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Full Length Research Paper

Foliar epidermal studies in the family Bignoniaceae JUSS. in Nigeria

G. E.Ugbabe[1] and A.E. Ayodele[2]

[1]National Institute for Pharmaceutical Research and Development, P.M.B. 21, Garki- Abuja, Nigeria.
[2]Department of Botany and Microbiology, University of Ibadan, Nigeria.

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Comparative studies have been carried out on the leaf epidermal features of eleven species of the family Bignoniaceae in Nigeria. The species are relatively uniform in the qualitative macro morphological characters except in the leaf shape, which varies from ovate, elliptic, oblong-elliptic, oblong, oblanceolate to obovate-lanceolate. A more constant macro character for the species is the leaflet length /leaflet width ratio, which ranges from 2:1 to 4:1. The epidermal morphology of the adaxial and abaxial surfaces of the species was studied with the light microscope. The epidermal cells are polygonal, irregular or both. Anticlinal walls are straight, curved or undulate/ wavy. Leaflets of all species are hypostomatic with stomata restricted to the abaxial surface. The Anomocytic stomata type is most prominent except *Kigelia africana,* which has diacytic stomata. Striae are present on the adaxial surface of *Oroxylum indicum* and abaxial surface of *Spathodea campanulata*. Knobs are present on the abaxial and adaxial surfaces of *Markhamia lutea*, *Markhamia tomentosa,* abaxial surface of *Stereospermum kunthianum* and adaxial surface of *Tabebuia rosea*. Other features of the epidermis that show variation include stomatal size, shape and frequency. Epidermal cell shape, anticlinal wall undulation, striation on the epidermis, stomata type, distribution and stomata index are of taxonomic importance in the family while epidermal size and number are of little diagnostic value. The significance of these observations is discussed in relation to the taxonomy of the family.

Key words: Foliar epidermis, Bignoniaceae, Nigeria.

INTRODUCTION

Bignoniaceae Juss. is a family of trees, shrubs or lianas and rarely herbs (Watson and Dallwitze, 1992). The family is made up of about 100 and 800 species (Watson and Dallwitze, 1992) and it is distributed in the tropics and forms an important part of the vegetation (Shashina, 1989), while a few of the species are found in the temperate and sub-tropical regions The members of the family have showy flowers.

Hutchinson and Dalziel (1954) recorded five genera in Nigeria, these are *Kigelia* Lam., *Markhamia* Seemann. ex K. Schum., *Newbouldia* Seemann. ex Bureau., *Spathodea campanulata* P. Beauv. and *Stereospermum*. Beside these genera, there are also introduced species such as *Crescentia cujete* Linn., *Tabebuia rosea* (Ber - thol) D. C, *Tecoma stans* (Linn) H, B A and K. and Oroxylum *indicum* Vent. in the country.

The members of this family have leaves, which are usually pinnately compound. However, a few species such as *C. cujete* have simple leaves, which are whorled. The leaflets are opposite, exstipulate and the inflorescence is often a dichasial cyme. Flowers are bisexual, zygomorphic, hypogynous with bracts and bractioles present. Placentation is axial. Seeds are exalbuminous, usually flattened with membranous wings although with few exceptions. The flowers are bell or funnel shaped. Members of this family are grown mostly for ornamental and medicinal purposes in Nigeria.

The bark *of Kigelia africana* (Lam.) Benth. is used as a remedy for rheumatism and dysentery (Dalziel, 1937) . A decoction of the fruit with pepper is taken in Nigeria for constipation and pile and the powdered fruit- ash is said to have dis-infective and curative properties (Burkhill, 1985). Plant preparations of *Markhamia tomentosa* (Benth.) K. Schuum. are administered as a rejuvant and

*Corresponding author. E–mail: graceeyinehi@yahoo.com.

diuretic medicine for oedema of the legs and elephantiasis of the scrotum as well as in the treatment of the respiratory tract and in the bouts of swamp fever (Irvine, 1961) .The bark decoction of *Newbouldia laevis* Seem. is drank for epilepsy and children convulsion (Burkhill, 1985). Analgestic properties are said to be present in the bark. The plant is also accredited with aphrodiasiac properties (Dalziel, 1937). The bark maceration of *Spathodea campanulata* P. Beauv. is taken for kidney and back pains and the pulp up bark is used in frictions on swellings, fungal infections, impetigo, herpes and other skin infections (Irvine, 1961). The leaf decoction is taken as a poison anti-dote and the leaves together with the leaves of a number of other plants and clay are made into a paste which is let down in water and drank in treatment of tuberculosis of the spinal cord (Burkhill, 1985). Nigerian materials have shown a fairly strong presence of alkaloids and the leaves and barks of tannin accounting for their astringency (Oliver, 1960). The bark of *Stereospermum kunthianum* Cham. is used against skin eruption (Burkhill, 1985), and the decoction of the bark is given for refactory cough, bronchitis and pneumonia (Burkhill, 1985). The roots are considered to be strongly diuretic and are used for anuria, urethral discharge and schistomiasis (Irvine, 1961). The bark of *Stereospermum acuminatissimum* K. Schum. is haemostatic and citrisant. It is commonly used on sores and wound (Burkhill, 1985).

The principal product of *C. cujete* Linn. is the fruit shell or calabash, which is used as containers for food and drinks and for decoration. The bark decoction of this species is used to clean wound (Burkhill, 1985) and also used for treating diarrhea with mucous. The flower yields nectar for honey (Irvine, 1961).

Several species of *Tabebuia* yield excellent timber. *Tecoma stans* (Linn.) H.B.& K is introduced to many countries as an ornamental plant. The root is a powerful diuretic, and it is known to have tonic, antisyphilitic and vermifugal properties Burkhill, (1985) . A decoction of the flowers and bark has been used for stomach pains and the plant has a reputation for alleviating and even curing diabetes (Burkhill, 1985).

In many West African countries including Nigeria medicinal plants are sold in local markets and street corners in sterile or fragmentary condition. This common practice usually renders crude drug plants highly susceptible to substitution and adulteration (Stace, 1965) . The problem of accurate identification of, and dearth of information about, the numerous medicinal plant species in a country like Nigeria whose flora is not well documented, have hampered the optimal utilization of these crude drugs. These have also discouraged the conduct of phytochemical and pharmacological research into the efficacy of these drug plants (Stace, 1965). This is especially the case when dealing with closely related genera or species.

The aim of this research is to generate reliable taxonomic data from leaf of the species of Bignoniaceae found in Nigeria with a view to helping to make identification easier and more accurate for collectors particularly during collections for medicinal purposes. This paper reports the leaf epidermal characters of eleven species as observed by the light microscope. It describes the significance of, and discusses the extent to which, these valuable features may be used for identifying sterile plant of each species, which are otherwise indistinguishable.

MATERIALS AND METHODS

This work is based on eleven species in the family Bignoniaceae. Fresh and herbarium specimens were used. Specimens of the family were studied at Forestry Research Institute of Nigeria Herbarium, (FHI) Ibadan, Nigeria; Botany and Microbiology department, University of Ibadan Herbarium (UIH) and National Institute for Pharmaceutical Research and Development Herbarium (NIPRDH), Abuja Nigeria. The species studied are listed in Table 1. The voucher specimens of the species collected have been deposited at Botany and Microbiology Department University of Ibadan. Duplicates are kept in the Forestry Research herbarium Ibadan (FHI) and NIPRDH Abuja.

