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Structural Variation of Stomata in Some Dicotyledonous Trees

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ABSTRACT
24 tree taxa distributed in 13 orders and 14 families were documented on the nature and structure of stomata. The epidermis cells are generally arched has found in 15 taxa, the remaining 9 taxa with wavy epidermal cells. Anomocytic, anisocytic, paracytic and mixed stomata complex with preponderance of solely anomocytic type in 13 taxa were observed. Stomata size ranging from 10.08µm±0.16 x 7.06µm±0.10 in *Cleistanthus polystachyus* to 29.57µm±0.24 x 16.80µm± 0.18 in *Barteria nigritiana* and stomata index values varying from 1.06% in *Canarium schweinfurthii* to 17.35% in *Carpolobia lutea* were recorded in this study.

Keywords: Leaf Epidermis, Stomata Type and Size, Dicotyledonous Trees.

INTRODUCTION
Trees form a conspicuous part of the Nigerian floristic scenery. In terms of composition, the Nigerian flora consists of more than 900 indigenous and naturalized tree forms (Keay et. al., 1964a, b). Though, recent records depict abysmal number of 560 indigenous and naturalized tree species in Nigeria due to deforestation and poor tree management practices (Gani, 2011).
Utility value of trees include provision of green fertilizer for agriculture, air, soil and water conservation, erosion control, as sun and wind breakers, fodder, fuelwood, timber afforestation, food uses, medicinals, industrial raw materials and other uses (Agboola and Adedire, 1998, Schreppers *et. al.*, 1998). Trees are also useful as comprehensive greenery in floricultural landscaping activities, which is an organized tree planting process promoting aesthetics and sustaining cooling comfort of the environment (Al Menie *et. al.*, 2009).
Stomata serve for gaseous communication between the internal and external environments of an higher green plant (Swarthout, 2008). Stomata are minute functional pores on the leaf and some stem epidermis (Roberts, 1978). Physiological functions like photosynthesis, respiration and transpiration takes place with the help of stomata, as it is through them that inter-change of gases such as oxygen, carbon-dioxide and also water vapour passes between the inter-cellular space of the internal tissues of the higher green plant and the outer atmosphere (Pandey and Chadha, 2008). Stomata can also be diagnostic as a systematic tool in the classification of problematic higher plants taxa (Ogbe and Osawaru, 1988).
Earlier contributors to phytodermology and stomata studies of dicotyledonous plants world wide include Metcalfe and Chalk (1950a, b. 1979). Camargo and Marenco (2011) reported stomatal features in 35 rainforest tree species in Central Amazonia, South – America. In Nigeria, Karatela and Gill (1983) studied leaf epidermal features of both Cocoa and Cola trees. Karatela and Gill (1985) on *Irvingia* species, Gill and Nyawuame (1990) recorded stomata features of some Nigerian Bicarpellatae trees. Idu *et. al.*, (2000) reported stomata structure of some Fabaceae trees. Kadiri and Ayodele (2003) studied epidermal features of *Rauvolfia*. Ogundipe and Wujek (2004)- Bignoniaceae. Folorunso et. al., (2009)- Bombaceae, Kadiri et al., (2011) on *Uapaca* species. In spite of the importance of the stomata apparatus in plant physiology and taxonomy, information on it's structure and size on Nigerian tree is scanty. This study provides additional reports on the structure and size of stomata in some Nigerian dicotyledonous trees.

MATERIALS AND METHODS
Leaf specimens collected, identified at Forest Herbarium Ibadan (FHI) and later deposited as voucher materials at the University of Benin herbarium were used for the study. The designations H10 and HORW are voucher specimens from Okomu oil palm and lyanomo rubber plantations respectively by Onyibe (1987, 1990). OBM collections were by the present authors, all collections within Edo State, Nigeria.
Abaxial leaf surface records only were taken because of confinement constancy of stomata on lower leaf surface. The leaf portions were de-colourised by immersion in 90% alcohol and were washed in 5 changes of distilled water after which the leaf portionswere kept in a beaker of 5% sodium hydroxide solution immersed in a water bath at 100^0Celsius for ten minutes to further enhance leaf de-colourisation and later washed in 5 changes of water after which they were mounted at uniform magnification of X400.
Terminologies of stomata complex types used after Metcalfe and Chalk, (1950a, b, 1979), Rasmussen (1981). Size measurements were carried out on 50 stomata for each taxon investigated with ocular graticule using a Swift collegiate 4,000 light microscope. Number of stomata per field of view was recorded. Stomata index after Dilcher 1974 were calculated as a percentage of the number of stomata to total number of epidermal cells plus stomata per unit area.

