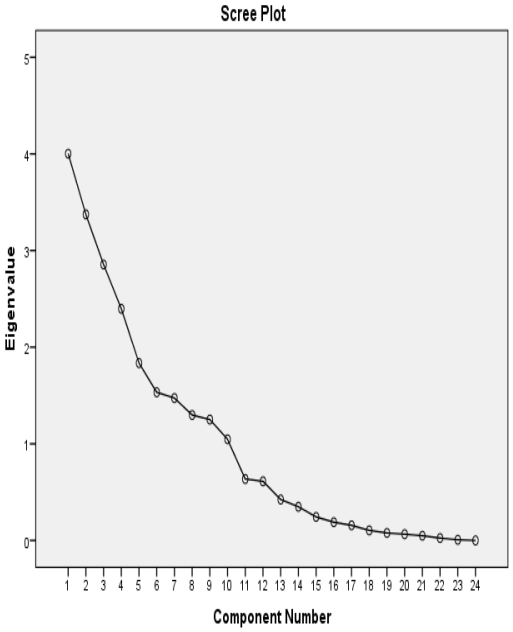


Fig. 14: Principal Component Analysis for OTUs of *A. digitata*

Discussion

Taxonomy relies greatly on morphology to discriminate groups. Computerized geometric morphometric methods for quantitative shape analysis measure, test and visualize differences in form in a highly effective, reproducible, accurate and statistically powerful way Viscosi and Cardini (2011).Morphology is the basic tool of taxonomy, because identification is primarily based on the characters of the plant and of taxonomic significance as they can be used to delimit taxa e.g. species and varieties. In this study, intraspecific variations are prominent as evident in the morphological features of the examined OTUs of *A. digitata*. The observation was in line with earlier works of Okwulehi and Okoli (1999); Edeoga and Eboka (2000); Nwachukwu *et al.* (2007) and Zhigila and Oladele (2014) who used comparative morphology of different species in establishing relation among various taxa.

Leaf morphology among the OTUs of *A. digitata* shows a close affinity and some distinctions. In general, the leaves were observed to be multifoliate, entire leaf margin, acuminate leaf apex, pulvinus leaf base, palmate leaf type and alternately arranged; hence, these features are the same in all OTUs, and will be unreliable criteria to use as diagnostic characters. Other qualitative characters especially the leaf surface (glossy or scarbid), leaf stalk surface (smooth or hairy) and leaf stalk colour could be good diagnostic features in the OTUs studied. However, there were significant differences among leaf quantitative morphological characteristics measured (Table 1). In general, leaves in OTU 10 (32.91 cm) were larger than those from other OTUs; while leaves from OTU 16 (15.16 cm) were the smallest. Medial (Terminal) leaflet length to broadest part and the medial leaflet width followed the same pattern of medial leaflet length. This has confirm an experiment by (Sanchez *et al*., 2009) that pruning plays a role in determining the size of baobab tree leaves, as leaves from pruned branches were found

significantly smaller and thinner than leaves from not pruned branches in the same trees grown in the same environmental conditions. However, pruning does not affect the shape and the occurrence of number of leaflets of the leaves. The frequency of the number of leaflet per leaf varies significantly (Table 1 and Figs 1–5). Leaves with 5 and 6 leaflets occurred in all the samples studied. It was noticed that OTUs 4, 6 and 10 recorded no leaves with 3 leaflets; OTU's 1, 4, 6 and 8 have no leaves with 4 leaflets and leaves with 8 leaflets recorded the least as it occurs only in OTUs 4, 6, 8 and only with the least frequency (3.51%) in OTU 9. Leaves with 5 leaflets recorded the highest frequency, for instance in OTUs 15 and 17 with 73.5 and 67.4% respectively and therefore can be inferred that the varieties have dominantly 5 leaflets hence; the species name digitata (fingers).