The macro characters assessed on mature leaves at comparative positions include leaflet length, leaflet width at widest point, petiolule length, blade length, position of maximum width from apex, leaf apex, leaf margin, leaf shape, leaf surface and leaf base. Others are derived ratios of the length and width of the leaflets, length of petiolule, flower colour and fruit shape. Diagrams of the macro characters of the leaves were also made. Micro characters assessed on each specimen include number of epidermal cells per view (X 400), thickness of cell wall, size of epidermal cells at widest point, number of stomata per view (X 400), length of stomata, width of stomata and stomata index (S.I). Other characters assessed are the shape of epidermal cells and cell wall pattern.

Epidermal preparation

Epidermal preparation follows the method of Ayodele and Olowokudejo (1997). About 5 mm – 1 cm squared leaf fragments were obtained from the standard median portion of the leaf and macerated in concentrated Trioxo- nitrate v acid in Petri- dish for a period of about 24 h. The appearance of bubbles on the surface of the leaf fragments indicated their suitability for separation. They were transferred into water in a Petri- dish with a pair of forceps. Both epidermises were carefully separated by teasing them apart and pulling each epidermis back on itself. The epidermises were cleaned with the carmel hair brush. These were rinsed in distilled water and later transferred into 50% alcohol for about two minutes to harden. They were then stained in Toluidine- blue for 5 - 10 min and excess stain washed off in water. The epidermises were passed through 50, 70 and 90% and absolute alcohol to dehydrate them. They were then mounted in glycerine on a slide with the edge of the cover slips ringed with nail vanish to prevent dehydration. The slides were labeled appropriately and examined under the light microscope while photographs of the micro morphological features were taken using NICON AFX-DX Microscope with NICON FX-35DX camera attached at a magnification of X400. Quantitative measurements were based on 25 stomata and 25 epidermal cells chosen randomly from each species. Three to five specimens were used for each species. The range, mean and standard error were determined for all species. Terminologies are based on Metcalfe and Chalk (1979). The stomata Index was calculated using the formula of Salisbury (1927):

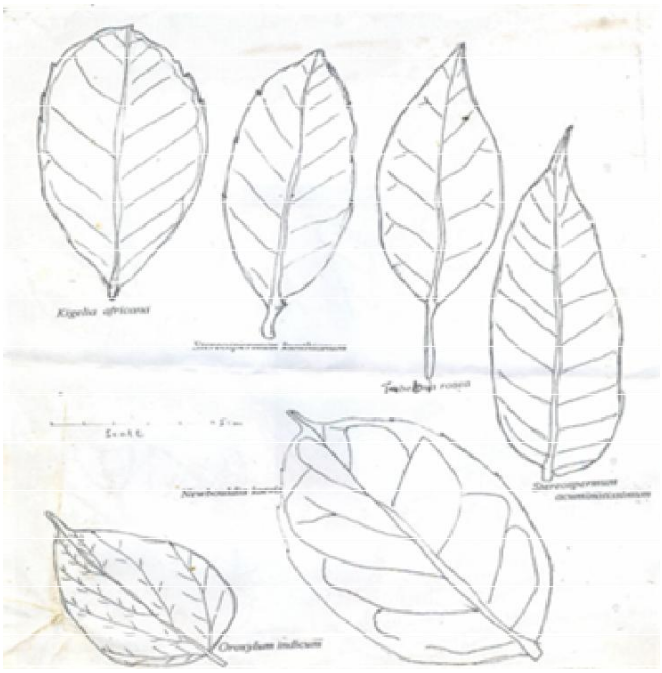


Figure 1a. Showing the leaf forms of the species Bignoniaceae in Nigeria.

$$S.I = \frac{S}{S+E} \times 100$$

Where S = number of stomata per unit area; E = number of epidermal cells in the same unit area.

RESULTS

Table 1 shows the distribution of species of the Bignoniaceae in Nigeria. Appendix 1 is the summary of major characteristics in the family. Figures1a and 1b shows the various leaf forms in the species. Table 2 - 5 show the macromorphological and micromorphological characters of the species studied in the family. Photomicrographs of the abaxial (lower) and adaxial (upper) surfaces are shown on Plates I – IV

Macromorphological characters

The leaves are mostly pinnate except in *C. cujete* which has simple and whorled leaves. The shape ranges from ovate, elliptic, oblong-elliptic, oblong, oblanceolate to obovate- lanceolate (Table 2, Figure 1). The leaves are mostly glabrous or softly pubescent. The apices are acuminate or rounded while the bases are attenuate, cuneate, truncate or acute. They are rarely rounded or cordate. The leaf sizes show considerable variation within the family with the largest (234 cm^3) recorded in *M. tomentosa* and the smallest (31.9cm^3) in *T. stans*. The petiolule length ranges from 0.1 cm in *Markhamia lutea to* 5.5 cm in *Tabebuia rosea* (Table 2). The smallest blade length of 4.1 cm was recorded for *Oroxyllum indicum* while the largest of 26.0 cm was recorded for *M. lutea* (Table 2) . The lowest blade/petiolue length ratio of 4:1 was fund in *T. rosea* while the highest of 53:1 was recorded in *S. campanulata.* The leaflet length/width range from 2:1 in *K. africana, M. lutea*, *N. laevis, O. indicum* and *Stereospermum kumthianum* to 4:1 in *T. stans* (Tab. 2) . The lowest leaflet width at widest point was recorded in *T. stans* (1:1 cm) and the highest was recorded in *N. laevis* (18:3 cm).

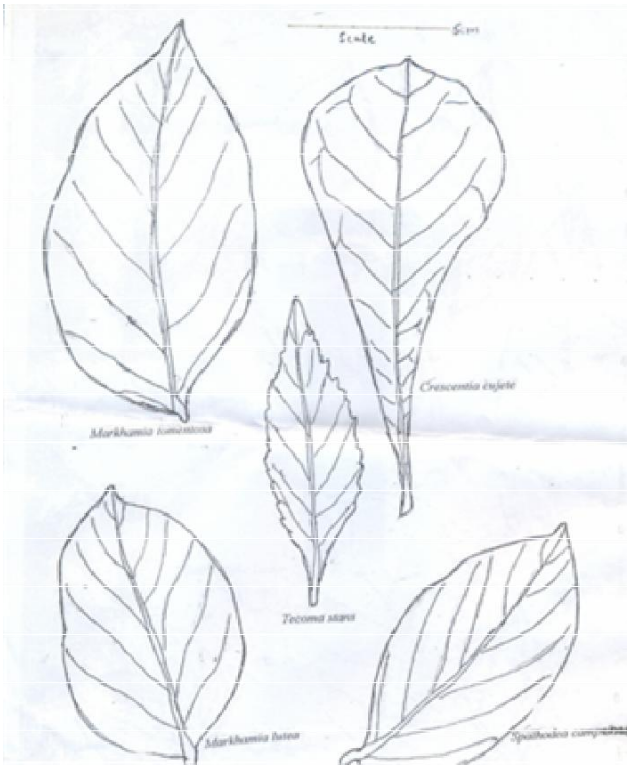


Figure 1b. Showing leaf of the family Bignoniaceae in Nigeria.