$$\text{S.I} = \frac{S}{E+S} x \frac{100}{1}$$

For statistical analysis, Standard error was determined for all taxa.

RESULTS

Qualitative and Quantitative Stomata Characters of the Dicotyledonous trees reports after Hutchinson and Dalziel (1954, 1958, 1963) phylogenetic sequence as recorded in the Flora of West Tropical Africa (F. W. T. A.).

Table 1: Qualitative Stomata Characters of the Dicotyledonous Trees

S/N	Taxon	Voucher Material	Epidermal Cell	Stomata Type
1.	Order Polygalales Family Polygalaceae *Carpolobia lutea* G. Don.,	HIO-66	Wavy	Anomocytic
2.	Order Passiflorales Family Passifloraceae *Barteria nigritiana* Benth.,	HORW-122	Arched	Anomocytic
3.	Order Myrtales Family Combretaceae *Terminalia superba* Engls and Diels	HIO-173	Arched	Anomocytic
4.	Order Tiliales Family Sterculiaceae *Pterygota bequaertii* De Wild	HIO-94	Arched	Anomocytic and Paracytic
5.	Order Euphorbiales Family Euphorbiaceae *Hevea brasiliensis* Muell Arg.,	HIO-001	Arched	Anomocytic
6.	*Macaranga monandra* Muell Arg.,	HORW-058	Wavy	Anomocytic
7.	*Mallotus opposifolius* (Geisel) Muell. Arg.,	HIO-148	Arched	Anomocytic
8.	*Manihot glaziovii* Muell. Arg.,	HIO -80	Arched	Anomocytic
9.	*Ricinodendron heudelotii* (Baill;) Pierre ex Pax.,	HORW-192	Arched	Anomocytic
10.	Order Malphighiales Family Phyllanthaceae *Bridelia ferruginea* Benth.,	HORW-144	Arched	Anomocytic
11.	*Cleistanthus polystachus* Hook. F. ex Planch.,	HIO-35	Arched	Anomocytic
12.	Order Fabales Family Fabaceae Sub-family-Caesalpinoideae *Berlinia grandiflora* (Vahl.,) Hutch. And Dalz.,	OBM-20	Arched	Paracytic
13.	Sub-family Mimosoideae *Dichrostachys cinerea* (L.,) Wight and Arn.,	OBM-25	Arched	Paracytic
14.	*Pentaclethra macrophylla* Benth.,	HIO-133	Arched	Paracytic
15.	Sub-family Papilionoideae *Gliricidia maculata* (Jacq.,) Steudel	OBM-102	Arched	Anomocytic
16.	Order Urticales Family Moraceae *Milicia excelsa* (Welw.,) C. C. Berg	HORW-065	Wavy	Anomocytic, Diacytic and Paracytic
17.	Order Rutales Family Irvingiaceae *Irvingia gabonensis* (Aubry Leconte ex O Rorke) Baill.,	HORW-163	Wavy	Paracytic
18.	Family Burseraceae *Canarium schweinfurthii* Engl.,	HORW-146	Wavy	Anomocytic
19.	Order Apocynales Family Apocynaceae *Rauvolfia vomitoria* Afzel.,	HORW-114	Arched	Anomocytic
20.	*Voacanga africana* Stapf.,	OBM-45	Arched	Paracytic
21.	Order Rubiales Fmily Rubiaceae *Cuviera longiflora* Hiern	HORW-069	Wavy	Paracytic
22.	*Mitragyna ciliata* Aubrev and Pellegr.,	H10-114	Wavy	Paracytic and Diacytic
23.	Order Personales Family Bignoniaceae *Newbouldia laevis* (P. Beuv) Seeman ex Bur.,	HORW-073	Wavy	Anisocytic
24.	Order Lamiales Family Verbenaceae *Vitex ferruginea* Schum and Thonn.,	HIO-144	Wavy	Anomocytic and Anisocytic

Table 2: Quantitative Stomata Characters of the Dicotyledonous Trees.

