Annals of West University of Timişoara, ser. Biology, 2018, vol. 21 (1), pp.29-46

COMPARATIVE MORPHOLOGY OF LEAF EPIDERMIS IN THE GENUS *IPOMOEA* (CONVOLVULACEAE) IN SOUTHERN NIGERIA

Kehinde Abiola BOLARINWA[1], Oyetola Olusegut OYEBANJI[2], James Dele OLOWOKUDEJO[2]

[1]Biology Unit, Distance Learning Institute, University of Lagos, Akoka, Lagos, Nigeria

[2]Department of Botany, University of Lagos, Nigeria

**Corresponding author e-mail: bolarinwakehinde85@gmail.com*

Received 15 March 2018; accepted 8 May 2018

ABSTRACT

Leaf epidermal morphology of eight species of Ipomoea found in Southern Nigeria has been studied using light microscope. Epidermal characters such as stomata type, epidermal cell type, anticlinal wall patterns, trichomes, presence of glands, stomata number and size, epidermal cell number and size, cell wall thickness, gland number and gland length vary within and amongst the species. The cells of adaxial and abaxial epidermises are polygonal or irregular with straight, sinuous or curved anticlinal wall pattern. Stomata are present on both adaxial and abaxial surfaces. Stomata complex is paracytic except in I. asarifolia and I. purpurea where its staurocytic; stomata index is higher on the abaxial side while trichome is absent on the abaxial surface of I. cairica and I. purpurea, likewise on the adaxial surface of I. involucrata. Glands are observed in all the species. Interspecific variation was further revealed in the quantitative micromorphology characters of Ipomoea species studied which was statistically supported at $p<0.001$ significance level. The taxonomic significance of these features in identification and elucidation of species affinity is discussed.

KEY WORDS: *Ipomoea, epidermal cell, stomata type, taxonomy, quantitative and qualitative characters.*

INTRODUCTION

Ipomoea L., commonly referred to as morning glory, is the largest cosmopolitan genus in the family Convolvulaceae (Verdcourt, 1963) and has approximately 500-700 species represented in the World (Austin & Huaman, 1996). The distribution of this genus covers the tropical and subtropical regions of the world. Lawrence (1951) recorded only two species in Europe while Hutchinson & Dalziel (1963) documented 37 species in West Africa and of these, 30 were found in Nigeria; 10 are restricted to the North, 3 to the South while others are found both in the Northern and Southern part of Nigeria. The species in Southern Nigeria include: *I. alba*, *I. aquatica*, *I. argentaurata*, *I. asarifolia*, *I. batatas*, *I. cairica*, *I. carnea, I. hederifolia*, *I. heterotricha*, *I. involucrata, I. muricata*, *I. mauritiana*, *I. nil*, *I. pes-caprae*, *I. quamoclit* and *I. stenobasis*. The species may be annual or perennial herbs, climbers and shrubs. They can be found in many habitats from the savanna, forest, farm lands, swamp and polluted sites.

In Nigeria, some of these species are cultivated for food, ornamental and medicinal uses. *I. asarifolia* (ginger-leaf morning glory) is a long-trailing perennial climber in sandy and waste places, although it's not edible, but it has been reported to be useful in the treatment of diarrhoea in horses (Burkill, 1985). *I. aquatica* is an aquatic, floating, trailing herb in damp

sites and it serves as fodder for cattle and pigs. Also, the dry sap is taken as purgative. *I. batatas* commonly known as Sweet potato is a native of tropical America and its often cultivated throughout the region for its sweet edible starchy tuber, also they are antidiabetic and antiscorbutic (Burkill, 1985). *I. cairica* (Railway creeper) is a slender perennial twinner in damp sites used as ornamentals and medicine. *I. carnea* Jace. is a shrub and often used for aesthetic and medicinal purposes (Chand & Rohatgi, 2005).

Moreover, *I. hederifolia* is an annual twinner that is usually planted as ornamental. The infusion of vegetative parts of *I. involucrata* is taken to prevent fever while the decoction of fresh sap is taken as remedy for gonorrhea. More so, *I. purpurea* (purple morning glory) has been reported to be used as purgative in Nigeria (Burkill, 1985). Inspite of the economic importance of *Ipomoea* species, little attention has been paid to their taxonomy. The application of epidermal morphology in taxonomic studies has been validated in botanical reviews by many authors. Stace (1965) dealt with characters to be found on isolated cuticle, Dilcher (1974) surveyed characters enabling identification of angiosperm leaf remains while Stace (1984) elaborated on the use of leaf surface characters in taxonomic studies. Furthermore, Olowokudejo (1990), Kadiri (2003), Sonibare *et al*. (2005), Ayodele & Olowokudejo (2006), Adegbite (2008), Kadiri *et al*. (2009), Yasmin *et al*. (2010), Ianovici *et al.* (2009), Sarojini *et al*. (2013), Abdurahman *et al*. (2016) are some of the early workers who have successfully applied epidermal characters to solve taxonomic problems. However, Cadance & Lucansky (1986), Gill & Nyawuame (1991), Ugborogho *et al*. (1992), Martins *et al*. (2012). Aworinde *et al*. (2013) have reported on the anatomy of *Ipomoea*.

An important advantage of leaves over the reproductive organs is that they are more generally present on the plant for a much greater part of life span. For this reason, they are valuable not only in making primary taxonomic decisions but also in the determination of incomplete plants e.g. sterile specimens, archaeological remains, fragmentary fossils and drug-based plants.

Therefore, this study is undertaken to determine the patterns of variation in epidermal characters and its significance in the accurate identification and classification of *Ipomoea* species from Southern Nigeria.

MATERIALS AND METHODS

Specimens of eight taxa of *Ipomoea* were collected from different habitats in Southern Nigeria and examined (Table 1 & Plates 1-8). These species were taken to University of Lagos herbarium (LUH) for identification. LUH acronym followed Holmgren *et al*. (1981). Floras such as Hutchinson & Dalziel (1954), Akobundu & Agyakwa (1987) were used to identify the collected species (Table 1). Ten leaf samples collected randomly from each taxon from different geographical locations were examined for both macro and micro morphological analyses.

Epidermal Preparation techniques. An area of about 0.5 – 1 cm^2 of the matured leaves of each representative species was cut out from the median portion of the lamina near the midrib. The cut - out portion of each leaf was boiled for about 20 minutes to revive the cells. Each sample was soaked in concentrated trioxonitrate (v) acid (HNO_3) in a capped McCartney bottle for 1-8 hours. However, the period of maceration differs in species because of the variation in thickness of the mesophyll. After maceration, the leaf portion was transferred to the

petri dish containing water. The abaxial and adaxial epidermises were separated from the mesophyll using fine forceps and mounted pins. Tissue debris was brushed off the epidermis with a soft brush. The separated epidermis was mounted on a glass slide and absolute alcohol was added for 3 minutes to harden the cells and then stained with safranin for 5 minutes and then glycerine was added with the outer surface uppermost and then covered with a cover slip. The edges of the cover slip were sealed with a nail varnish to prevent dehydration. The slides were appropriately labeled and examined under the light microscope. Photomicrographs were taken using Motic camera v2.0.

TABLE 1: Details of *Ipomoea* specimens studied

Species	Locality (state)	Synonymns	Ecology	Lectotype
Ipomoea asarifolia (Desr.) Roem. & Schult.	Oyo, Ogun and Lagos	Nil	W	FWTA, ed. 2, 2:348; LUH 7233
Ipomoea aquatica Forrsk.	Oyo, Osun and Lagos	Nil	W	FWTA, ed. 2, 2:349; LUH 7237
Ipomoea batatas (Linn.) Lam.	Oyo, Osun, Ogun and Lagos	Nil	C	FWTA, ed. 2, 2:350;
Ipomoea cairica (Linn.) Sweet	Lagos	*Ipomoea palmata* Forssk. *I. stipulacea* Jacq. *I. tuberculata* (Desr.) Roem & Schult.	W	FWTA, ed. 2, 2:351, LUH 6932
Ipomoea carnea Jace.	Benin and Lagos	*Ipomoea fistulosa* Mart. ex Choisy	C	LUH 5424
Ipomoea hederifolia Linn.	Oyo and Osun	*Ipomoea coccinea* var. *hederifolia* (L.) Gray *Ipomoea luteola* Jacq.	W	FWTA, ed. 2, 2:347, LUH 1037
Ipomoea involucrata P. Beauv	Lagos, Ogun, Oyo, and Osun	Nil	W	FWTA, ed. 2, 2:347, LUH 4047
Ipomoea purpurea (Linn.) Roth	Oyo	Nil	W	FWTA, ed. 2, 2:352,

Keys: W= Wild, C= Cultivated, FWTA= Flora of West Tropical Africa

Micromorphometrics. The following characters were assessed for all the taxa examined:

Qualitative characters: Stomata complex, epidermal cell type, anticlinal wall patterns, trichomes and presence of glands.