Micromorphological characters

The epidermal cells are either polygonal or irregular (Table 3). The anticlinal walls are straight, curved or undulate. Those with irregular cells are usually with undulate or curved walls (Table 3, Plates I - IV). The number of epidermal cells per view (X400) varies in the family and even within genera ranging from 43 in *Kigelia africana* to 1020 in *Markhamia tomentosa* on the adaxial surface, while on the abaxial surface it ranges from 16 in *Kigelia africana* to 601 in *Markhamia tomentosa* (Table 4). The

Table 1. List of specimens studied.

Taxa/species	Locality	Collectors	Herbarium Numbers	Date Collection
Crescentia cujete Linn	Botanical garden U. I Onisha Baissa FRIN Ifon-Abusoro Road Ibadan Ibadan U. I. Ibadan	J. Lowe Onochie Emwiogbon J.A. Olorunfemi and Oguntayo Onochie Ugbabe Grace	U.I.H 2624 F.H.I 7198 F.H.I 31333 F.H.I 48082 F.H.I 93541 F.H.I 3328 F.H.I 106915	2/6/1973 2/5/1944 5/4/1972 26/3/1964 17/7/1980 16/1/1945 11/6/2004
Kigelia africana (Lam) Benth	Song – Mubi Kaima - Yanogoa area Aba Hill F.R Adamawa Abeokuta, Egba Kotangora Idu-village Abuja Idu-industrial Area – Abuja Anambra State NIPRD – Abuja	Olorunfemi and Macauley Dr. Williamson B. O. Saramola Olorunfemi and Macauley D. U. Chimbo J. M. Dalziel Ohaeri A. Ohaeri A. Wambebe C.O.N. Ugbabe Grace	U.I.H 13524 U.I.H 13799 F.H.I 5960 F.H.I 62035 F.H.I 16448 F.H.I 49869 N.I.P.R.D.H 3973 N.I.P.R.D.H 3669 N.I.P.R.D.H 3428 F.H.I 106899	25/3/1968 April 1970 26/10/1943 9/3/1968 5/8/1963 20/12/1907 10/12/1996 1/2/1994 15/10/1991 24/9/2003
Markhamia lutea (Benth) K. Schum	Abeokuta Owo – ondo State Otobi Forest Benue State Kabba	J. Olorunfemi Dr. Jones Dr. Jones M. G. Latilo	F.H.I 40321 F.H.I 3496 F.H.I 1042 U.I.H 13424	16/12/1958 21/4/1943 15/2/1942 1/7/1963
Markhamia Tomentosa K. Schum	Nyanya – Abuja Botany department U.I Olokemeji forest Reserve Enugu – Ngwo Olokemeji Abeokuta Ondo – Idanre Ilorin Enugu Kabba Odoba (Ugbokolo) Industrial area Idu-Abuja	Eimunjeze Adebisuyi and Macauley J. Lowe Ugbabe Grace J. Lowe K. Obaseki and Salawu J. R. Charter C.E.Darter Onyeagocha Daramola H. T. harwood Ugbabe Grace	U.I.H 16011 U.I.H 19117 F.H.I 106906 UIH 3426 F.H.I 23844 F.H.I 38719 F.H.I 40678 F.H.I 16597 F.H.I 38042 F.H.I 38351 N.I.P.R.D.H 5452	21/5/1973 4/7/1980 2/12/2003 26/8/1963 14/7/1950 June 1955 21/6/1959 1/10/1949 22/6/1958 12/8/1958 12/8/1958
Newbouldia laevis Seem. Ex Bureau.	Oporoma – Ijo F.R.I.N Ibadan-Abeokuta Road Gashaka Olokomeji Mamu (Awka) Biological Sciences A.B.U. Zaria Orozo- Abuja U.I Ibadan	Williamson J. Lowe Wit. Leeuwenbery and Olorunfemi Latilo and Daramola Ross A. F.Emwiogbon Ohaeri A. O. Akeju/Ekuta/Odilison Ugbabe Grace	U.I.H 13875 U.I.H 15584 F.H.I 66930 F.H.I 28967 F.H.I 10724 F.H.I 63979 N.I.P.R.D.H 3442 N.I.P.R.D.H335 F.H.I 106905	20/12/1972 11/5/1974 5/12/1972 29/12/1952 21/1/1932 16/3/1972 4/12/1992 21//1990 2/12/2003
6. *Oroxylum indicum* Vent.	Botany dept. U. I.	J. Lowe	UIH 19114	18/6/1980

Table 1. Contd.

Spathodea Campanulata *P. Beauv*.	Botanical garden U.I. Obudu-Adikpo Road Mambilla plateau Tonti-kurmi Ago-Are Oyo State Ajasse-Igbomina Ekiti Ibadan Ife-Road Ogori Iwo Okene Enugu Garki-Abuja U. I. Ibadan	W. J. Harwood J. D. Chapman Latilo and Daramola Eimunjeze and Oguntayo Daramola Onachie Olorunfemi and Osanyinlusi J. Smith A. O. Ohaeri Ugbabe Grace	UIH 16154 UIH 16387 FHI 68554 FHI 28741 FHI 28741 FHI 28741 FHI 71415 FH 47291 FHI 49283 FHI 88331 FHI 392 NIPRDH 3568 FHI 106900	10/2/1974 3/4/1973 8/10/1973 26/11/1954 26/11/1954 August 1980 9/10/1974 15/11/1963 March1960 19/9/1978 15/9/1992 2/12/2003
Stereospermum acuminatissimum K. Schum	Old Idanre Sha Plateau Shasha Owena – Akure Shasha Mambila plateau Olokemeji F. R.	J. Lowe Wimbush and King Onyeachusim Ahmed and Chicea Latilo Chapman Ugbabe Grace	UIH 21358 FHI 57839 FHI 47851 FHI 24455 FHI 47851 FHI 31097 FHI 106904	1/5/1989 3/12/1965 4/7/1965 30/10/1948 12/9/1973 30/8/1971 2/12/1965
Stereospermum Kunthianum Cham	Mokwa Olokemeji Oyo-Iseyi Wood Eruwa-Abeokuta Borgu Tunga zomo and Tunga Giwa Nigeria Iseyin-Okeho Road Bauchi NIPRD Garden Nyanya-Abuja NIPRD Compound Airport Road Abuja Chaza- Suleja	J. Lowe Griffins Greig Smith Obgem E. U. Clifford C. Geerling J. Kennedy Ibhanesehor and Adejimi Z.O. Gbile and Daramola G. Ugbabe and J. Ibrahim G. Ugbabe Ohaeri A. O. Akeju/Ekutu/Odilis on Ugbabe Grace	UIH 3436 UIH 3434 UIH 586 FHI 68923 FHI 19737 FHI 10737 FHI 89557 FHI 51166 NIPRDH 5423 NIPRDH 5089 NIPRDH 3449 NIPRDH 3356 FH 1106903	15/2/1965 8/2/1966 April 1963 13/12/1955 18/11/1972 17/4/1928 3/5/1977 28/4/1972 17/3/2003 18/5/2001 13/2/1992 26/9/1990 24/9/2003
Tabebuia rosea (Bertol) D. C.	NISER U. I. Ibadan Ibadan Enugu Ile-Ife university U. I. Ibadan	B. Squo Gray and Ogbe Daramola Enwiogbon Fashola Ibhanesebhor and Ariwaodo Ugbabe Grace	UIH 20444 FHI 50887 FHI 47275 FHI 63140 FHI 105166 FHI 106901	March1984 14/11/1960 25/6/1963 28/1/1972 18/1/1994 12/12/03