The fruit pods as observed in the present study seem to be diagnostic among the OTUs. The major diagnostic feature is the fruit pod shape, colour and size (Table 1 and Fig. 11). The shapes of the fruit pods observed were ovate (Fig.9), elongated (Fig. 7), cordate (Fig. 8) and orbicular (Fig. 8). The sizes were considered to be small when the mean of pods ranges from71 to 150 mm (Fig. 11a); 151 – 230 to be medium (Fig. 11b) and large pod lengths measuring from 231 – 310 mm (Fig. 11c). In Table 3, OTU 21 recorded the highest mean pod length (301.31 mm) and the highest mean pod width was recorded in OTU 10 (143.70 mm). The fruit pod colour also varies from pale green to dark green. The pod end form showed two distinct features – round or acute on both ends. The number of seeds per pod (Table 3) varies greatly among the OTUs with OTU 20 recorded the highest number (337.6) averagely and the lowest was recorded in OTU 13 (50.00). The seed shape among the OTUs showed close range of variations. Most of the seeds have bean/kidney shape (Fig. 10) and so unreliable character for diagnosis. The seed colour ranges from brown to coffee brown. The stalk length showed that OTU 23 with 576.78 mm mean stalk length was the longest and OTU 14 with 52.28 mm mean stalk length was the shortest (Table 3).

The result of the clustering analysis showed that branching occurred at very low phenon line, which suggests broad and overall similarities among the OTUs. This can be attributed to hybridization and ability of baobab to self-pollinate. This analysis conforms to the delimitation of the OTUs into four major groups using morphological characters but there are discrepancies in the sorting of the OTUs into the component groups. According Lawal *et al.* (2007), these discrepancies are not unconnected with the clustering methods used i.e. Single Linkage, Average Linkage, Complete Linkage and Centroid Method. In the average linkage, there is always an attempt to relate the new OTU to an average value of extant group rather than to the similarity or difference within it. The complete linkage on the other hand joins an OTU to a cluster based on the greatest similarity with the farthest OTU already within the same cluster. The centroid method has a marked defect in that there is the tendency towards chaining in which most of the OTUs join an initial cluster once at a time. Principal Component Analysis was used to augment and validate the results of Cluster Analysis (Fig. 14). Clearly, each component was a negative linear combination of the variables.

Conclusion

In conclusion, the present analysis using morphological features of *A. digitata* suggests the existence of variation among the samples and may form a basis for the possibility of delimitation of the taxon and mapping out of breeding schemes for improved yield. Specifically, the OTUs 4, 5, 7, 8, 10 and 12 showed major variation among the groups. However, additional effort using other taxonomic markers like RAPD, ISSR, AFLP etc to support the present findings with a view to enhance the delimitation of the varieties of *A. digitata* is hereby recommended.

References

Assogbadjo A.E., Kyndt, T., Sinsin, B., Gheysen, G. and van Damme, P. (2006). Patterns of genetic and morphometric diversity in baobab (*Adansonia digitata*) populations across different climatic zones of Benin (West Africa). Annals of Botany, 97(5): 819–830.

Assogbadjo A.E., Glèlè Kakaï R, Chadare FJ, Thomson L, Kyndt T, Sinsin B, Van Damme

P (2008). Folk classification, perception and preferences of baobab products in West Africa: consequences for species conservation and improvement. Economic Botany 62(1):74–84

Assogbadjo A.E., Kyndt T, Chadare FJ, Sinsin B, Gheysen G, Eyog-Matig O, Van Damme P (2009). Genetic fingerprinting using AFLP cannot distinguish traditionally classified baobab morphotypes. Agrofor Syst 75:157–165

Baobab Fruit Company, (2003). Baobab Fruit Pulp (*Adansonia digitata*). http://www.baobabfruitco.com/. Accessed 30 Sep 2008

Baum, D.A., Small, R.L. and Wendel, J.F. (1998). Biogeography and Floral Evolution of Baobabs (Adansonia Bombacaceae) as Inferred from Multiple Data Sets. Systematic Biology, 47: 181–207.

Chadare, F.J., Hounhouigan, J.D., Linnemann, A.R., Nout, M.J.R. and Boekel, M.A.J. (2008). Indigenous knowledge and processing of *Adansonia digitata* L. food products in Benin. Ecology Food Nutrition, 47:338–362.