Quantitative characters: stomata number, stomata width, stomata length, epidermal cell number, epidermal cell length, epidermal cell width, cell wall thickness, gland number and gland length. All measurements were taken from randomly 20 selected views using micrometer.

Stomatal Number (SN): The frequency of stomatal was determined by counting in 20 fields of view at X40 objective lens.

Stomatal Index (SI): The SI was determined using SI= S/E+ S× 100 according to Abdulrahaman *et al*., (2016)

Note: S= number of stomatal per square millimeter; E= number of ordinary epidermal cell per square millimeter.

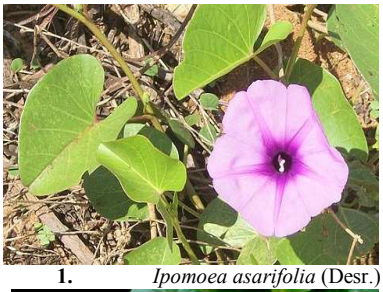
Stomatal Size (SS): The length and breadth of the stomatal size was measured using an eye piece micrometer. The mean SS was calculated from a sample size of 20 stomata.

Epidermal Cell Number (ECN): The frequency of EC was determined by counting in 20 fields.

Epidermal Cell Size (ECS): The length and breadth of epidermal cell using eye piece micrometer and the mean was calculated.

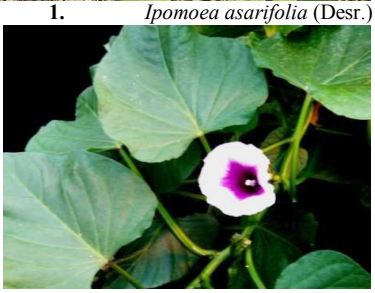
Trichome Size (TS): The length and breadth of the trichome was measured using an eye piece micrometer. The mean TS was calculated from a sample size (n=20).
Gland Size (GS): Also, the calibrated eye piece was used to measure the length and breadth of the Glands from n=20 sample size.

Statistical Analysis. Descriptive statistics such as mean, standard error, stomatal index, analysis of variance and correlation were calculated for all variables.



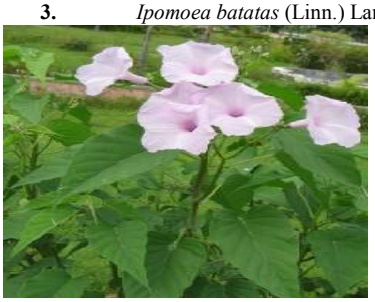
1. *Ipomoea asarifolia* (Desr.) Roem. & Schult.

2. *Ipomoea aquatica* Forrsk.

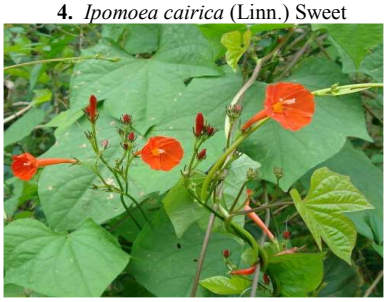


3. *Ipomoea batatas* (Linn.) Lam.

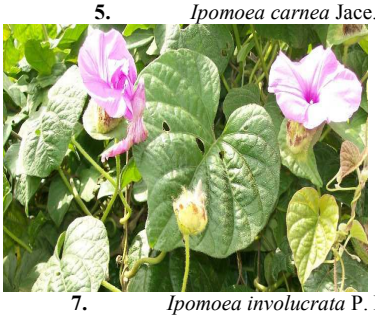
4. *Ipomoea cairica* (Linn.) Sweet



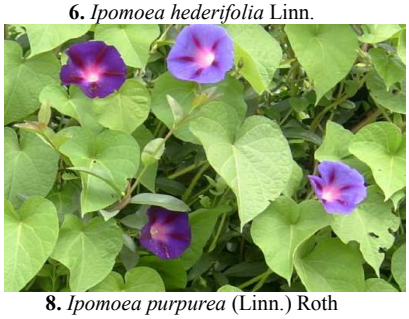
5. *Ipomoea carnea* Jace.



6. *Ipomoea hederifolia* Linn.



7. *Ipomoea involucrata* P. Beauv



8. *Ipomoea purpurea* (Linn.) Roth

RESULTS AND DISCUSSIONS

The morphological features of the leaf epidermis are summarized in Tables 2-6 which include both quantitative and qualitative characters. Table 1 shows the distribution of *Ipomoea* species in Nigeria. Plates 9-12 are the photomicrographs showing epidermal cells, stomata, trichome, and glands.

Quantitative micromorphological character

Cell Shape. The adaxial surface of some representative taxa viz: *I. involucrata* (Plates 9B and D), *I. batatas* (Plate 9F-H), *I. asarifolia* (Plate 10B and D), *I. purpurea* (Plate 12B), and *I. cairica* (Plate 12D) all have irregularly shaped epidermal cell while *I. aquatica* (Plate 11B and D) has polygonal epidermal cells and the remaining two taxa *I. carnea* (Plate 10F and H) and *I. hederifolia* (Plate 11F) have both polygonal and irregular epidermal cells. The adaxial surface of *I. involucrata* (Plate 9A and C), *I. asarifolia* (Plate 10a and C), *I. carnea* (Plate 10E and H), *I. aquatica* (Plates 11A and C) and *I. hederifolia* (Plate 11E) showed polygonal, irregular shape epidermal cells while *I. purpurea* (Plate 12A) has polygonal shape and the remaining two species which include (Plate 9E and G) and *I. cairica* (Plate 412C) have irregular shape epidermal cells.

TABLE 2: Summary of macromorphological qualitative characters of *Ipomoea* species studied

Character	Life form	Flower color	Leaf texture	Leaf apex	Leaf base	Leaf margin	Leaf Shape	Leaf type	Petiole surface	Stem feature
I. aquatica	Climber	Pale or dark red – purple flowers	Glabrous	Mucronate	Cordate	Entire	Ovate	Simple	Pubescent	Succulent & hollow
I. asarifolia	Twiner	Large red to purple flowers	Glabrous	Truncate	Cordate	Entire	Reniform	Simple	Glabrous	Woody
I. batatas	Climber	Red-purple centre	Glabrous	Apiculate	Cordate	Entire	Ovate	Simple	Glabrous	Fibrous
I. carnea	Shrub	Pale or deep pink	Glabrous	Accuminate	Cordate	Entire	Elliptic	Simple	Glabrous	Woody & hollow
I. cairica	*Climber*	Pale or reddish - purple	Glabrous	Accuminate	Hastate	Palmate	Lyrate	Digitate	Glabrous	Fibrous
I. hederifolia	Climber	Orange or pink - red	Glabrous	Apiculate	Cordate	Entire	Hastiform	Simple	Glabrous	Fibrous
I. involucrata	Climber	Red to purple flowers	Pubescent	Mucronate	Cordate	Entire	Ovate	Simple	Glabrous	Fibrous
I. purpurea	Twiner	Violet- blue	Glabrous	Acute	Cordate	Entire	Ovate	Simple	Glabrous	Fibrous

Anticlinal Wall Pattern. The abaxial surfaces of *I. involucrata* (Plate 9B and D), *I. asarifolia* (Plates 10B and D), *I. purpurea* (Plate 12B) are undulate compare to *I. carnea* (Plates 11B and D) which has only straight while *I. batatas* (Plates 9F and H) and *I. cairica* (Plate 12D) have sinuous and moderately sinuous anticlinal wall pattern respectively. The adaxial surface of *I. involucrata* (Plate 9A and C), *I. asarifolia* (Plate 10A and C), *I. carnea* (Plates 10E and G), *I. hederifolia* (Plate 11E) have straight, curved wall pattern compare to *I.aquatica*

(Plates 11A and C) and *I. purpurea* (Plate 12A) that have only straight while *I. batatas* (Plates 9E and G) and *I. cairica* (Plate 12C) have sinuous and moderately sinuous anticlinal wall patterns respectively.