S/N	Taxon	Stomata Length (µm± S.E.)	Stomata Breadth (µm± S.E.)	Pore size (µm± S.E.)	Stomata Per Field of View	Stomata Index Percentage
1.	Order Polygalales Family Polygalaceae *Carpolobia lutea* G. Don.,	17.14±0.20	17.81±0.21	8.40±0.12	42	17.35
2.	Order Passiflorales Family Passifloraceae *Barteria nigritiana* Benth.,	29.57±0.24	16.80±0.18	16.13±0.18	20	10.50
3.	Order Myrtales Family Combretaceae *Terminalia superba* Engls and Diels	16.13±0.20	12.26±0.24	8.90±0.18	10	16.6
4.	Order Tiliales Family Sterculiaceae *Pterygota bequaertii* De Wild	20.18±0.27	14.78±0.24	13.10±0.14	10	7.69
5.	Order Euphorbiales Family Euphorbiaceae *Hevea brasiliensis* Muell Arg.,	20.16±0.21	16.80±0.19	5.04±0.16	20	3.85
6.	*Macaranga monandra Muell. Arg.*,	22.34±0.32	13.44±0.18	20.16±0.22	10	14.20
7.	*Mallotus opposifolius* (Geisel) Muell. Arg.,	17.81±0.15	9.41±0.16	8.90±0.12	5	1.96
8.	*Manihot glaziovii Muell.* Arg.,	26.88±0.30	25.20±0.25	17.81±0.22	6	10.70
9.	*Ricinodenron heudelotii* (Baill.,) Pierre ex Pax	15.60±0.19	10.20±0.13	9.80±0.24	8	5.06
10.	Order Malphighiales Family Phyllanthaceae *Bridelia ferruginea* Benth.,	16.80±0.21	11.76±0.12	10.08±0.19	7	1.70
11.	*Clestanthus polystachus* Hook. F. ex Planch.,	10.08±0.16	7.06±0.10	7.73±0.11	200	16.60
12.	Order Fabales Family Fabaceae Sub-family-Caesalpinoideae *Berlinia grandiflora* (Vahl.,) Hutch and Dalz.,	22.51±0.25	10.20±0.13	9.80±0.24	8	5.06
13.	Sub-family Mimosoideae *Dichrostachys cinerea* (L.,) Wight and Arn.,	20.50±0.24	13.10±0.16	11.09±0.20	20	9.90
14.	*Pentaclethra ma crophylla* Benth.,	17.81±0.21	14.45±0.17	13.44±0.20	20	9.09
15.	Sub-family Papilionoideae *Gliricidia maculata* (Jacq.,) Steudel	22.81±0.25	14.78±0.20	11.76±0.17	12	5.79
16.	Order Urticales Family Moraceae *Milicia excelsa* (Welw.,) C. C. Berg	18.48±0.24	1680±0.21	13.44±0.20	4	5.66
17.	Order Rutales Family Irvingiaceae *Irvingia gabonensis* (Aubry Leconte ex. O. Rorke) Baill.,	18.48±0.28	12.10±0.18	11.42±0.22	12	7.40
18.	Family Burseraceae *Canarium schweinfurthii* Engl.,	24.63±0.22	13.94±0.19	17.30±0.24	3	1.06
19.	Order Apocynales Family Apocynaceae *Rauvolfia vomitoria* Afzel.,	29.06±0.28	10.08±0.19	6.72±0.16	7	2.28
20.	*Voacanga africana* Stapf.,	26.88±0.22	19.49±0.23	17.14±0.17	22	15.00
21.	Order Rubiales Family Rubiaceae *Cuviera longiflora* Hiern	22.85±0.19	13.44±0.15	13.78±0.13	6	7.4
22.	*Mitragyna ciliata* Aubrev and Pellegr.,	32.42±0.21	16.13±0.21	15.62±0.18	10	10.00
23.	Order Personales Family Bignoniaceae *Newbouldia laevis* (P. Beauv.) Seeman ex Bur.,	17.81±0.22	14.78±0.26	11.42±0.15	10	6.25
24.	Order Lamiales Family Verbenaceae *Vitex ferruginea* Schum and Thonn.,	25.54±0.29	18.82±0.31	18.48±0.24	11	10.89