mean epidermal size ranges from 16.4 µm in *M*. *tomentosa* to 37.2 µm in *K. africana*. The mean cell wall thickness ranges from 0.8 µm in *M. lutea, M. Tomentosa* and *O. indicum* to 1.9 µm in *C. cujete* (Table 4). Variations in the number of epidermal cells on both surfaces also occur. All species studied have more epidermal cells on the adaxial surface than on the abaxial surface (Table 4). All species are hypostomatic (with stomata restricted to the abaxial surface) (Table 5, Plate I and IV). The anomoaytic (epidermal cells around the guard cells not distinguishable from other epidermal cells) stomatal types are most prominent except in *K. africana*, which has dia-cytic stomata (Table 3, plate 1). The mean stomata num-ber varies from 18 in *T. stans* and 101 in *K. africana* (Ta-ble 5). The stomata index range from 7.6 in *T. stans* to 41.8 in *S. campanulata* (Table 5). Mean stomata length is in the range of 9.6 µm in *M. lutea* to 18.1µm in *T. rosea* and *K. africana* (Table 5). Mean stomata width also ranges from 9.6 µm in *M. lutea* and *S. kunthianum* to 16.8 µm in *K. africana*.

Table 1. Contd.

11. *Tecoma stans* (L) H. B & K	Abadina village U. I	J. A. Enwiogbon	UIH 11116	1/2/1956
	Ibadan	J. A. Emwiogbon	UIH 13446	6/2/1963
	FRIN Ibadan	Jones	FHI 147151	6/2/1963
	Ibadan	Fagbemi and	FHI 13871	27/10/1945
	Naragata game reserve	Soannyilusi	FHI 89874	11/3/1977
	Jos	Ibhaneshbor	FHI1066413	12/6/2002
	Idi – Araba Lagos	Ohaeri A. O.	NIPRDH 4034	12/11/1996
	NIPRD Compound	Ohaeri A. O.	NIPRDH 3077	26/7/1997
	NIPRD Compound	G. Ugbabe and J. Ibrahim	NIPRDH 5403	19/3/2003
	NIPRD Compound	Ohaeri A. O.	NIPRDH 3338	10/10/1991
	NIPRD Compound	Ohaeri A. O.	NIPRDH 4335	11/6/98
	Industrial Area	Ugbabe Grace.	FHI 106902	24/9/2003
	Idu – Abuja			
	NIPRD – Abuja			

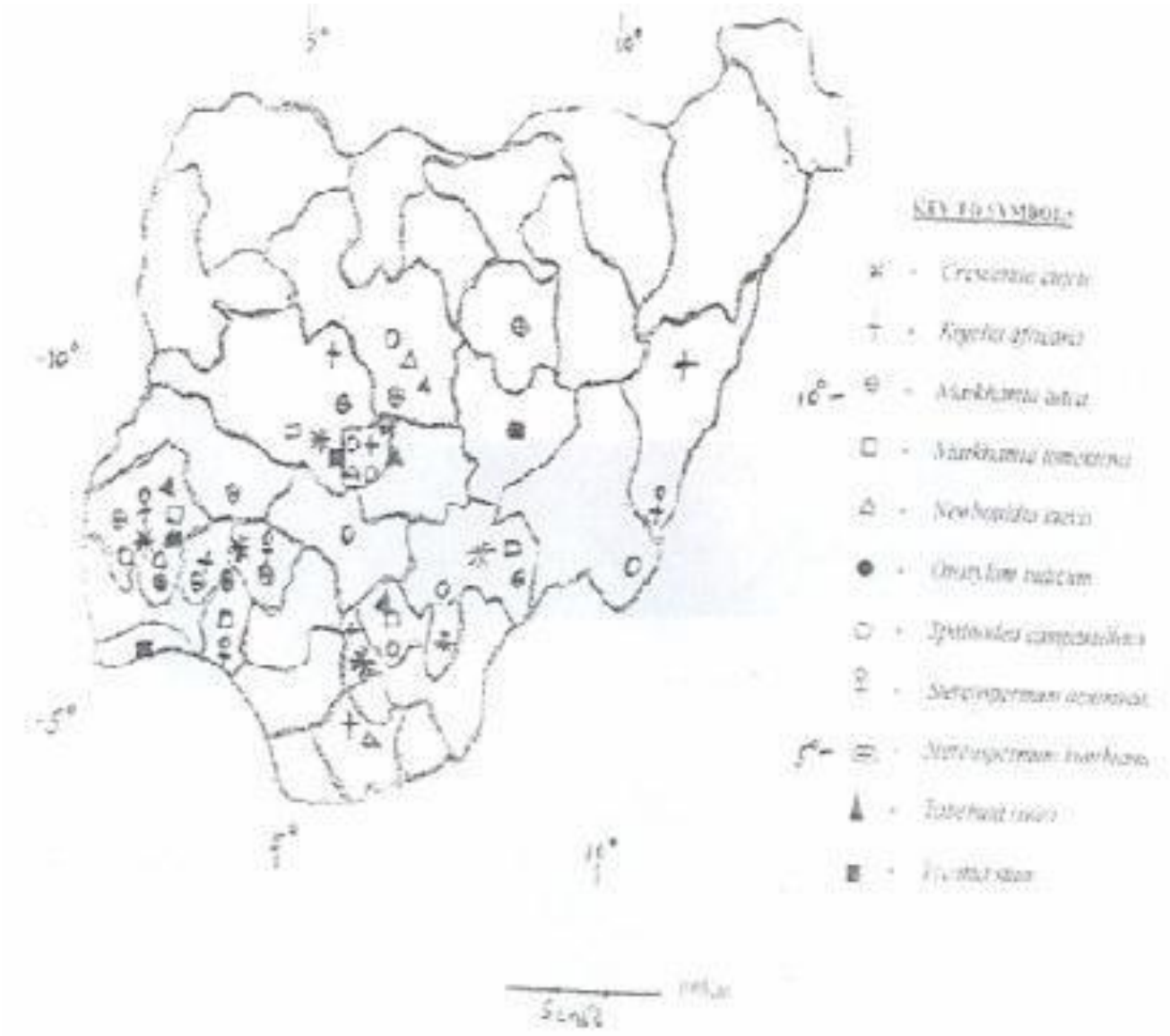


Figure 2. Map showing distribution of the Bignoniaceae in Nigeria.

Table 2. Qualitative and Quantitative Leaf Macromorphological Characters of the Family Bignoniaceae in Nigeria.