Stomata Complex. Two types of stomatal complex were observed. The stomata complex observed is predominantly paracytic except for *I. asarifolia* and *I. purpurea* which is staurocytic (Table 3).

Trichomes. Trichome is present in all the abaxial surface of the entire representative species studied except for the abaxial surface of *I. purpurea* and *I. cairica* where trichome is absent while for the adaxial surface, trichome is present for all representatives except in *I. involucrata*. All the trichomes observed are simple and unicellular (Table 3).

TABLE 3: Qualitative epidermal characters of southern species of the genus *Ipomoea*

Species	Epidermal layer	Epidermal cell shape	Anticlinal wall pattern	Trichomes	Stomata complex
I. aquatica	abaxial	Polygonal	Straight	Simple unicellular	Paracytic
	adaxial	Polygonal	Straight	Simple unicellular	Paracytic
I. asarifolia	Abaxial	Irregular	Undulate wavy	Simple unicellular	Staurocytic
	Adaxial	Irregular, Polygonal	Straight, curve	Simple unicellular	Staurocytic
I. batatas	Abaxial	Irregular	Sinuous	Simple unicellular	Paracytic
	Adaxial	Irregular	Sinuous	Simple unicellular	Paracytic
I. cairica	Abaxial	Irregular	Moderately sinuous	Absent	Paracytic
	Adaxial	Irregular, Polygonal	Straight, curve	Simple unicellular	Paracytic
I. carnea	Abaxial	Irregular, Polygonal	Straight	Simple unicellular	Paracytic
	Adaxial	Irregular, Polygonal	Straight	Simple unicellular	Paracytic
I. hederifolia	Abaxial	Irregular, Polygonal	Straight, curve	Simple unicellular	Paracytic
	Adaxial	Irregular, Polygonal	Straight, curve	Simple unicellular	Paracytic
I. involucrata	Abaxial	Irregular	Undulate wavy	Simple unicellular	Paracytic
	Adaxial	Irregular, Polygonal	Straight, curve	Absent	Paracytic
I. purpurea	Abaxial	Irregular	Undulate wavy	Absent	Staurocytic
	Adaxial	Polygonal	Straight	Simple unicellular	Staurocytic

Quantitative micromorphological results. The study revealed the distribution and variation in sizes of epidermal and stomata characters (Table 4). From the study, the mean epidermal cell number of *Ipomoea* ranged from 21- 41 on the abaxial as observed in *I. batatas* and *I. carnea* while on the adaxial it ranged between 12 – 41 as recorded for *I. involucrata* and *I. carnea*. Also, the highest average epidermal cell length on the abaxial was between 39.83 and 69.75 µm as recorded for *I. carnea* and *I. batatas* while on the adaxial, *I. carnea* had the least mean value of 43.00 µm and the highest was 65.05 µm as observed in *I. cairica*. The average epidermal cell width ranged from 18.79 µm in *I. carnea* and 31.15 µm in *I. hederifolia* on the abaxial while on the adaxial surface it ranged between 16.37 – 31.65 µm as observed in *I. carnea* and *I. cairica* respectively. The thickness of the epidermal wall on the abaxial ranged from 1.67 – 22.38 µm as recorded for *I. batatas* and *I. carnea* while on the adaxial, the minimum and maximum mean value ranged from 1.67 – 5.01 µm as observed in *I. batata* and *I. involucrata* respectively.

Tables 4a&b showed that there is high significant difference in the abaxial and adaxial epidermal characters of the studied *Ipomoea* species from Southwest, Nigeria at $P< 0.001$.

TABLE 4: Quantitative epidermal cell characters of southern species of genus *Ipomoea*

Species	Surface	Epidermal Cell Number Min(Mean ± S.E)Max	Epidermal cell Length (µm) Min(Mean ± S.E)Max	Epidermal cell width (µm) Min(Mean ± S.E)Max
I. involucrata	Abaxial	23(24.2 ± 0.29) 36	35.07 (58.05 ± 0.68) 83.50	15.03 (23.96 ± 0.43) 40.08
	Adaxial	0(12.05 ± 0.73) 5	31.37(53.01 ± 0.770 86.64	18.37(25.38 ± 0.27) 40.58
I. batatas	Abaxial	3(21.9 ± 0.32) 14.5	33.4(48.68 ± 0.52) 70.14	16.7(25.12 ± 0.28) 35.07
	Adaxial	1(13.6 ± 0.27) 6.5	33.4(44.84 ± 0.37) 60.12	18.7 (29.89 ± 0..35) 41.75
I. asarifolia	Abaxial	18(47.2 ± 0.23) 30	48.43(67.05 ± 0.73) 73.48	16.7(28.97 ± 0.33) 40.08
	Adaxial	19(29.7 ± 0.35) 42	40.08(55.69 ± 0.55) 73.48	23.38(31.56 ± 0.30) 40.08
I. carnea	Abaxial	15(41.1 ± 0.86) 57	28.39(49.63 ± 0.80) 80.16	11.69(22.88 ± 0.37) 38.41
	Adaxial	3(23.1 ± 0.57)19	48.43(65.05 ± 0.45) 83.5	23.38(31.65 ± 0.26) 40.08
I. aquatica	Abaxial	12(23.2 ± 0.67) 28	25.5(39.83 ± 0.55) 65.13	16.7(18.71 ± 0.15) 21.71
	Adaxial	3(19.1 ± 0.54) 27	28.39(43.00 ± 0.66) 73.48	11.69(16.37 ± 0.21) 30.06
I. hederifolia	Abaxial	7(27.1 ± 0.42) 16	36.74(58.53 ± 0.56) 81.83	18.37(31.15 ± 0.43) 31.73
	Adaxial	2(24.3 ± 0.37)13	36.74(59.95 ± 0.70) 91.85	16.7(28.39 ± 0.29) 43.08
I. purpurea	Abaxial	5(24.5 ± 0.30) 19	40.08 (40.06 ± 0.55) 98.55	15.03(29.45 ± 0.31) 40.08
	Adaxial	0(27.8 ± 0.95) 4	48.43(45.46 ± 0.51) 75.48	16.7(27.10 ± 0.23) 28.39
I. cairica	Abaxial	8(29.7 ± 0.42) 16	25.05(42.00 ± 0.43)63.46	8.36(19.79 ±0.38) 35.07
	Adaxial	3(31.4 ± 1.06) 99	20.04 (45.34 ± 0.48) 60.12	15.05(21.79 ± 0.29) 30.06

TABLE 4A: Analysis of variance of abaxial epidermal cell characters

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3939.378	2	1969.689	40.471	6.25E-08	9.772
Within Groups	1022.037	21	48.668			
Total	4961.415	23				

TABLE 4B: Analysis of variance of adaxial epidermal cell characters

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3939.378	2	1969.689	40.471	6.25E-08	9.772
Within Groups	1022.037	21	48.66847			
Total	4961.415	23				

Also, the mean stomata number of genus *Ipomoea* ranged from 8.00 in *I. batatas* and 30.00 in *I. cairica* on the abaxial while on the adaxial, he highest and minimum mean value were recorded for *I. cairica* and *I. carnea* having 1 and 10 stomata respectively. *Ipomoea cairica* had the least mean stomatal length on both surfaces; 16.78 and 5.76 µm on the abaxial and adaxial surfaces respectively while *I. aquatica* had the highest mean stomata length of 25.43 and 25.14 µm on the adaxial and abaxial surfaces respectively. The mean stomatal width ranged from 4.26 to 8.60 µm as recorded for *I. cairica* and *I. asarifolia* on the abaxial surface respectively while it ranged between 4.18 to 8.35 µm on the adaxial surface of *I. purpurea* and *I. asarifolia* (Table 5).

