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The Significance of Leaf Epidermal Character in Taxonomy of Twenty-One Cola Species in Nigeria

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ABSTRACT

Cola belongs to the family Sterculiaceae and the name was given by Schott and Endl in 1832. Most of the Cola species are trees and grow in moist environments. They bear flowers that may be grouped into panicles of cyme or appears as fascicles on branches or trunks. Their leaves may be entire, pinnately nerved or digitally divided. The plants are used for different medicinal purposes. Some of their seeds are used as currency, to suppress hunger and for flavoring in Cola drinks. The materials (leaves) for the study were collected mostly from the southern part of the country. The fresh leaves were collected in black polythene bags from the field and stored in 50% alcohol. The leaves were later cut into $2cm^2$ and put on a labelled petri-dishes. Concentrated nitric acid was added to cover the leaves. The epidermides were separated from the mesophyll using forceps and camel hair brush. The peels were stained in safranin, rinsed in water and mounted in glycerol on glass slides. They were covered with cover slips and the edges sealed with hair vanish to prevent dehydration. Observations and measurements of the epidermal characters were made using CX31 photomicroscope and micrometer eye piece. The epidermal cells were either irregular or polygonal in shape while the stomata were anomocytic, anisocytic or paracytic in nature. Trichome bases were observed in most of the epidermides. Stellate and peltate trichomes were observed in Cola gigantea and Cola heterophylla respectively. The characters observed were of great importance taxonomically and can be used to identify some of the taxa even at the species level. The similarities and overlapping of some of the characters symbolize their closeness.

KEYWORDS: Significance, Leaf, Epidermis, Taxonomy, Cola

I. INTRODUCTION

The genus ColaSchott. and Endl. belongs to the family Sterculiaceae and the name was given by Schott and Endlicher in 1832 (Burkill, 2000). Before that year, a few Cola species were known under the generic name sterculia linn (Opeke, 1982).

In 1805 Palisot de Beauvois published an account of specimens that he had collected during a visit in 1786 to parts of what is now Nigeria (Tachie-Obeng and Brown, 2001). Among the species collected by Beavois was the local Cola tree, named by him as sterculia acuminata (Russel, 1955). The genus Cola is the largest in the family Sterculiaceae (Cheek, 2002) and it is indigenous to Africa (Airy-Shaw, 1985). Members are trees which grow in moist environments (Nyananyo, 2006). According to Russel (1955), the systematics of Cola species was in a state of "indescribable confusion" by the beginning of the twentieth century as a result of profusion of new species named on the basis of very meager evidences.

Literature is very sparse on Cola and most of the work done on the genus have been on the chemical constituents and these have been concentrated on very few species (Niemenk et al., 2008). Sonibere (2009) showed that the presence of alkaloids, saponins, tannin and cardenolides in Cola acuminata, Cola nitida, and Cola gigantea indicates their closeness taxonomically. Kola nuts are highly

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esteemed by the people throughout tropical west Africa as charms and remedies, as amulets and aphrodisia. White or light-colored nuts effect love magic while red has the opposite effects. Dried fruits have also been used as currency and are given as tokens of friendship (Ratsch, 1992). Kolanutsreputation for suppressing fatigue and promoting endurance is legendary and Russel (1955) claimed that the British consul at Bachia, Brazil wrote a letter in 1890 suggesting that this powerful commodity should be brought to the attention of her Majesty's war office (Cousins and Hoffman, 2002).

The powdered back of Cola gigantea A. chev. is applied to sores and ulcers and the decoction taken internally as a remedy for pile (Irvine, 1961). Burkill (2000) noted that Cola acuminata has impacts 0n various aspects of life. Some people plant it to commemorate a social event, births, marriage etc.

Yoruba's invoke it in an "Odu" incantations to enable someone wage a successful fight.

According to Irvine (1961), the beaten back of Cola digitata forms a foamy mass which is used to cure baldness in Liberia.

The wood of Cola laurifolia is used for making bows and firewood and the seeds used for treatment of dysentery and diarrhea (Irvine, 1961).

Caffeine, a constituent of kola excites the central nervours system at several levels and is a mental, skeletal muscles, respiratory and cardiac stimulant (Hutchinson and Dalziel, 1958). Kola nuts seeds are exported to be used in the preparation of soft drinks. Commercially, its use is limited to flavouring in Cola drinks and in the manufacture of pharmaceuticals (Tendall, 1997).