Genus /Species	Leaf Apex	Leaf Margin	Leaf Shape	Leaf Surface	Leaf Base	Leaflet length (cm)	Leaflet width at widest point (cm)	Petiolule length (cm)	Fruit Shape	Blade length / petiolule length	Leaflet length /leaflet width
Crescentia cujete	Acuminate	Entire	Obovate-lanceolate	Glabrous	Attenu-ate	4.8 (10.5±4.2) 14.5	2.5 (3.7±1.0) 5.4	1.0(1.4±0.3)1.6	Globose gourd-like (seeds not winged)	7:1	3:1
Kigelia Africana	Rounded or apiculate	Entire, slightly dentate-serrate in upper part	Ellipticoblong oblong-lanceleo-late	Glabrous	Attenuate Or Unequal sided	4.1(12.6±6.9) 22.8	2.5(5.7±3.0)10.6	0.2(0.5±0.3)1.1	Sausage-like (seeds not winged)	24:1	2:1
Markhamia lutea	Gradually acuminate	Serrate	Oblong, Oblong, Elliptic	Glabrous	Acuminate or cuneate	10.1(16.9±7.0)26.0	5.5(7.0±1.6)9.0	0.2(0.4±0.1)0.4	Elongated linear (seeds winged	45:1	2:1
Markhamia tomentosa	Gradually acuminate	Serrate	Oblong-elliptic or ovate	Pubescent	Shortly wedged at base or cuneate	7.4(13.5±5.9) 24.1	3.4(5.7±2.0)8.5	0.1(0.3±0.3)1.1	Elongated linear (seeds winged)	44:1	3:1
Newbouldia laevis	Long acuminate	Entire	Oblanceo-Late Broadly elliptic	Glossy	Rounded	9.0(14.2±2.6) 18.5	4.0(5.9±1.5)18.3	0.1(0.3±0.1)0.5	Elongated linear (seeds winged)	46:1	2:1
Oroxylum indicum	Long acuminate	Entire	Obovate	Glabrous or pubescent	Rounded	4.0(8.2±3.1)13.0	2.8(4.2±1.5)6.2	0.3(1.2±1.0)2.3	Absent	6:1	2:1
Spathodea campanulata	Gradually acuminate	Entire	Elliptic or oblong	Pubescent	Shortly cuneate	5.8(10.66±3.0)14.7	2.1(4.2±1.2)5.6	0.1(0.2±0.2)0.6	Elongated linear (seeds winged)	53:1	3:1
Stereosper -mum accuminatissi-mum	Long acuminate	Serrate, entire	Elliptic, oblong, oblanceo-late	Sparingly pubescent	Truncate	8.5(11.1±2.5) 15.7	2.3(3.8±1.0)5.2	0.1(0.6±0.6)1.8	Elongated linear (seeds winged)	18:1	3:1
Stereospermum kunthianum	Shortly acuminate	Entire, crenate-serrate	Oblong, Oblong-Elliptic	Softly pubescent	Cuneate	4.7(8.3±2.4)12.2	1.9(3.0±0.7)4.0	0.2(0.8±0.5)1.6	Elongated linear (seeds winged)	9:1	2:1
Tabebuia rosea	Gradually acuminate	Entire	Oblanceolate ovate	Glabrous	Acute	4.4(8.9±4.5)15.9	1.5(3.0±1.3)4.3	0.3(1.70±1.7)5.5	Absent	4:1	3:1
Tecoma stans	Gradually acuminate	Serrate	Lanceolate	Glabrous	Cuneate	5.0(7.7±2.1)11.2	1.1(2.0±0.6)2.9	0.1(0.3±0.3)1.1	Elongated linear (seeds winged)	25:1	4:1

Table 3. Qualitative leaf Macro characters of species of the family Bignoniaceae in Nigeria

Genus/Species	Shape of epidermal cell (adaxial)	Shape of epidermal cell (abaxial)	Anticlinal wall patter (adaxial)	Anticlinal wall patter (abaxial)	Stomatal type (adaxial)	Stomatal type (adaxial)
Crescentia cujete	Polygonal	Polygonal	Straight/curved	Straight/curved	Absent	Anomocytic
Kigelia africana	Irregular	Irregular	Undulate/sinuate	Curved/undulate	Absent	Diacytic
Markhamia lutea	Irregular	Irregular	Wavy/undulate/sinuate	Undulate/sinuate	Absent	Anomocytic
Markhamia tomentosa	Irregular	Irregular	Curved/undulate	Curved/wavy	Absent	Anomocytic
Newbouldia laevis	Irregular	Irregular	Straight/curved/undulate	Curved/undulate/sinuate	Absent	Anomocytic
Oroxylum indicum	Irregular	Irregular	Straight/curved/undulate	Curved/undulate/sinuate	Absent	Anomocytic
Spathodea campanulata	Irregular	Irregular	Curved/wavy	Curved/wavy	Absent	Anomocytic
Stereospermum accuminatissimum	Irregular	Irregular	Curved/undulate	Curved/wavy	Absent	Anomocytic
Stereospermum kunthianum	Irregular	Irregular	Curved/undulate	Wavy/undulate with knobs	Absent	Anomocytic
Tabebuia rosea	Polygonal	Irregular	Straight/curved	Straight/curved /undulate	Absent	Anomocytic
Tecoma stans	Irregular	Irregular	Curved/undulate	Curved/undulate	Absent	Anomocytic

Table 4. Quantitative leaf micro morphological characters of the Bignoniaceae in Nigeria.

Genus/species	Surfaces	No. of epidermal cells per mm^2	Size of epidermal cell at widest point (µm)	Thickness of cell wall (µm)
Crescentia cujete	upper surface	255 (313 ± 33.3) 360	12.8 (24.0 ± 4.6) 30.4	1.6(.16±0) 1.6
,, ,,	Lower surface	150 (223 ±34.1) 320	15.2 (27.6 ± 10.1) 56.0	0.8(1.9±0.5) 2.4
Kigelia africana	upper surface	43 (109 ± 26.4) 154	27.2(37.2±6.4) 52.8	0.8(0.9±0.2) 1.6
,, ,,	Lower surface	16 (43 ±12.9) 67	17.6(31.2±11.7) 46.4	0.8(1.2±0.3) 2.4
Markhamia lutea	upper surface	414 (600 ± 99.5) 810	12.0(19.2±3.5) 28.0	0.8(0.8±0). 0.8
,, ,,	Lower surface	180 (247 ± 39.9) 323	11.2(17.2±3.8) 23.2	0.8(0.8±0) 0.8
Markhamia tomentosa	upper surface	572 (847 ± 110.2) 1020	13.6(16.4±1.7) 20.8	0.8(1.2±0.4) 1.6
,, ,,	Lower surface	289 (400 ± 91.9) 601	12.0(20.0±4.6) 25.6	0.8(0.8±0) 0.8
Newbouldia laevis	upper surface	361 (455 ± 44.7) 552	13.6(20.4±3.2) 24.0	0.8(1.4±0.3) 1.6
,, ,,	Lower surface	176 (247 ± 43.2) 320	16.0(23.6±5.1) 32.0	0.8(0.9±0.3) 1.6
Oroxylum indicum	upper surface	357 (459 ± 69.5) 600	12.8(23.6±7.2) 51.2	0.8(0.9±0.3) 1.6
,, ,,	Lower surface	169 (225 ±45.5) 360	12.0(19.2±3.3) 25.6	0.8(0.8±0.0) 0.8
Spathodea campanulata	upper surface	188 (240 ± 28.4) 288	23.2(29.2±4.4) 36.0	0.8(1.3±0.4) 1.6
,, ,,	Lower surface	69 (100 ± 33.4) 200	24.0(34.4±8.2) 54.4	0.8(1.2±0.4) 1.6
S. acuminatissimum	upper surface	256 (329 ± 43.5) 425	19.2(24.8±3.3) 31.2	0.8(0.9±0.3) 1.6
,, ,,	Lower surface	180 (273 ± 46.5) 357	19.2(29.6±8.7) 53.6	0.8(1.1±0.4) 1.6
Stereospermum kunthianum	upper surface	196 (269 ± 46.1) 378	19.2(28.0±3.4) 32.0	0.8(1.2±0.4) 1.6
,, ,,	Lower surface	156 (246 ± 60.0) 352	18.4(26.45. ±2) 38.4	0.8(1.2±0.4) 1.6
Tabebuia rosea	upper surface	260 (478 ±91.9) 672	8.0(22.8±3.8) 32.0	0.8(1.41±0.4) 2.4
,, ,,	Lower surface	255 (259 ± 95.00 550	12.8(20.8±3.4) 28.8	0.8(1.5±0.3) 2.4
Tecoma stans	upper surface	240 (236 ± 46.5) 399	20(24.0±3.9) 36.0	0.8(0.9±0.3) 1.6
,, ,,	Lower surface	154 (219 ± 45.3) 328	14.4(26.0±5.2) 36.0	0.8(1.0±0.1) 1.6

Minimum (Mean ± Standard error) Maximum. All measurement in microns.