Moreso, there is high significant difference in the abaxial and adaxial stomata characters of the studied *Ipomoea* species from Southwest, Nigeria at $P< 0.001$ (Table 5a&b).

The genus *Ipomoea* had gland on both surfaces; however, the average gland number was between 1 and 2 on the abaxial surface of *I. aquatica* and *I. hederifolia* while only one was recorded for *I. aquatica* and *I. cairica* on adaxial surface respectively. Moreso, the mean gland length on the abaxial ranged between 2.18 – 52.69 µm in *I. aquatica* and *I. asarifolia* while the

range was from 23.86 to 44.27 µm as observed in *I. hederifolia* and *I. asarifolia* respectively (Table 6).

The Stomatal Index ranged from 27.1% in *I. batatas* to 40.70% in *I. carnea* on the abaxial surface while on the adaxial surface, it ranged was between 5.5% in *I. cairica* and 28.40% in *I. carnea* (Fig. 1).

TABLE 5: Quantitative Stomatal characters of Southern species of genus *Ipomoea*

Species	Surface	Stomatal Number Min(Mean ± S.E)Max	Stomatal length (µm) Min(Mean ± S.E)Max	Stomatal Width (µm) Min(Mean ± S.E)Max	Stomatal Index (%) Min(Mean ± S.E)Max
I. involucrata	Abaxial	7(11.3 ± 0.19)20	15.03(19.12 ± 0.14)21.71	5.01(6.01± 0.07) 8.35	20(31.8± 0.37) 45
	Adaxial	0(2.0 ± 0.07)5	15.03(17.12 ± 0.11)21.71	6.68(7.18 ± 0.07) 8.35	0(27.1± 0.43) 31.2
I. batatas	Abaxial	3(8.35 ± 0.15)13.5	16.7(20.04 ± 0.14)25.05	8.35 (8.60 ± 0.11) 11.69	19(27.1 ± 0.25) 40
	Adaxial	1(3.25 ± 0.06)11.5	16.7(21.46 ± 0.13)25.05	6.68(8.35 ± 0.11)20.04	12(16.8 ± 0.23) 37
I. asarifolia	abaxial	8(13.7 ± 0.18)22	16.7(20.04 ± 0.13)25.05	5.01(6.10 ± 0.07) 8.35	22(36.5 ± 0.37) 47
	Adaxial	4(7.75 ± 0.14)14	21.41(25.13 ± 0.18)31.73	5.01(6.43 ± 0.08) 8.35	10(21.1 ± 0.39) 37
I. carnea	abaxial	15(30.5 ± 0.56)57	13.36(17.20 ± 0.14) 23.38	3.34(4.26 ± 0.06)6.68	33.7(40.7 ± 0.23) 51.4
	Adaxial	3(9.65 ± 0.76)19	16.7(21.15 ± 0.20)26.72	5.01(5.58 ± 0.05)6.68	19.8(28.4 ± 0.26) 39.4
I. aquatica	Abaxial	7(10.3 ± 0.13)15	13.36(16.78 ± 0.16) 20.04	5.01(5.76 ± 0.04) 6.68	3(33.1 ± 0.47) 49
	Adaxial	1(2.30 ± 0.09)5	5.01(5.76 ± 0.04) 6.68	3.34(6.68 ± 0.03) 6.68	0(21.3 ± 0.44) 28
I. hederifolia	Abaxial	7(10.9 ± 0.14)13	11.69(17.28 ± 0.13) 20.03	3.34(5.34 ± 0.04) 6.68	18.5 (29.4 ± 0.33) 42.1
	Adaxial	2(9.1 ± 0.15)13	15.03(16.7 ± 0.07) 20.04	5.01(6.62 ± 0.04) 6.68	18.2 (26.4 ± 0.18) 32.3
I. purpurea	Abaxial	5(10.9 ± 0.15)19	13.36(25.43 ± 0.10) 21.71	5.01(3.38 ± 0.05)8.35	3(29.6 ± 0.44) 45
	Adaxial	0(0.9 ± 0.06)4	16.7(25.14 ± 0.13) 21.71	3.34(6.40 ± 0.02) 8.35	0(8.7 ± 0.50) 25
I. cairica	Abaxial	6(10.5 ± 0.03)16	16.7(19.96 ± 0.16) 25.05	3.34(5.51 ± 0.07) 8.35	16.2(26.5 ± 0.23) 33
	Adaxial	0(0.3 ± 0.02)2	16.7(10.96 ± 0.14) 25.05	3.34(4.18± 0.04) 5.01	0(5.5 ± 0.50) 25

TABLE 5A: Analysis of variance of abaxial stomatal distribution

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	771.582	2	385.791	19.160	1.84E-05	9.772
Within Groups	422.820	21	20.134			
Total	1194.402	23				

TABLE 5B: Analysis of variance of adaxial stomatal distribution

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	851.092	2	425.546	20.446	1.18E-05	9.772
Within Groups	437.072	21	20.812			
Total	1288.165	23				

TABLE 6: Quantitative gland characters of southern species of genus I*pomoea*

Species	Surface	Gland Number Min(Mean ± S.E)Max	Gland width (µm) Min(Mean ± S.E)Max
I. involucrata	Abaxial	0.45(1.5 ± 0.03) 18	23.38(34.07 ± 0.34) 50.10
	Adaxial	0.(0.5 ± 0.03) 4.5	28.39(41.38 ± 0.58) 58.45
I. batatas	Abaxial	0(1.4 ± 0.04) 3	33.4(52.69 ± 0.63) 70.14
	Adaxial	0(0.7 ± 0.04)2	31.73(44.27 ± 0.52) 65.13
I. asarifolia	Abaxial	1(1.4 ± 0.030 3	28.39(35.07 ± 0.48) 50.1
	Adaxial	0(0.7 ± 0.4) 2	28.39(35.63 ± 0.30) 43.42
I. carnea	Abaxial	1(1.4 ± 0.03) 3	16.7(27.39 ± 0.32) 38.41
	Adaxial	0(0.6 ± 0.03) 2	36.74(43.90 ± 0.28) 50.1

I. aquatica	Abaxial	0(0.9 ± 0.04)3	11.69(22.38 ± 1.12) 33.4
	Adaxial	0(0.8 ± 0.03) 2	18.37(25.26 ± 0.580 58.45
I. hederifolia	Abaxial	0(1.8 ± 0.05) 4	28.38(33.90 ± 0.24) 43.42
	Adaxial	0(0.7 ± 0.03) 2	13.36(23.86 ± 0.36) 28.39
I. purpurea	Abaxial	0(1.5 ± 0.03) 3	15.03(22.18 ± 0.21) 36.74
	Adaxial	0(0.4 ± 0.03) 1	28.39(25.48 ± 0.19) 52.4
I. cairica	Abaxial	0(1.1 ± 0.44) 8	35.07(39.91 ± 0.25) 40.76
	Adaxial	0(0.3 ± 0.03) 6	20..04(38.58 ± 0.34) 45.09

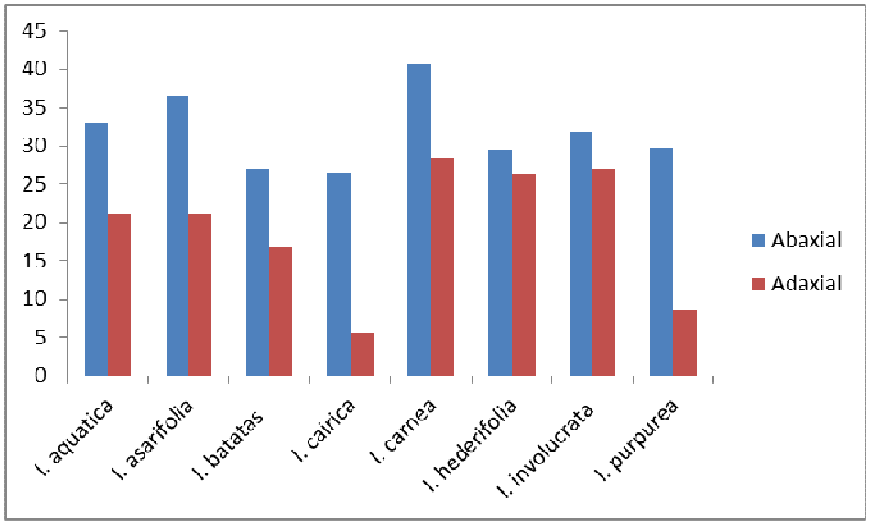


FIG. 1: Mean distribution of stomatal index (%) on adaxial and abaxial of *Ipomoea*

According to Raju & Rao (1977) there may be misgivings about the systematic value of the stomata type but this is allayed by (Cutter, 1969) who stated that not all the stomata present on a leaf are good examples of a single type and a fairly large number of stomata should be examined to determine the most prevalent. However, Stace (1965) had stated that stomata complex is a useful character in taxonomy especially in the identification of small leaf fragments. Therefore, stomatal complex contributed to the taxonomic characters used in this study. Nevertheless, the most useful characters were stomata type, size, distribution and index. Raju and Rao (1977) have also described the application of variation in absolute stomatal size, frequency of epidermal cells and the anticlinal configuration in species delimitation.