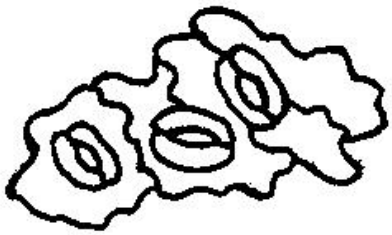

Figure 1: *Carpolobia lutea*: Anomocytic Stomata

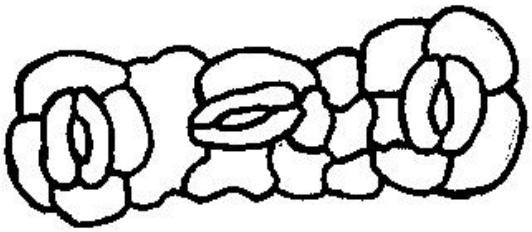

Figure 2: *Barteria nigritiana*: Anomocytic Stomata

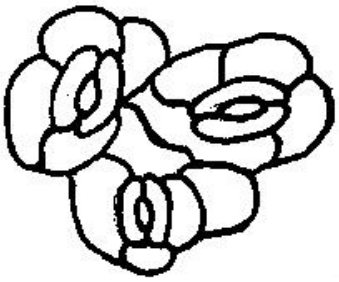

Figure 3: *Terminalia superba*: Anomocytic Stomata

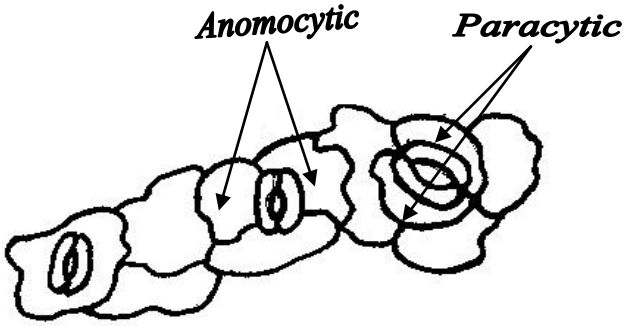

Figure 4: *Pterygota bequaertii*: Anomocytic and Paracytic Stomata

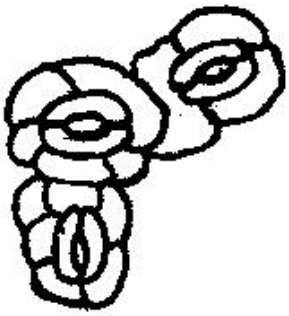

Figure 5: *Hevea brasiliensis*: Anomocytic Stomata

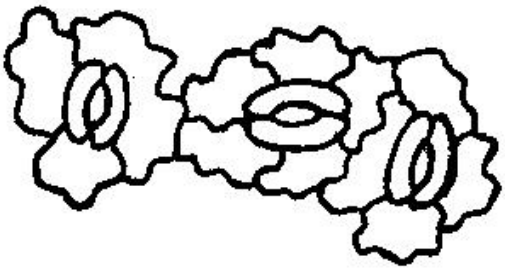

Figure 6: *Macaranga monandra*: Anomocytic Stomata

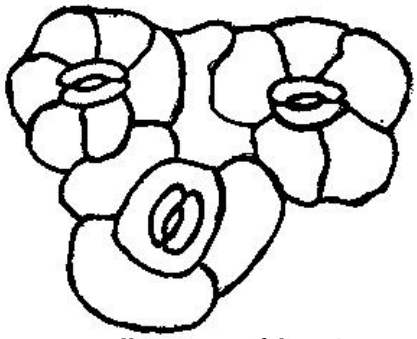

Figure 7: *Mallotus opposifolius*: Anomocytic stomata

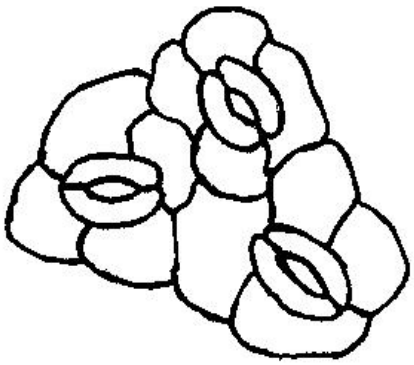

Figure 8: *Manihot glaziovii*: Anomocytic Stomata

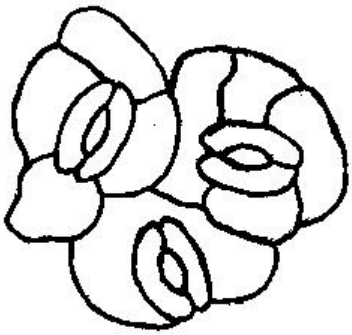

Figure 9: *Ricinodenron heudelotii*: Anomocytic Stomata

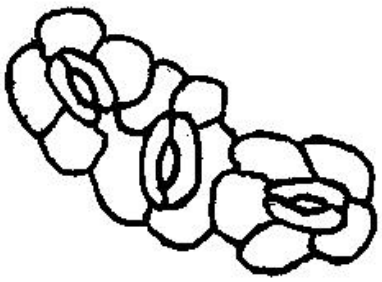

Figure 10: *Bridelia ferruginea*: Anomocytic Stomata