Table 5. Leaf micro morphological characters of the family Bignoniaceae in Nigeria.

Genus/Species	Surfaces	No. of stomata per mm^2	Length of stomata µm)	Width of stomata (µm)	Stomata Index (S.I) Percent (%)
Crescentia cujete	upper Surface	Absent	Absent	Absent	Absent
,, ,,	Lower surface	17 (27 ± 5.1) 36	13.6(16.8±2.0) 20.0	11.2(12.8±1.3) 16.0	10.8
Kigelia africana	upper surface	Absent	Absent	Absent	Absent
,, ,,	Lower surface	78 (101±14.4) 132	14.4(18.0±1.4) 20.0	14.4(16.8±1.1) 19.2	31.2
Markhamia lutea	upper surface	Absent	Absent	Absent	Absent
,, ,,	Lower surface	25(52±10.2) 70	10.4(9.6±1.6) 17.6	6.4(9.6±1.8) 15.2	17.3
Markhamia tomentosa	upper surface	Absent	Absent	Absent	Absent
,, ,,	Lower surface	36(46±7.4) 58	10.4(14.4±1.8) 17.6	7.2(10.4±2.1) 16.8	10.3
Newbouldia laevis	upper surface	Absent	Absent	Absent	Absent
	Lower surface	39(58±12.5) 100	11.2(13.2±10.3) 16.0	8.8(10.8±1.4) 15.2	19.3
Oroxylum indicum	upper surface	Absent	Absent	Absent	Absent
,, ,,	Lower surface	39(58±14.8) 98	10.4(14.8±1.9) 18.4	8.0(10.4±2.0) 15.2	20.5
Spathodea campanulata	upper surface	Absent	Absent	Absent	Absent
,, ,,	Lower surface	50(71±17.3) 112	12.0(16.4±2.2) 19.2	8.0(10.4±1.3) 13.6	41.8
Stereospermum accuminatissimum	upper surface	Absent	Absent	Absent	Absent
,, ,,	Lower surface	24(33±5.4) 42	12.0(16.0±2.6) 20.0	8.0(10.0±10.6)14.2	10.8
Stereospermum kunthianum	upper surface	Absent	Absent	Absent	Absent
,, ,,	Lower surface	20(30±5.9) 44	14.4(16.0±1.2) 18.4	8.0(9.6±1.5) 11.2	10.9
Tabebuia rosea	upper surface	Absent	Absent	Absent	Absent
	Lower surface	21(33±7.2) 49	13.6(18.0±4.0) 30.4	8.8(16.4±5.2) 30.4	8.4
Tecoma stans	upper surface	Absent	Absent	Absent	Absent
	Lower surface	12(18±3.1) 24	14.4(17.6±1.7) 20.0	8.0(14.8±2.3) 20.0	7.6

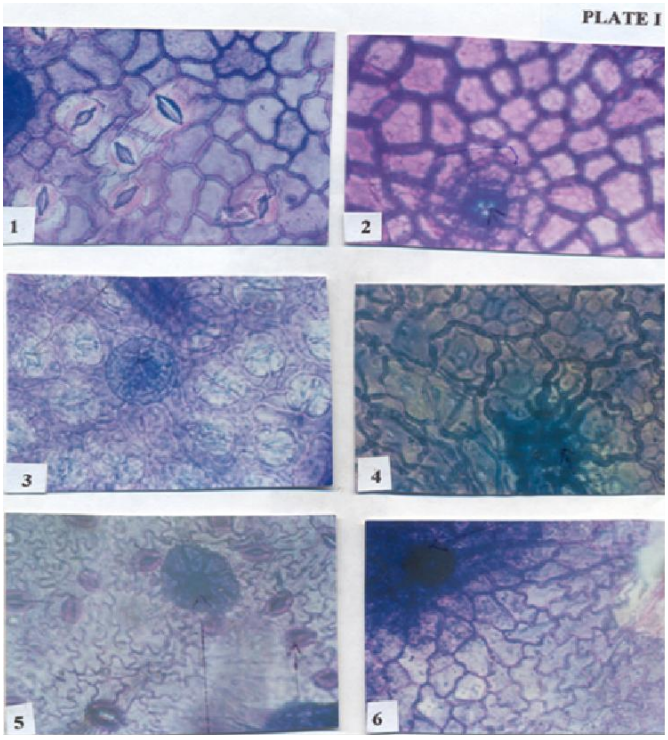
Minimum (Mean ± Standard error) maximum. All measurement in microns.

Trichome bases are present in all species studied occurring on both surfaces (abaxial and adaxial). Striae are present on the adaxial surface of *O. indicum* and abaxial surface of *S. campanulata.* Knobs are present on the abaxial and adaxial surfaces *of M. lutea, M. tomentosa,* and on the abaxial surface of *S. acuminatissimum* and *S. Kunthianum* (Plates I, II and III).

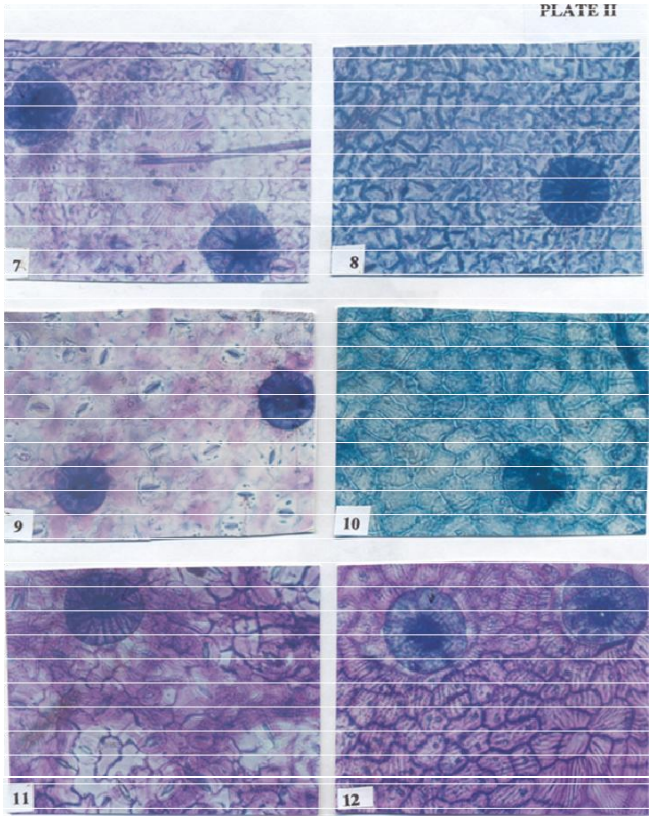
DISCUSSION

The species of the family studied show considerable variation in the quantitative macromorphological characters of the leaf (Table 2 and Figure 1). The leaf apex, fruit nature and fruit shape show more uniformity (elongate - linear) except in *C. cujete* and *K. africana* which are gourd like and sausage like respectively. The leaf margin is either entire, serrate or a combination of both (Table 2 and Appendix 1).