Notably, high level of correlation among the species studied (Appendix 1a&b-2a&b) showed that there is a strong relationship within the species which is an indication of close relationship i.e. related species. Nonetheless, analysis of variance further brings to light the latent specific variations that exist within the genus which supported the taxonomic classification of this genus.

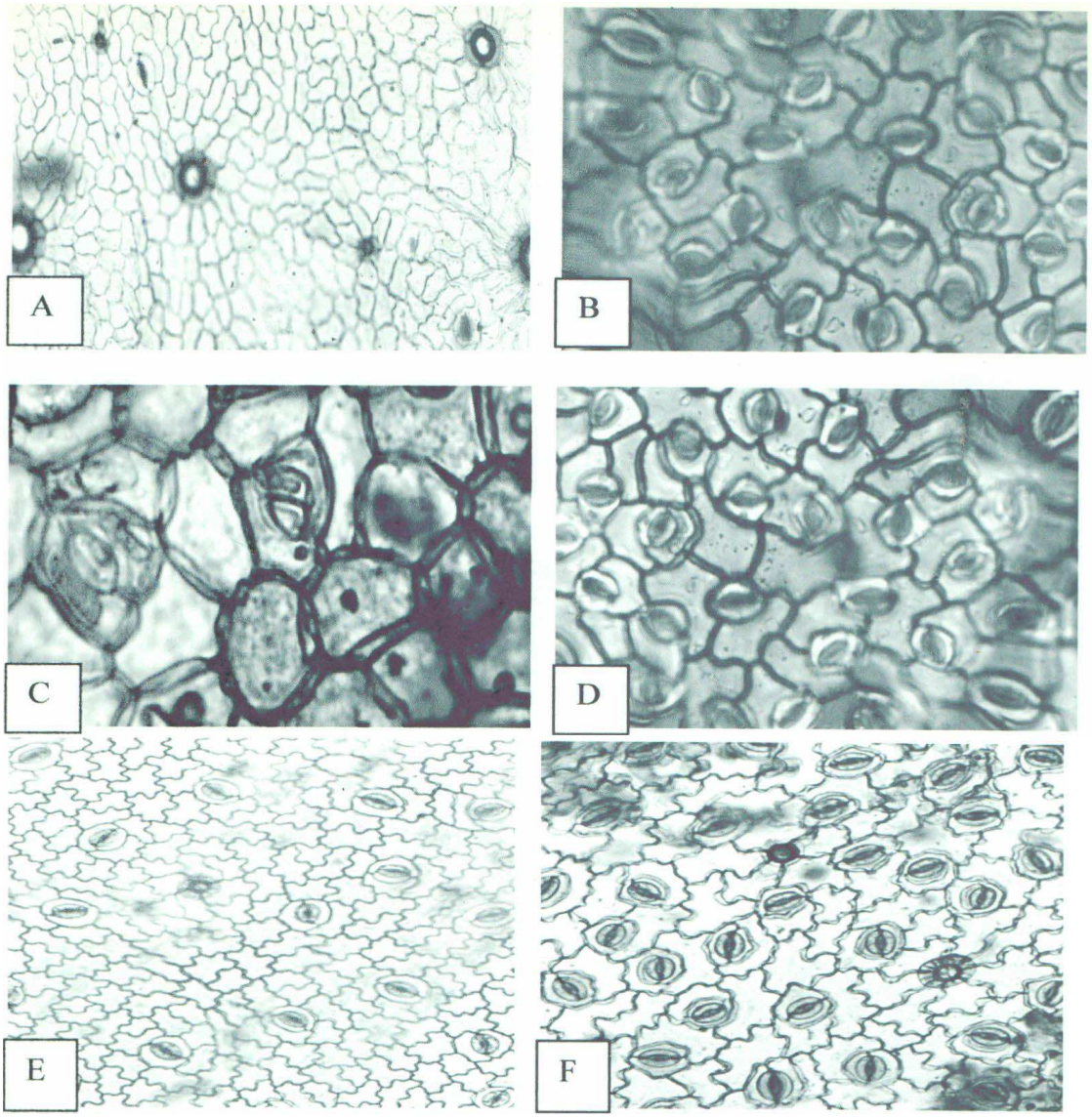


PLATE 9: Epidermal morphology of genus *Ipomoea*
A & B: *I. involucrata* showing adaxial (x 100) and abaxial (x400) cells collected from Unilag
C & D: *I. involucrata* showing adaxial and abaxial cells collected from Sango (x400)
E & F: *I. involucrata* showing adaxial (x 100) and abaxial (x400) cells collected from U.I (x100)
G & H: *I. involucrata* showing adaxial (x 100) and abaxial (x400) cells collected from Iju (x400)