Chia, A., Iortsuun, D.N. and Carthage, B.A. (2008). Studies on Seedling Growth of *Adansonia digitata*. Science World Journal, 3(1):21–24

Chicamai, B., Eyog-matig, O., Mbogga, M. (2004). Review and Appraisal on the Status of Indigenous Fruits in Eastern Africa. IPGRI-SAFORGEN raport, 131

Codjia, J.T.C., Assogbadjo, A.E. and Ekué, M.R.M. (2003). Diversité et Valorisation au Niveau Local des Ressources Forestières Alimentaires Végétales du Bénin. Cahiers Agricultures, 12: 321–331.

Diop, A.G., Sakho, M., Dornier, M., Cisse, M. and Reynes, M. (2005). Le Baobab African (*Adansonia digitata* L.): Principales Caractéristiques et Utilisations. Fruits, 61(1):55–69.

Edeoga, H.O. and Eboka, A.U. (2000). Morphology of the leaf epidermis and systematics in some *Dissotis* Species Benth (Melastomataceae). Global Journal of Pure and Applied Sciences, 6:371-374.

Eyog, M.O., Gaoué, O.G. and Dossou, B. (2002). Réseau «Espèces ligneuses alimentaires». Compte rendu de la première réunion du réseau tenue 11–13 décembre 2000 au CNSF Ouagadougou, Burkina Faso. Institut International des Ressources Phylogénétiques, Rome, Italy

Hill, R.S. (1980). A Numerical Taxonomic Approach to the Study of Angiosperm Leaves. Botanical Gazette, 141:213 – 229

Lawal, O.J., Ayodele, A.E. and Chukwuka, K.S. (2007). Morphological studies in *Lycopersicon esculentus* Mill. lines in Southwestern Nigeria. Journal of Biological Sciences, 7(5): 737-744.

Nordeide, M.B., Hatløy, A., Følling, M., Lied, E. and Oshaug, A. (1996). Nutrient composition and nutritional importance of green leaves and wild food resources in an agricultural District, Koutiala, in southern Mali. International Jouranal of Food Science and Nutrition, 47:455–468.

Nwachukwu, C. U., Mbagwu, F. N. and Onyeji, A. N. (2007). Morphological and leaf epidermal features of Capsicum annuum and *Capsicum frutescens* Solanaceae. Nature and Science, 5(3); 54-60

Okwulehi, I.C. and Okoli, B.E. (1999). Morphological and palynological studies in some species of *Corchorus* L. (Tiliaceae), New Botanist, 25:87-101.

Olorode, O. (1984). Taxonomy of West African Flowering Plants. Longman Group Limited. The Book Project, Obafemi Awolowo University, Ile-Ife, Nigeria.

Pandey, S.N. and Misra, S.P. (2009). Taxonomy of Angiosperms. Ane Books Pvt. Ltd. Parwana Bhawa, Darya Ganj, New Delhi, India.

PhytoTrade Africa. (2006). Baobab Dried Fruit Pulp—an Application for Novel Foods Approval in the EU as Food Ingredient, vol PhytoTrade Africa. Phytotrade, London

Radford, A.E., Dickson, W.C., Massey, J.R. and Bell, C.R. (1976). Vascular Plant Systematics. Harper and Row, New York.

Sanchez, A.C., Haq, N. And Assogbadjo, A.E. (2009). Variation in baobab (*Adansonia digitata* L.) Leaf morphology and its relation to drought tolerance. genetic resources and crop evolution An International Journal Springer Science, 24:222 – 223.

Sidibé, M. and Williams, J.T. (2002). Baobab *Adansonia digitata*.Southampton, UK: International Centre for Under-utilised Crops.

Sneath, P.H.A and Sokal, R.R. (1973). Numerical Taxonomy. W.H. Freeman and Company. San Francisco.

Viscosi, V. and Cardini, A. (2011). Leaf morphology, taxonomy and geometric morphometrics: a simplified protocol for beginners. PLoS ONE, 6(10): 2563

Wickens, G.E. and Lowe, P. (2008). The Baobabs, Pachycauls of Africa, Madagascar and Australia. Kluwer, Dordrecht.

Zhigila, D.A. and Oladele, F.A. (2014). Taximetrics study in varieties of *Moringa oleifera* and *Adansonia digitata*. A Thesis submitted to the Department of Plant Biology, Faculty of Life science, University of Ilorin, Ilorin, Kwara state, Nigeria.