The leaf shape is variable, from elliptic, oblong, obovate, ovate to oblong-elliptic and oblanceolate. These variations occur even within each genus. The epidermal cell shape is irregular with undulate walls in all indigenous species studied while introduced species like *C. cujete* and *T. rosea* have polygonal epidermal cells with straight to curved walls. However, other introduced species like *O. indicum* and *T. stans* have irregular epidermal cells with undulate cell wall pattern (Table 3). The anticlinal walls are more sinuous on the abaxial than on the adaxial surface of the same leaf (Table 3 and Plates I-IV). The epidermal cells walls also vary in size and wall thick-



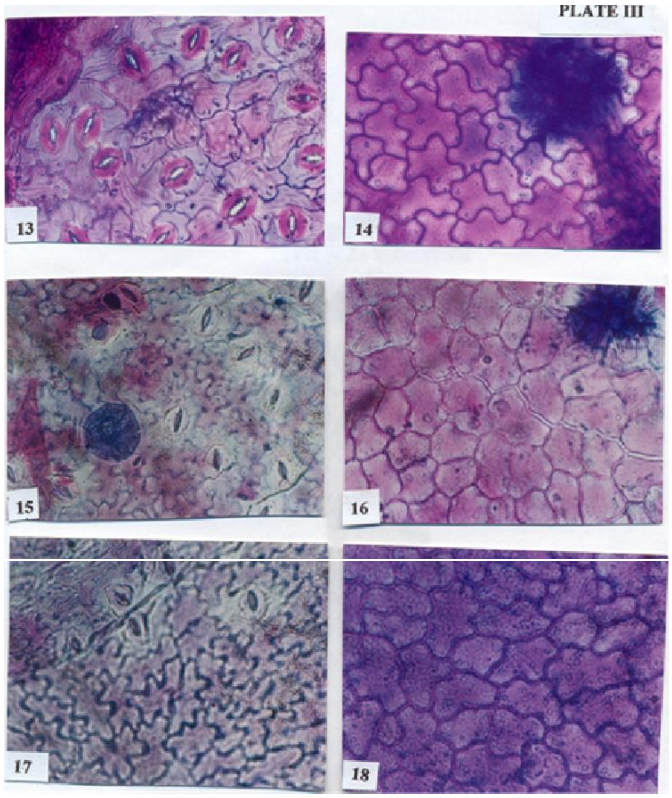
Plates 1 – 6 showing Photomicrographs of leaf surface in the family Bignoniaceae in Nigeria. Plate 1and 2. *Crescentia cujete.* Plate1, Abaxial surface showing polygonal cells with straight to curved anticlinal walls and anomocytic stomata. Plate 2. Adaxial surface showing polygonal cells with straight to curved anticlinal walls and no stomata. Plates 3 and 4. *Kigelia Africana.* Plate3. Abaxial surface showing irregular cells with curved to slightly undulate anticlinal walls and diacytic stomata and trichome base. Plate 4 Adaxial surface showing curved to slightly irregular cells with curved to wavy anticlinal walls with no stomata but have trichome base. Plates 5 and 6. *Markhamia lutea.* Plate 5. Abaxial surface showing irregular cells with ano-mocytic stomata and wavy anticlinal walls, and trichome bases. Plate 6. Adaxial surface with irregular and wavy anticlinal walls, undulate / wavy anticlinal cell walls and no stomata and with knobs on the cell wall and trichome base (All Plates X 400).



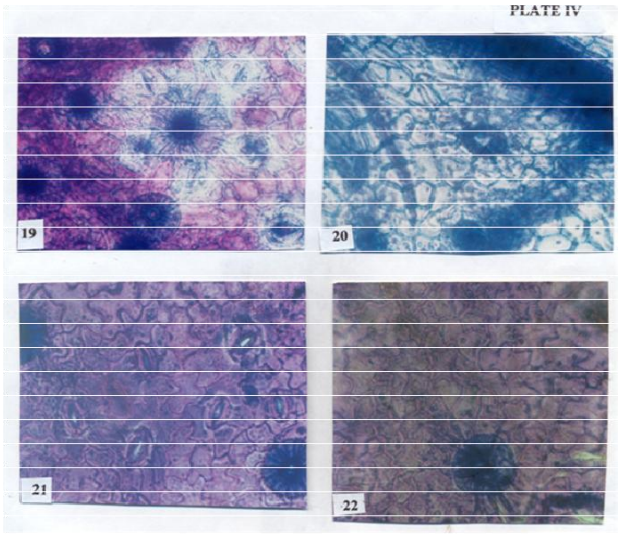
Plates 7 - 12. Showing Photomicrographs of leaf surface in the family Bignoniaceae in Nigeria. Plates 7 and 8 *Markhamia tomentosa.* Plate 7. Abaxial surface showing irregular cells with wavy/undulate anticlinal walls, anomocytic stomata and trichome bases. Plate 8 Adaxial surface showing irregular cells with undulate/wavy anticlinal walls and no stomata but with trichome bases. Plates 9 and 10 *Newbouldia laevis.* Plate 9. Abaxial surface showing irregular cells with wavy/undulate walls, anomocytic stomata and with trichome bases. Plate 10. Abaxial surface with polygonal cells with straight to curved anticlinal walls, no stomata but with trichome bases. Plates 11 and 12. *Oroxylum indicum.* Plate 11. Abaxial surface showing irregular cells with curved to undulate/wavy anticlinal wall, anomocytic stomata and trichome bases. Plate 12. Adaxial surface showing polygonal or irregular cells with curved to wavy anticlinal walls, no stomata but have trichome bases and striae. (All plates X 400).

ness in different parts of the same leaf as observed by Rudall (1992) . The largest mean size of the epidermal cell at widest point was recorded in *K. africana* (37.2 ± 6.4 µm) and the smallest in *M. tomentosa* (16.4 ±1.7 µm) on the adaxial surface (Table 4). *S. campanulata* has the largest mean size of epidermal cells (34.4 ± 8.2 µm) and *M. lutea* has the smallest (17.2 ± 3.8 µm) on the abaxial surface. The species with the thickest cell wall is *C. cujete* (1.6 ± 0 µm) on the adaxial surface and 1.9 ± 0.5 µm on the abaxial surface. While the thinnest cell wall of 0.8 ± 0 µm occur in *M. lutea*, *M. tomentosa*, and *O. indicum* on the abaxial surface. According to Rudall (1992) large epidermal cells with thin walls are adaptation for water storage.