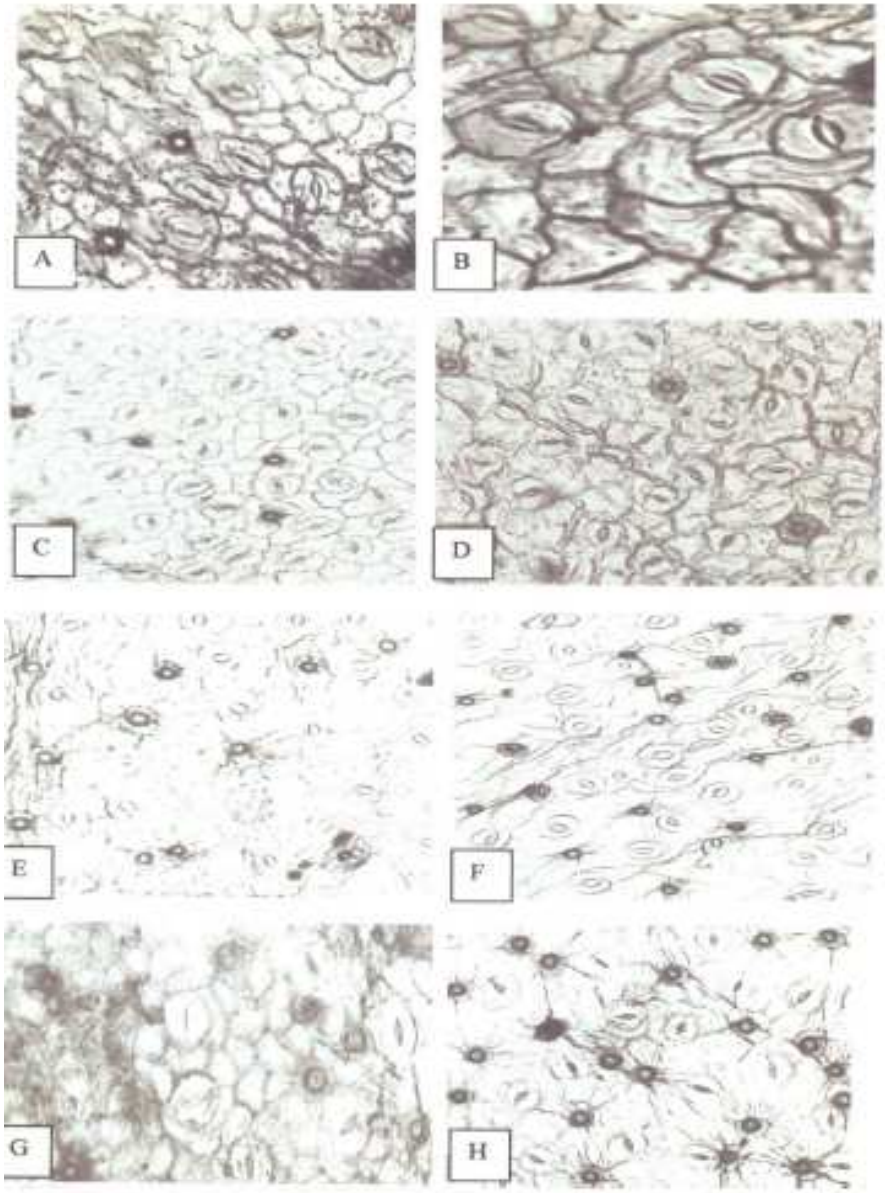


PLATE 10: Epidermal morphology of genus *Ipomoea*
A &B*: I. asarifolia* showing adaxial and abaxial cells collect from U.I (x400)
C & D: *I. asarifolia* showing adaxial and abaxial cells collect from Epe (x100)
E & F: *I. carnea* showing adaxial and abaxial cells collect from Delta (x100)
G & H: *I. carnea* showing adaxial (x400) and abaxial cells collect from Ogun state (x100)

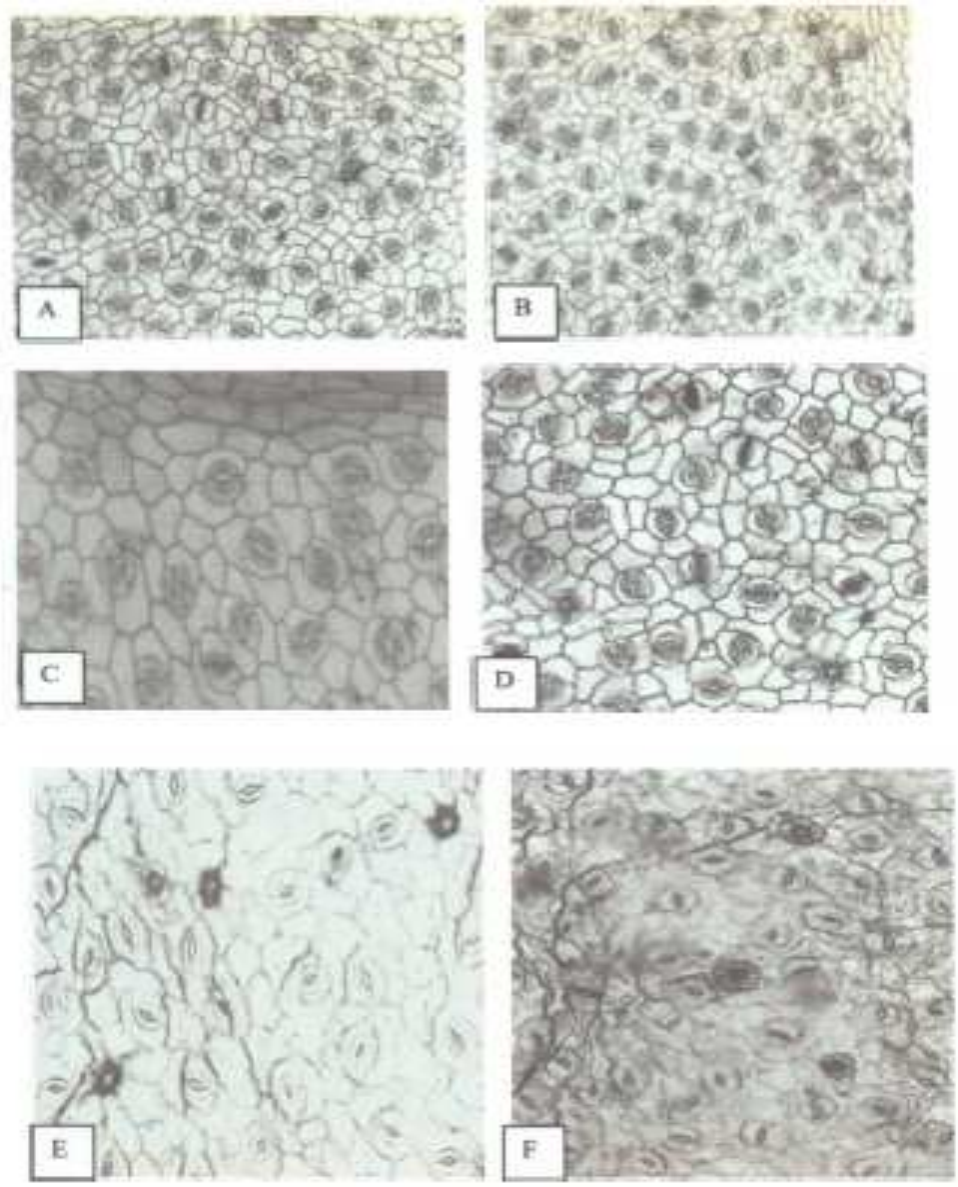


PLATE 11: Epidermal morphology of genus *Ipomoea*
A &B: *I. aquatica* showing adaxial and abaxial cells collect from Ibadan (x100)
C & D: *I. asarifolia* showing adaxial and abaxial cells collect from Unilag (x100)
E & F: *I. carnea* showing adaxial and abaxial cells collect from U.I (x100)