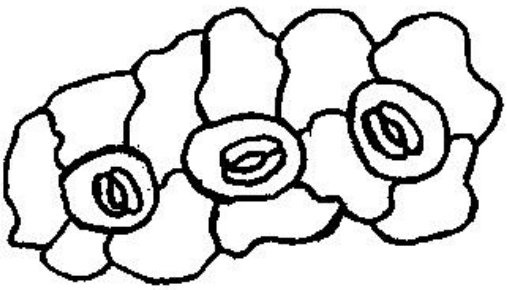

Figure 11: *Cleistanthus polystachus*: Anomocytic stomata

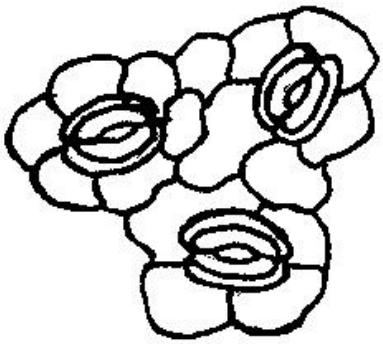

Figure 12: *Berlinia grandiflora*: Paracytic Stomata

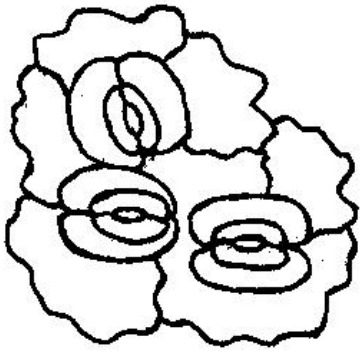

Figure 13: *Dichrostachys cinerea*: Paracytic Stomata

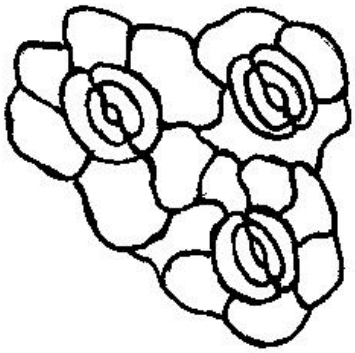

Figure 14: *Pentaclethra maacrophylla*: Paracytic Stomata

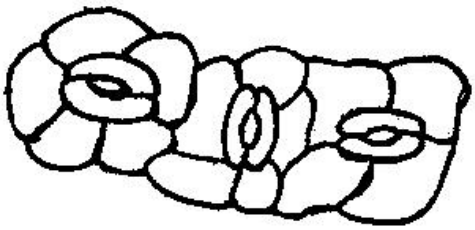

Figure 15: *Gliricidia maculata*: Anomocytic Stomata

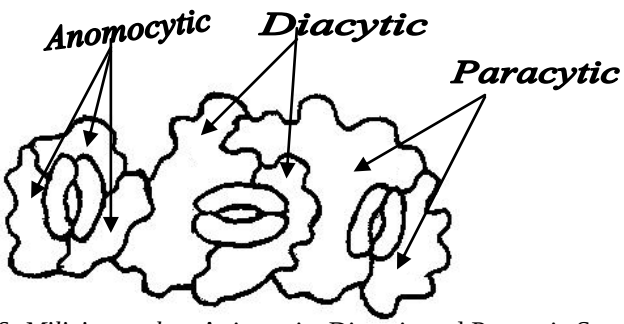

Figure 16: *Milicia excelsa*: Anisocytic, Diacytic and Paracytic Stomata

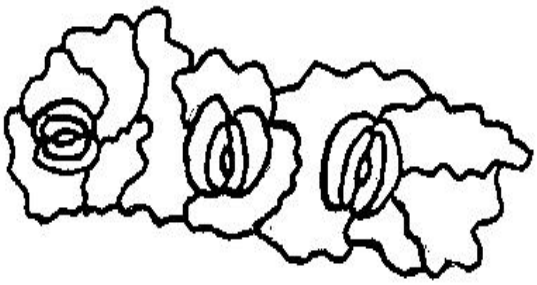

Figure 17: *Irvingia gabonensis*: Paracytic Stomata

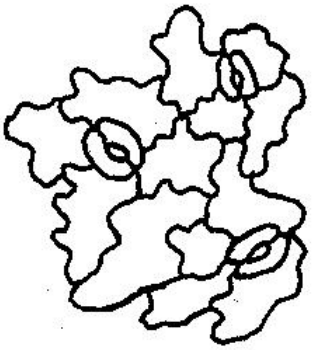

Figure 18: *Canarium schweinforthii*: Anomocytic Stomata

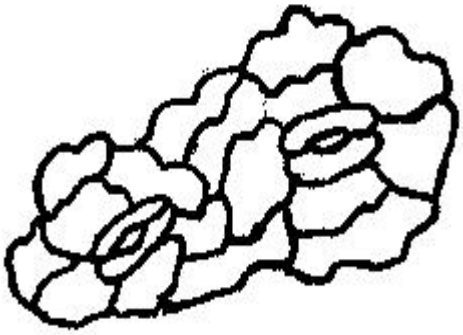

Figure 19: *Rauvolfia vomitoria*: Anomocytic Stomata

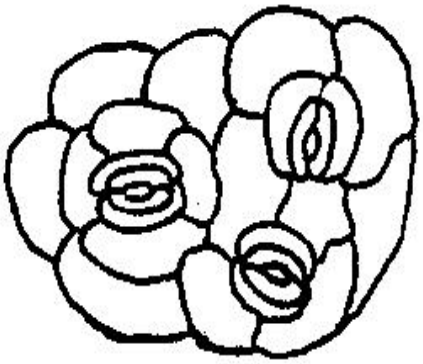