This study is very important from the standpoint of the difficulties experienced in identification of some of the Cola species because of their similarities morphologically. In addition, the Cola species have severalmedicinal uses but they may be difficult to differentiate from oneanother whether in terms of leaf morphology or fruits. The anatomical characteristics are then useful to solve these problems to avoid adulteration.

Data generated from leaf epidermal characters were used in resolving taxonomic problems or in the identification of some species (Gul, et al., 2019. Ashtaq et al., 2019., Rashid et al., 2019., Atalay, 2016., James et al., 2021., Ayodele and Olowokudejo, 2006., Das, 2002 and Ahmed et al., 2019).

II. MATERIALS AND METHODS

Fresh leaves of the twenty-oneCola species were collected from the field in black polythene bags. The areas of collection were Cross River, River, Edo, Ondo, Oyo, and Niger states. The Cola species studied are as found in tables 1, 2 and 3.

Epidermal preparation

Fresh leaves of each specimen were preserved in 50% ethanol. The preserved leaves were rinsed in ordinary water. About $2cm^2$was cut from the standard median portion of each of the Cola species. Three to five specimens were used for each species except for those that were collected from a single location. Each specimen was put in a labeled petri-dish and concentrated nitric acid was added so that the leaves were covered with the acid. These were left in the sun outside the laboratory to hasten the action of the acid. Formation of air bubbles in the leaves indicated the separation of the upper and lower epidermides from the mesophyll. The specimens were transferred into new labeled petri-dishes and rinsed three times in water.

The epidermides were separated with a pair of forceps and cleaned with camel hair brush by removing the residuals mesophyll layer. The peels were stained in safranin for about 30 minutes, rinsed in water and mounted in 25% glycerol on clean glass slides and covered with cover slips. The edges of the cover slips were sealed with nail vanish to prevent dehydration. Observations and measurements were made using the micrometer eye piece. Twenty-five measurements of each character were randomly made from each specimenand the mean and standard error calculated.

The stomatal index was calculated using the formular of Salisbury (1927).

$$S.I = \frac{S}{S+E} x100\%$$

Where S.I is the stomatal index, S is the number of stomata per area of view and E is the number of epidermal cells per the same area of view.

Characters were described based on Stace (1965), Olowokudidejo (1993) and Dilcher (1974). Photomicrographs of the specimens were taken using Olympus CX31 photomicroscope.

III. RESULT

The epidermal cells were either irregular or polygonal on both surfaces of Cola acuminata, C. digitata, Cola lateritia and C. laurifolia (table 1, plates 1A and 1B, 1E and 1F, 2H and 2I, 3A and 3B).

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The cell shape on the abaxial surface may be different from that of the adaxial surface of the same leaf as in C. flaviflora, C. gigantea, C. nitida, C. pachycarpa and C. rostrata (Table 1, plates 1I and 2A, 2B and 2C, 3I and 4A, 4C and 4D, 4E and 4F).

Anticlinal wall pattern may be straight curved or undulate (table 1). The anticlinal cell walls were curved and straight on both surfaces of C.chlamydantha, C.ficifolia and C.pachycarpa. (table 1. Plates1C and 1D, 1G and 1H, 4C and 4D)

Undulation of the anticlinal cell wall was more pronounced on the abaxial surface in C.chlamydantha, C.ficifolia, C.flaviflora, C. glabra, and C.nigerica (table1, plates 1C, 1G, 1I, 2D, 3G) while they were straight in C. acuminata, C. digitata, C.lateritia, C. laurifolia and C. nitida (plates 1A, 1E, 2H, 3A, 4A) and curved in C. heterophylla, C.pachycarpa and C. rostrata (plates 2F, 4C, 4E).

The number of epidermal cells per field of view (X400) in the genus ranged from 90 in C. heterophyllaon the adaxial surface while on the abaxial surface the range was from 99 in C. flaviflora, C. heterophyllaandC. nitida (table 2). The mean epidermal cell width ranged from 15.6µm in C.lepidota to 58.9µm in C.ficifolia on the adaxial surfaces and from 21µm to 71µm on the abaxial surfaces of C. laurifolia and C.ficifolia respectively (table 2). Mean cell wall thickness varied from 2.4µm in C.flaviflora and C. glabra to 5.1µm in C.acuminata on the adaxial surfaces while on the abaxial surfaces it was between 2.4µm in C.ficifolia to 5.0µm in C.nigerica (table 2).