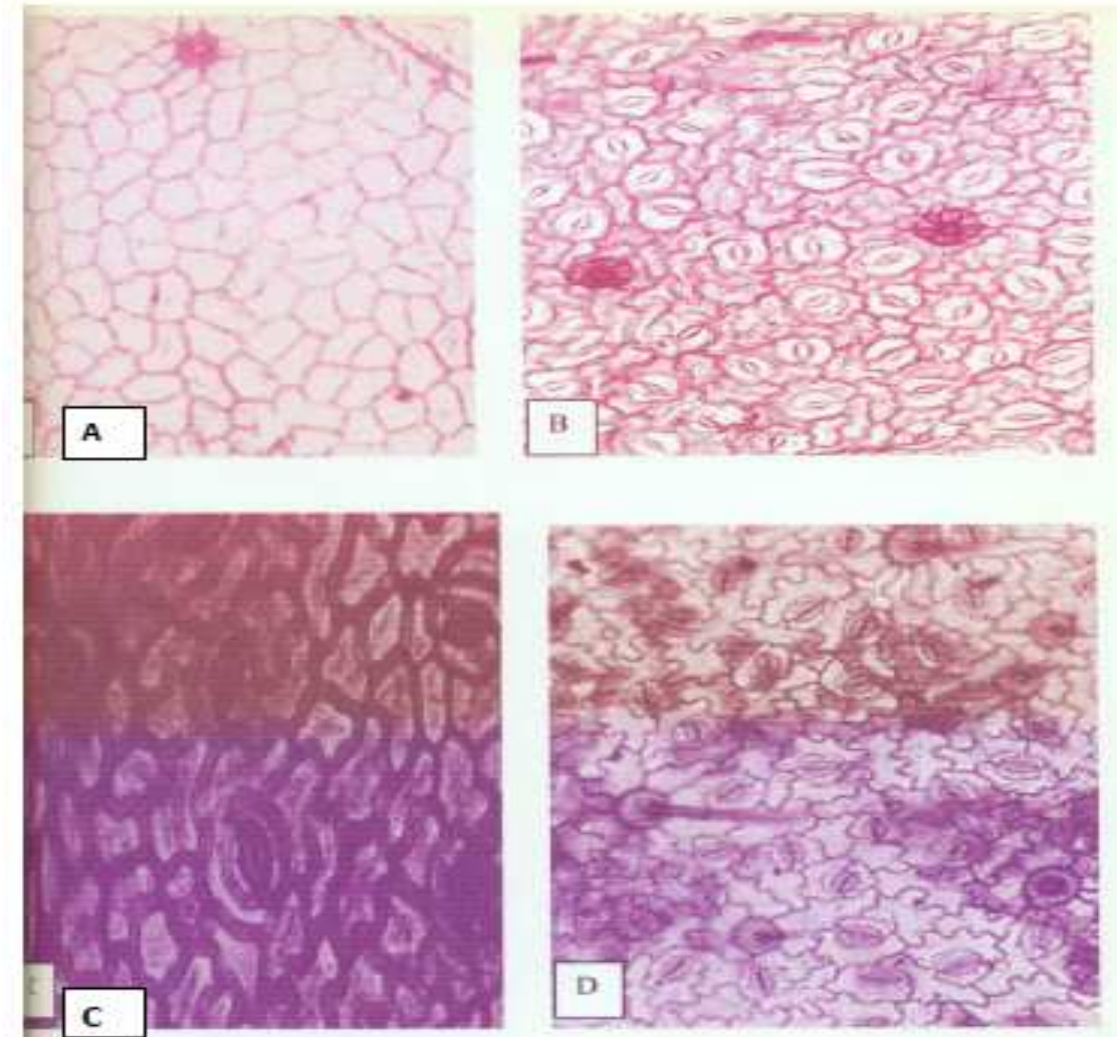


PLATE 12: Epidermal morphology of genus *Ipomoea*
A &B: *I. purpurea* showing adaxial and abaxial cells collect from U.I (x100)
C & D: *I. asarifolia* showing adaxial (x400) and abaxial cells collect from Unilag (x100)

The *Ipomoea* species studied ranged from having irregular, polygonal or combination of both features in their epidermal cells with undulate, curve or both; moderately sinuous and sinuous anticlinal wall pattern. The anticlinal wall of the *Ipomoea* species studied is similar to that of the results of Folorunso, (2013). The stomata type is paracytic in *I. aquatica*, *I. batatas, I. cairica, I. carnea*, *I. hederifolia* and *I. involucarata* while its staurocytic in *I. asarifolia* and *I. purpurea*. According to Ugborogho *et al*., (1992), paracytic, anisocytic, contiguous, amphianisocytic and hemiparacytic are the stomata types in *Ipomoea* however, the dominant type is paracytic stomata, and this is in line with the results of this study but the study also observed that the four other stomata types were not present in the *Ipomoea* species studied. This investigation has disclosed that even though the specimens used were obtained from different geographical locations, certain characters of the leaf epidermis are relatively constant and are useful for diagnosis.

A comparison of specimens from the coastal rainforest of West Africa with those from the dry Sudan savannah showed that leaf size is responsive to environmental variations (Dilcher, 1974). Some variation in cell size and anticlinal wall pattern in some plants may be attributed to ecogeographical differences such as light intensity, atmospheric humidity and pressure (Ayodele & Olowokudejo, 1997; Ianovici, 2012).

The stout variation in epidermal cell number between and within species with noticeable interspecific overlaps may be attributed to ecogeographical differences. Metcalfe & Chalk (1950) reported that epidermal cell sizes, shape and outline are affected by atmospheric humidity. Nothwithstanding, Stace (1965) cautioned against too much of prominence upon epidermal character which vary with environmental changes. These charaters are considered to be suitable because of their likelihood to vary with changes in ecological conditions. Also, Stace (1984) and Abdel & Osman (2007) have reported on the effect of environment onleaf surfaces and the case of phenotypic plasticity have been shown to be genetically controlled by adaptations to the environment rather than ecophenetic responses. They observed that although many epidermal characters did adapt readily to changing conditions but there were still many more suitable characters left to indicate taxonomic relationships. Based on the above consideration, the epidermal cell characters found appropriate were: cell size, shape and stomatal numbers.

Batterman & Lammers (2004) documented the taxonomic importance of trichomes in angiosperms. Trichomes are present on the adaxial surface of *I. involucrata*, both surfaces of *I. batatas, I. asarifolia, I. carnea, I. hederifolia*, abaxial surface of *I. purpurea* and that of *I. cairica* and absent in others. Metcalfe and Chalk (1950) held that trichome frequency and sizes were environment bound. Glands are observed in all the taxa observed but the abaxial surface taking the most number of glands. Aworinde *et al*., (2013) identified trichomes in *Ipomoea* species to unicellular, this is also incongruence with the results of this study while Khan, *et al*. (2013) reported multicellular type of trichome in *Ipomoea cairica, I. nil* and *I. purpurea* which contradicts the results of this study.

In relation to intraspecific variation generally, Stace (1965) stated that variation of epidermal characters such as stomata size, frequency, epidermal wall patterns and trichomes are due to 3 major causes; the age of the leaf, ecology of the plant and the position of the leaf on the plant. The type of the epidermal cells and their corresponding stomata, stomatal index, trichomes and their distribution pattern are important sources of taxonomical characters. Extent

of trichome development is often affected by environmental factors, hence becomes prominent in almost all the species. The presence and type of trichomes in the genus *Ipomoea* may not provide a distinct information however, it is an integral taxonomic character that should be considered in the delimitation of this genus.

Jayeola (1998) also confirmed that ecology of plants have significant impact on the leaf surface hence, influencing the epidermal features of plants. Due to wide spread of *Ipomoea* occurring in different ecosystems, the quantitative variations in this study could be associated to adaptation of these species to various environments.

Epidermal surfaces of *Ipomoea* revealed a number of important micromorphological characters, and these characters exhibit interesting interspecific variations that are of significance in identification. The artificial, indented dichotomous key produced below allows separation of all species.

Dichotomous key for South Western Nigeria *Ipomoea*

1a. Stomatal type paracytic, life form climber/shrub
- 2a. Trichome present on adaxial and abaxial surfaces, gland number < four
  - 3a. Anticlinal wall pattern straight, stem hollow
    - 4a. Epidermal cell shape polygonal, leaf shape ovate……... ***aquatica***
    - 4b. Epidermal cell shape irregular-polygonal, leaf shape elliptic …… ***carnea***
  - 3b. Anticlinal wall pattern curved, stem not hollow
    - 5a. Leaf shape ovate, flower red-purple center ……. ***batatas***
    - 5b. Leaf shape hastiform, flower orange or pink-red……***hederifolia***
- 2b. Trichome absent on abaxial and adaxial surfaces, gland number > four
  - 6a. Anticlinal wall pattern moderately sinuous, leaf type digitate, margin palmate……***cairica***
  - 6b. Trichome absent on adaxial surface, anticlinal wall pattern undulate wavy, straight-curve(adaxial), leaf type simple, margin entire……. ***involucrata***

1b. Stomatal type staurocytic, life form mainly twiner
- 7a. Trichome present on abaxial and adaxial surface, leaf apex truncate ……... ***asarifolia***
- 7b. Trichome absent on abaxial surface, leaf apex acute …….. ***purpurea***

APPENDICES

APPPENDIX 1A: CORRELATION OF ABAXIAL EPIDERMAL OF *IPOMOEA* SPECIES STUDIED

	I. involucrata	*I. batatas*	*I. asarifolia*	*I. carnea*	*I. aquatica*	*I. hederifolia*	*I. purpurea*	*I. cairica*
I. involucrata	1							
I. batatas	0.993	1						
I. asarifolia	0.880	0.820	1					
I. carnea	0.749	0.667	0.973	1				
I. aquatica	0.980	0.951	0.956	0.864	1			
I. hederifolia	0.992	0.999	0.815	0.661	0.948	1		
I. purpurea	0.948	0.978	0.685	0.500	0.867	0.980	1	
I. cairica	0.898	0.840	0.999	0.964	0.966	0.836	0.712	1

Note: 1 is a perfect correlation

APPENDIX 1B: CORRELATION OF ADAXIAL EPIDERMAL OF *IPOMOEA* SPECIES STUDIED

	I. asarifolia	*I. batatas*	*I. involucrata*	*I. aquatica*	*I. cairica*	*I. carnea*	*I. hederifolia*	*I. purpurea*
I. asarifolia	1							
I. batatas	0.917	1						
I. involucrata	0.976	0.981	1					
I. aquatica	0.991	0.858	0.941	1				
I. cairica	0.920	0.689	0.816	0.963	1			
I. carnea	0.994	0.954	0.994	0.972	0.874	1		
I. hederifolia	0.999	0.929	0.983	0.986	0.907	0.997	1	
I. purpurea	0.996	0.882	0.956	0.998	0.949	0.982	0.993	1