Figure 20: *Voacanga africana*: Paracytic Stomata

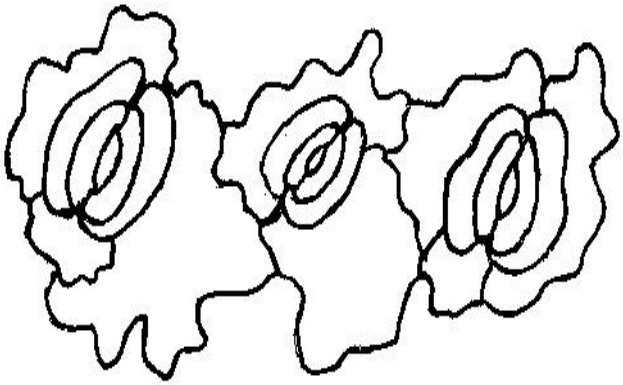

Figure 21: *Cuviera longiflora*: Paracytic Stomata

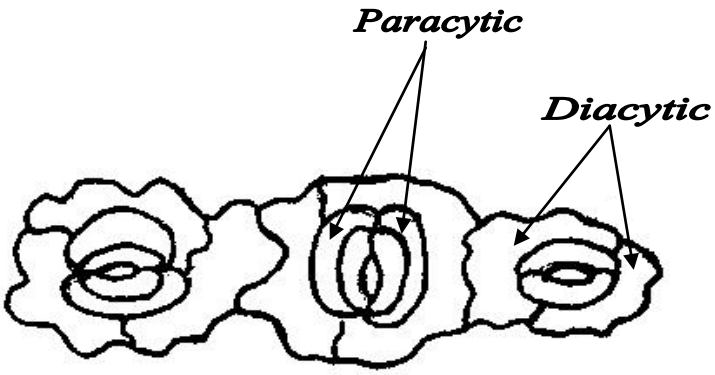

Figure 22: *Mitragyna ciliata*: Paracytic and Diacytic Stomata

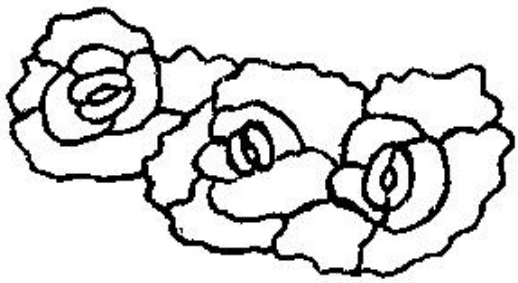

Figure 23: *Newbouldia laevis*: Anisocytic Stomata

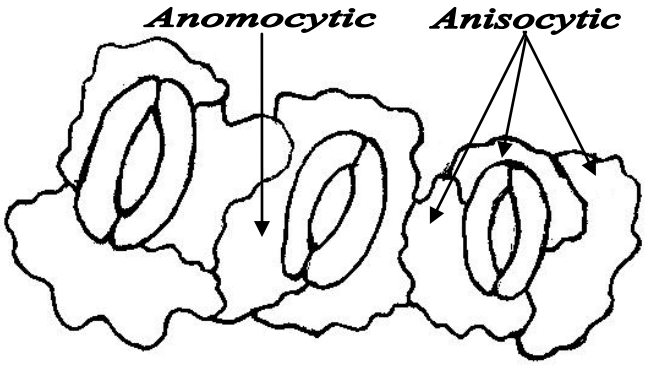

Figure 24: *Vitex ferruginea*: Anisocytic stomata

DISCUSSION

Higher plants anatomical characteristics such as stomata complex types, stomata size and stomata index can be used to establish systematic divisions. (Metcalfe and Chalk 1950a, b, 1979). Stomatal parameters can also be used to suggest phylogenetic relationships in tree taxa and other plant life forms. Stace (1965) states that stomata size may vary on the same leaf, but this does not prevent it from being used as a taxonomic character in delimiting different species within a genus, Pataky (1969) suggested stomata size of less than 15μm as small and larger ones those more than 38μm of which *Cleistanthus polystachyus* with the lowest stomata size record of 10.08$\mu m\pm$0.16 X 7.06$\mu m\pm$0.10 falling into the small category in this study. The highest stomata size of 29.57$\mu m\pm$0.24 X 16.80$\mu m\pm$ was observed in *Barteria nigritiana.*

The role of stomata index in biosystematics studies to delimit species because of it's near constancy for any given species has been reported by Cutler (1984), Abdulrahamaan and Oladele (2003). Stomata index values varied from 1.06% in *Canarium schweinfurthii* to 17.35% in *Carpolobia lutea* in this study. The highest number of stomata per field of view of 200 was recorded in *Cleistanthus polystachyus* (Euphorbiaceae). The high number of stomata may be an adaptive ecological ability to curtail water stress as a understorey forest tree.

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