There were more epidermal cells on the adaxial surface except in C. ficifolia.

Epidermal cells per field of view (X400) in the genus was from 90 in C. heterophylla to 676 in C. nitida on the abaxial surface (table 2).

Stomatal types were anomocytic in the genus but anisocytic in C. digitata and C. lepidota (table 3, plate 1E, and 3C) and paracytic in C. ficifolia, and C. flaviflora. (table 3, plates 1G and 1I). All the species were hypostomatic except for C. nitida where it wasamphistomatic (Plate 4B). The range of the number of stomata per field of view (X400) was from 7 in C. megalophylla to 105 in C. laurifolia. Stomata were found along the veins on the adaxial surface of C. nitida (table 3, plate4B).

Stomatal index ranged from 0.02% in C. acuminata to 0.06% in C. nitida on the adaxial surfaces while it ranged from 6.5% in C. nitida to 29.7% in C. gigantea on the abaxial surfaces (table 3) trichomes were absent on the epidermal surfaces except in C. gigantea and C. heterophylla where they were stellate and peltaterespectively (table 3, plates 2B and 2G). however, circular and star-shape trochome bases were recorded on most of the either surface of the epidermides.

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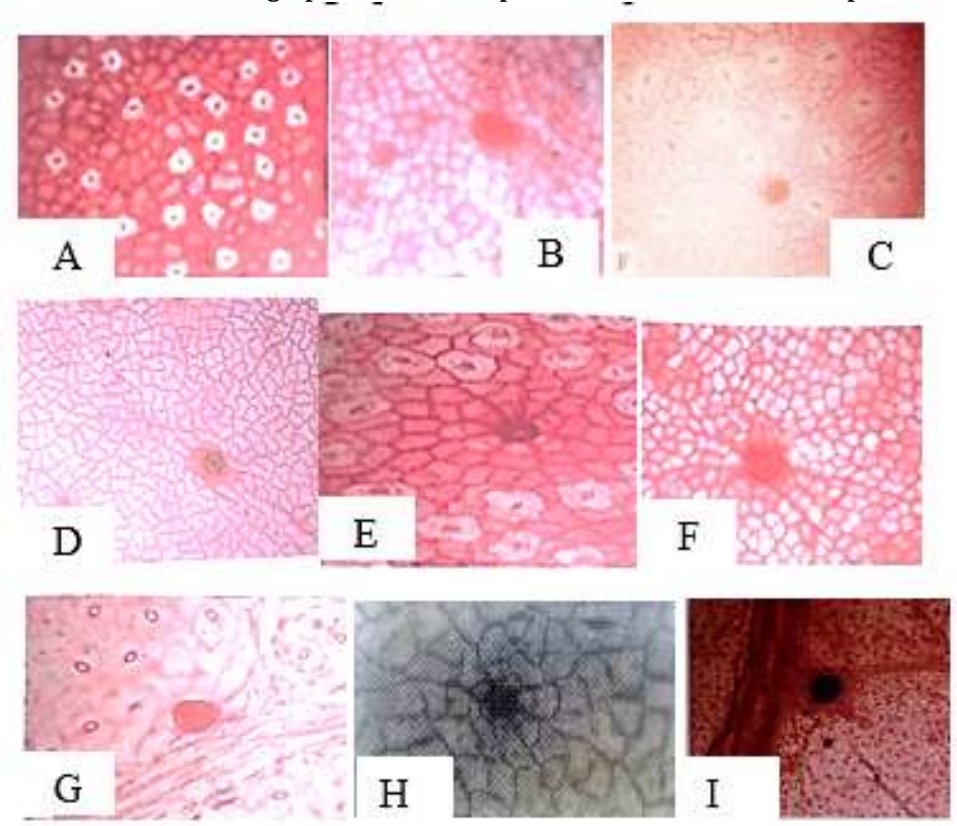
Plate 1: Photomicrographs of the Leaf Epidermal Characters of Cola Species