Note: 1 is a perfect correlation

APPEMDIX 2A: CORRELATION OF ABAXIAL STOMATA DISTRIBUTION OF *IPOMOEA* SPECIES STUDIED

	I. aquatica	*I. asarifolia*	*I. batatas*	*I. cairica*	*I. carnea*	*I. hederifolia*	*I. involucrata*	*I. purpurea*
I. aquatica	1							
I. asarifolia	0.988	1						
I. batatas	0.904	0.828	1					
I. cairica	0.997	0.973	0.933	1				
I. carnea	0.402	0.537	-0.026	0.332	1			
I. hederifolia	0.998	0.995	0.876	0.990	0.458	1		
I. involucrata	0.999	0.986	0.908	0.997	0.393	0.997	1	
I. purpurea	0.996	0.9728	0.935	0.999	0.327	0.989	0.997	1

Note: 1 is a perfect correlation

APPENDIX 2B: CORRELATION OF ADAXIAL STOMATA DISTRIBUTION OF *IPOMOEA* SPECIES STUDIED

	I. aquatica	*I. asarifolia*	*I. batatas*	*I. cairica*	*I. carnea*	*I. hederifolia*	*I. involucrata*	*I. purpurea*
I. aquatica	1							
I. asarifolia	0.256	1						
I. batatas	0.562	0.943	1					
I. cairica	0.637	0.908	0.995	1				
I. carnea	0.068	0.981	0.862	0.812	1			
I. hederifolia	0.0846	0.984	0.871	0.821	0.999	1		
I. involucrata	0.618	0.918	0.997	0.999	0.826	0.835	1	
I. purpurea	0.515	0.960	0.998	0.988	0.8902	0.897	0.992	1

Note: 1 is perfect correlation

REFERENCES

- Abdel khalik K., Osman K. A. 2007. Seed morphology of some species of Convolvulaceae from Egypt (Identification of species and systematic significance). *Feddes Repertorium.* 1-2: 27-34.
- Abdulrahaman A. A, Jimoh Y. L., Aluko T. A., Oladele F. A. 2016. Identification and authentication of dry samples of Some medicinal plants using leaf epidermal features as marker. *Annals of West University of Timişoara, ser. Biology*, 19 (1): 3-16.
- Adegbite A.E.2008. Leaf anatomical studies in some species of the tribe Cichorieae (Asteraceae) in Nigeria. *Comp. Newsl.* 46:49-58.
- Akobundu I.O., Agyakwa C.W.1987. *Guide to West African Weeds*. IITA, Ibadan, 522pp.
- Austin H. Z. 1996. A synopsis of *Ipomoea* (Convolvulaceae) in the Americas. *Taxon* 45: 3-38.
- Aworinde D.O., Ogundairo B.O., Erinoso S.M., Sharaibi O.J. 2013. Foliar Epidermal and Petiole Anatomical Studies of Some Nigerian Species of *Ipomoea* (Convolvulaceae). *Current Botany* 4(3): 55-58.
- Ayodele A. E., Olowokudejo J.D. 2006. The family Polygonaceae in West Africa: Taxonomic significance of leaf epidermal characters. *South African Journal of Botanical* 3: 442-459**.**
- Batterman M.R.W., Lammers T.G. 2004. Branched foliar trichomes of *Lobeliodeae* (Campanulaceae) and the infrageneric classification of *Centropogon*. *Syst. Bot.* 29(2): 448-458.
- Burkill H. M. 1985. *The useful plants West Tropical Africa* (2nd ed.) Families A-D. Kew, Uk: Royal Botanical Gardens. 1: 960p.
- Chand N., Rohatgi P. K. 2005. Impact toughness ofIpomoea carnea particulate-polyester composite. *Journal of Materials Science Letters*. 6 (6): 695–697.
- Dilcher D.L. 1974. Approaches to the identification of angiosperm leaf remains. *Botanical Revision.* 40: 1-157.
- Folorunso A. E. 2013. Taxonomic Evaluation of Fifteen Species of *Ipomoea* L. (Convolvulaceae) from South-Western Nigeria using Foliar Micromorphological Characters. *Not Sci Biol.* 5(2):156-162
- Gill S.L., Nyawuame H. G. K 1991. Cuticular studies of some species of Convolvulaceae used in traditional medicine in West Africa. *Feddes Repertorium*, 102:3-4: pp 189–198.
- Holmgren P. K., Keuken W., Schofield E. K. 1981. Index herbariorum. Part I. The herbaria of the world. *Regnum Vegetabile.* 106: 1-452.
- Hutchinson, J. 1964. *The Genera of Flowering plants (Angiosperms).* Dicotyledon. Oxford University Press, London. 1:516pp.
- Ianovici N**.** 2012. Researches on anatomical adaptations of the alpine plants - *Plantago atrata*, *Annals of West University of Timişoa**ra**, ser. Biology*, 15 (1): 1-18
- Ianovici N., Novac I.D., Vlădoiu *D.,* Bijan A., Ionaşcu A., Sălăşan B., Rămuş I. 2009. Biomonitoring of urban habitat quality by anatomical leaf parameters in Timişoara, *Annals of West University of Timişoara, ser. Biology*, 12:73-86
- Kadiri A. B, Olowokudejo J. D., Ogundipe O. T. 2009. Leaf epidermis morphology of West African species of the genus *Acalypha* (Euphorbiaceae). *Botanica Lithuanica* 15(2): 6578.
- Kadiri A. B. 2003. Foliar Epidermal Morphology of the Medicinal Genus *Momordica* Linn. (Cucurbitaceae) in Nigeria. *Nigerian Journal of Science.* 37 (1): 25–33.
- Khan G., Zhang F., Gao Q., Zia-ur-Rehman M., Rehman K., Khan M., Chen S. 2013. Trichomes diversity in the tropical flora of Pakistan. *Journal of Medicinal Plants Research* **7**(22): 1587-1592.
- Lawrence G. H. 1951. *Taxonomy of Vascular Plants*. The Macmillian Company, New York. 823pp.
- Lowell C., Lucansky T. W. 1986. Vegetative Anatomy and Morphology of *Ipomoea hederifolia* (Convolvulaceae). *Bulletin of the Torrey Botanical Club* 113(4): 382-397.
- Martins F.M., Lima J. F., Mascarenhas A. A., Macedo T. P. 2012. Secretory structures of *Ipomoea asarifolia*: anatomy and histochemistry. *Revista Brasileira de farmacognosia*, 22(1):13-20.
- Olowokudejo J. D. 1990. Comparative morphology of leaf epidermis in the Genus *Annona* (Annonaceae) in West Africa. *Phytomorpholohy* 40 (3&4): 407-422pp.
- Sarojini Devi N., Padma Y., Narasimhudu C.L., Venkata R. 2013. Diversity of stomata and trichomes in *Euphorbia* L. – I. *Bangladesh Journal of Plant Taxononomist* 20(1): 27-38**.**
- Sonibare M. A, Jayeola A. A, Egunyomi A., Murata J. 2005. A survey of epidermal morphology in *Ficus* Linn. (Moraceae) of Nigeria**.** *Bot. Bull. Acad. Sin.* 46**:** 231-238
- Stace C.A. 1965. Cuticular studies as an aid to plant taxonomy. *Bulletin Britain Museum National History* **4**: 1-78.

- Stace C.A. 1984. *The taxonomic importance of the leaf surface. In*: Herwood, V.H. and Moore, D.M. (eds.), Current Concepts in Plant Taxonomy. *Systematic Association Special, Academic* Press, London. 25:pp. 67-94.
- Ugborogho R. E., Ogunwenmo K. O., Aina O. I. 1992. Epidermal morphology of six taxa of *Ipomoea* L. in Nigeria. *Feddes Rep*. 103:543-550
- Verdcourt B. 1963. The Miocene non-marine mollusca of Rusinga Island, Lake Victoria and other localities in Kenya. *Palaeontographica Abt*. A 121 (1-3): 1-37.
- Yasmin G., Mir Ajab Khan N. S., Muhammad Q. H. 2010. Taxonomic significance of leaf epidermal anatomy of selected *Persicaria* Mill. species of family Polygonaceae from Pakistan. *African Journal of Biotechnology* 9(25):3759-3768.