The shape, size and cell wall thickness of the species studied exhibit a wide range of variation. According to Sheteolu and Ayodele (1997) these are genotypic in nature, which in many cases have definite taxonomic application. The mean number of epidermal cells per view (X 400) is highest in *M. tomentosa* (847 ±110) and lowest in *K. africana* (109 ± 26.4) on the adaxial surface. On the abaxial surface the highest was still recorded on *M. tomentosa* (400 ± 92) and the least on *K. africana* 43 ± 13 (Table 4) . Generally, there are more epidermal cells per view on the adaxial surface than on the abaxial, surface (Table 4). But according to Metcalfe and Chalk (1979), the epidermal cells vary considerably in size, shape and orientation in different parts of the lamina of a single leaf, e.g there are often marked diffe-rences between, epidermal cells overlying the veins and



Plates 13 – 18. Showing Photomicrographs of leaf surface in the family Bignoniaceae in Nigeria. Plates 13 and 14. *Spathodea Campanulata.* Plate 13. Abaxial surface showing irregular cells with undulate anticlinal walls, anomocytic stomata and striae present. Plate 14. Adaxial surface showing irregular cells with undulate anticlinal walls, no stomata but with trichome bases. Plates 15& 16. *Stereospermum acuminatissimum.* Plate 15. Abaxial surface showing irregular cells with undulate/wavy anticlinal walls, anomocytic stomata and trichome bases present. Plate 16. Adaxial surface with irregular cells with curved to undulate anticlinal walls, no stomata but have trichome bases. Plates 17 and 18. *Stereospermum Kunthianum.* Plate 17. Abaxial surface with irregular cells with wavy anticlinal walls, anomocytic stomata and knobs present. Plate18. Adaxial surface with irregular cells with curved to undulate anticlinal walls and no stomata. (All Plates X 400).



Plates 19-22. Showing Photomicrographs of leaf surfaces in the family Bignoniaceae in Nigeria. Plates 19 and 20. *Tabebuia rosea.* Plate 19. Abaxial surface showing irregular cells with curved to undulate anticlinal walls, anomocytic stomata, trichome bases and scales present. Plate 20. Adaxial surface showing polygonal cells with straight to curved anticlinal walls, no stomata but have trichome bases. Plates 21 and 22. *Tecoma stans.* Plate 21 Abaxial surface showing irregular cells with undulate/wavy anticlinal walls, anomocytic stomata and trichome bases present. Plate 22. Adaxial surface showing irregular anticlinal walls, no stomata but have trichome bases (All Plates X 400).

those situated above the mesophyll between the veins. Epidermal cells formed near the leaf margins are often quite different in appearance from that elsewhere. These local differences make it important that comparisons are the leaf surface, when cell shape and size are being used for diagnostic or taxonomic investigations.

Striations occur on the adaxial surface of *O. indicum* and on the abaxial surface of *S. campanulata* and are of taxonomic importance. According to Mueller (1966), leaf surface patterns have been shown to be under strong genetic control and that environment has little or no influence on the appearance of the leaf surface. Striations on these two species distinguish them from the others.

The presence of knobs on the adaxial surface of *K. africana, M. tomentosa M. lutea, S. acuminatissimum* and *S. kunthianum* can be used to distinguish them from the other species in the family.

The leaves are hypostomatic. Anomocytic stomata ty-pes were observed in all species except *K. afriana***,** which has diacytic stomata. The largest stomata size was rec-orded in *K. africana* (18.9 ± 1.4 x 16.8 ± 1.1 µm), which has the lowest number of epidermal cell per view (109 ± 26.4); while the smallest stomata size is found in *M. lutea* (9.6 ± 1.6 x 9.6 ± 1.9 µm). According to Wilkinson (1979), shade or humid atmosphere and moist condition are known to correlate with smaller stomata, while full sunlight and drier condition seems to produce larger stomata size. *M. lutea* is found in humid environment while *K. africana* is found in a more or less drier environment. The shape of the guard cells is useful being usually constant within species (Sheteolu and Ayodele, 1997). Those of *K. africana* and *Tabebuia rosea* are circular while in other species they are elliptic (Plates 1 - 22) . Stomata index and stomata numbers overlap (Table 5), hence of no taxonomic importance in this study.

Trichome bases are found on both the abaxial and adaxial surfaces of all species studied (Plate I - IV) and are multi-serrate with modified trichomes foot or attachment, which are radial. The Trichome bases also have relatively large lumina and fairly thick walls. Trichome scales are present on the abaxial surface of *T. rosea*. Scales are specially adapted for water absorption.

This feature can be used to distinguish *T. rosea* from the other species.

Appendix 1. Summary of major characteristics of the family Bignoniaceae in Nigeria.

S/No	Genus/Species	Leaf shape	Leaf Apex	Leaf base	Leaf surface	Leaf margin	Epidermal cell shape	Cell wall pattern abaxial	Cell wall pattern adaxial	Stomata type abaxial	Stomata type adaxial	Stomata index	Stomatal distribution	Trichomes
1	*Crescentia cujete*	G	B	A	A	A	B	B	C,E	C	B	B	A	C
2	*Kigelia africana*	A,F,C	A,C	A	A	A,D	A	A	D,E	E	A	C	A	C
3	*Markhamia lutea*	B,F	B	B,D	B	D	A	A	A	A	A	B	B	C
4	*Markhamia tomentosa*	F	B	D	A	D	A	A	A	E	A	B	A	C
5	*Newbouldia laevis*	A,C	B	A	C	A,D	A	A	E	E	A	B	A	C
6	*Oroxylum indicum*	D	B	A	A,B	A	A,B	A	E	D,E	A	C	A	C
7	*Spathodea campanulata*	A,C	B	D	B	A	A	A	A	A	A	C	A	C
8	*Stereospermum accuminatissimum*	B,F	B	E	B	A,D	A,B	A	A	C,E	A	B	A	C
9	*Stereospermum kunthianum*	B,F	B	D	B	A,D	A	A	A	D,E	A	B	A	C
10	*Tabebuia rosea*	C,E,C	B	B	A	A	B	A,B	A,B,E	B,C	A	A	A	C
11	*Tecoma stans*	A	B	D	A	B	A	A	A,C	A	A	A	A	C

KEY: 1. Leaf Shape: A – Elliptic, B – Oblong, C – Oblanceolate, D – Obovate, E – Lanceolate, F - Oblong-Elliptic, G - Obovate-Lanceolate, H – Ovate. **2. Leaf Apex:** A – Rounded, B – Acuminate, C – Apiculate, D – Cuneate. **3. Leaf base:** A - Unequally-sided, B – Cuneate, C – Rounded, D – Cordate, E – Acute. **4. Leaf Surface:** A – Glabrous, B – Pubescent, C – Glossy. **5. Leaf Margin:** A – Entire, B – Undulate, C - Slightly undulate, D – Slightly Serrate. **6. Epidermal cell shape:** A – Irregular, B – Polygonal. **7. Epidermal cell wall pattern:** A – undulate, B – Straight, C – Curved, D - Slightly curved, E - Slightly undulate, F - Markedly undulate. **8. Stomata type:** A – Anomocytic, B – Paracytic, C – Cyclocytic. **9 Stomata distribution:** A – Hypostomatic, B – Hypoamphistomatic. **10 Stomatal Index:** A - Less than 10, B - Greater than 10 less than 20, C - Greater than 20. **11. Trichomes:** A - Present on Abaxial surface only, B - Present on Abaxial surface only, C - Percent on both surfaces.

Conclusions

The result of this study largely supports the delimitation of the taxa of the family by Hutchinson and Dalziel (1954). However, the status of C. cujete in the family needs further investigation. As with other morphological characters, the possession of simple and whorled leaves, globose fruits and polygonal epidermal cells with straight and curved anticlinal walls on both surfaces of the leaf easily separate the species from others in the family.

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