A. Cola acuminata: abaxial surface showing polygonal cells, straight anticlinal walls, anomocytic stomata and circular trichome bases.
B. Cola acuminata: adaxial surface showing polygonal cells, straight anticlinal walls and circular trichome bases.
C. Cola chlamydantha: abaxial surface showing irregular cells with undulating anticlinal cell walls, anisocytic stomata and pocket-shaped glandular trichomes.
D. Cola chlamydantha: adaxial surface showing irregular cells with undulating anticlinal cell walls and star-shaped trichome bases.
E. Cola digitata: abaxial surface showing polygonal and irregular cells with straight and curved anticlinal cell walls, aninocytic stomata and star shape trichome bases.
F. Cola digitata: adaxial surface showing polygonal and irregular and irregular cells with straight and curved anticlinal cell walls and circular trichome bases.
G. Cola facifolia: abaxial surface showing polygonal cells, undulating anticlinal cell walls, paracytic stomata and pocket shaped glandular trichome bases
H. Cola facifolia: abaxial surface showing polygonal cells with curved and straight anticlinal cell walls and star-shaped trichome bases.
I. Cola flaviflora: abaxial surface showing irregular cells with undulating anticlinal cell walls, paracytic stomata and circular trichome bases.

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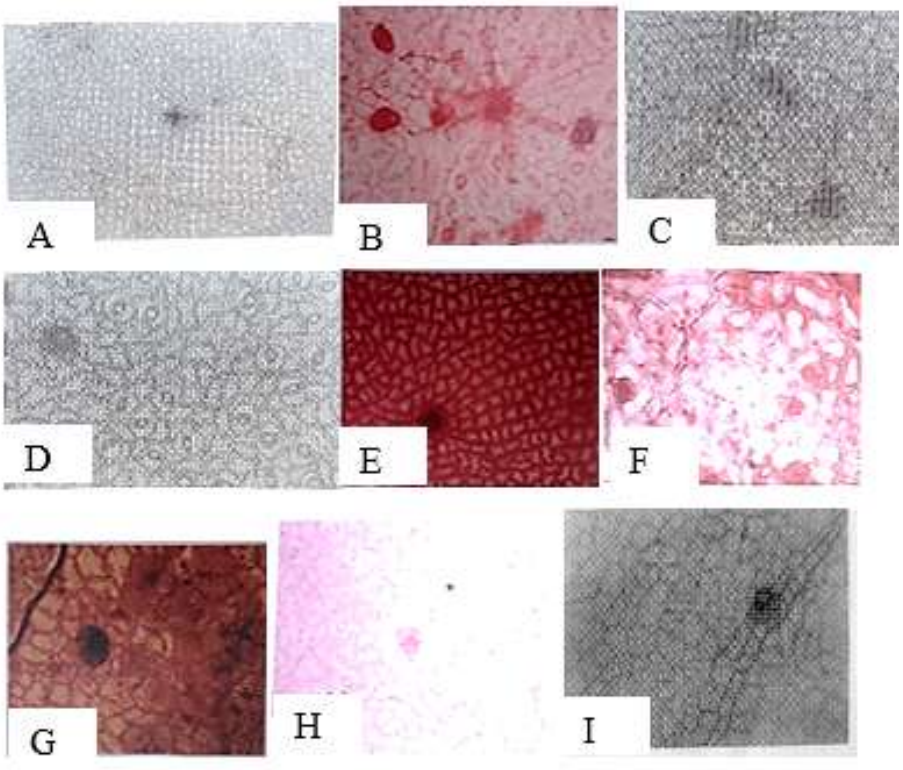
Plate 2: Photomicrographs of the Leaf Epidermal Characters of Cola Species



A. Cola flaviflora: adaxial surface showing polygonal cells and circular trichome bases
B. Cola gigantea: abaxial surface showing irregular cells with curved anticlinal cell walls, anomocytic stomata, pocket-shaped glandular and stellate trichomes.
C. Cola gigantea: adaxial surface with polygonal cells, straight anticlinal cell walls and pocket-shaped glandular trichomes
D. Cola glabra: adaxial surface showing polygonal cells with sinulate anticlinal cell walls, anomocytic stomata and star-shaped trichome bases.
E. Cola glabra: adaxial surface showing polygonal cells with straight anticlinal cell walls and star-shaped trichome bases.
F. Cola heterophylla: abaxial surface showing irregular cells with curved and straight cell walls, anomocytic stomata and pocket-shaped glandular trichomes
G. Cola heterophylla: adaxial surface showing polygonal cells with curved and straight anticlinal cell walls, peltate trichomes and pocket-shaped glandular trichomes.
H. Colalateritia: abaxial surface showing polygonal cells, straight anticlinal walls, anomocytic stomata and pocket-shaped glandular trichomes.
I. Cola lateritia:adaxial surface showing polygonal cells with straight anticlinal cell walls and pocket-shaped glandular trichomes.

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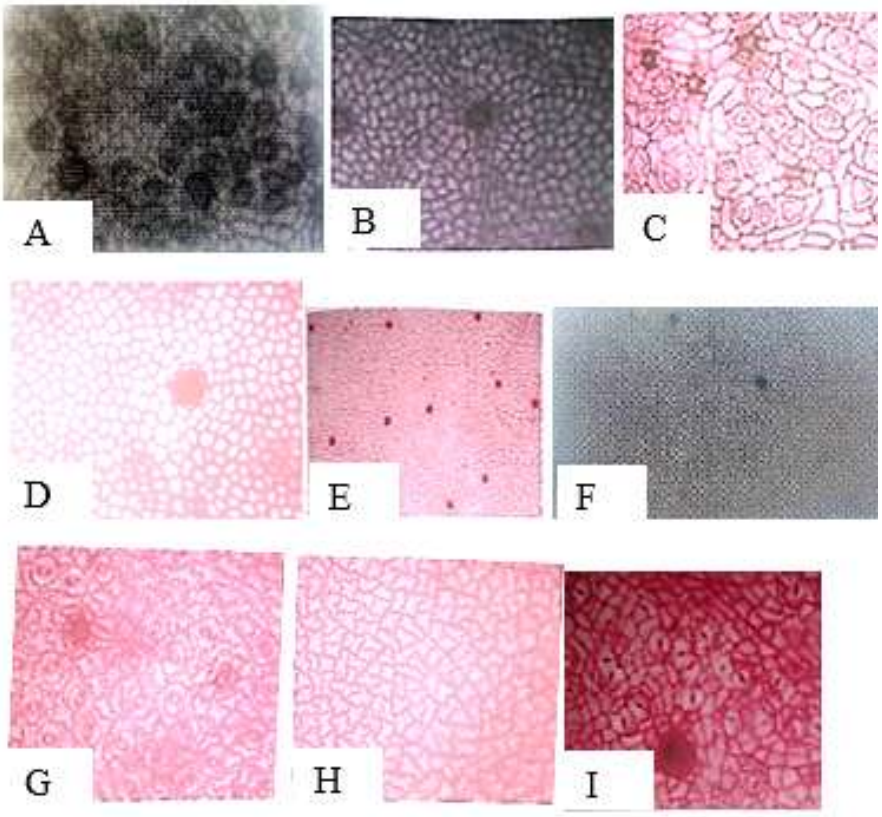
Plate 3: Photomicrographs of the Leaf Epidermal Characters of Cola Species



A. Cola laurifolia: abaxial surface showing polygonal cells with straight anticlinal cell walls, anomocytic stomata and star-shaped trichome bases.
B. Cola laurifolia: adaxial surface showing irregular cells with straight anticlinal cell walls and pocket-shaped trichomes.
C. Cola lepidota: abaxial surface showing irregular cells with straight and curved anticlinal cell walls, anisocytic stomata and star-shaped trichome bases.
D. Cola lepidota: adaxial surface showing polygonal cells with straight anticlinal cell walls and star-shaped trichome bases.
E. Cola megalophylla: abaxial surface showing polygonal cells with straight and curved anticlinal cell walls and circular trichome bases.
F. Cola megalophylla: adaxial surface showing hexagonal cells with straight anticlinal cell walls and circular trichome bases.
G. Cola nigerica: abaxial surface showing irregular cell with sinulate anticlinal cell walls, anomocytic stomata and star-shaped trichome bases.
H. Cola nigerica: adaxial surface showing irregular cells with sinulate anticlinal cell walls.
I. Cola nitida: abaxial surface showing anomocytic stomata, polygonal cells with straight anticlinal cell walls and pocket-shaped glandular trichomes.

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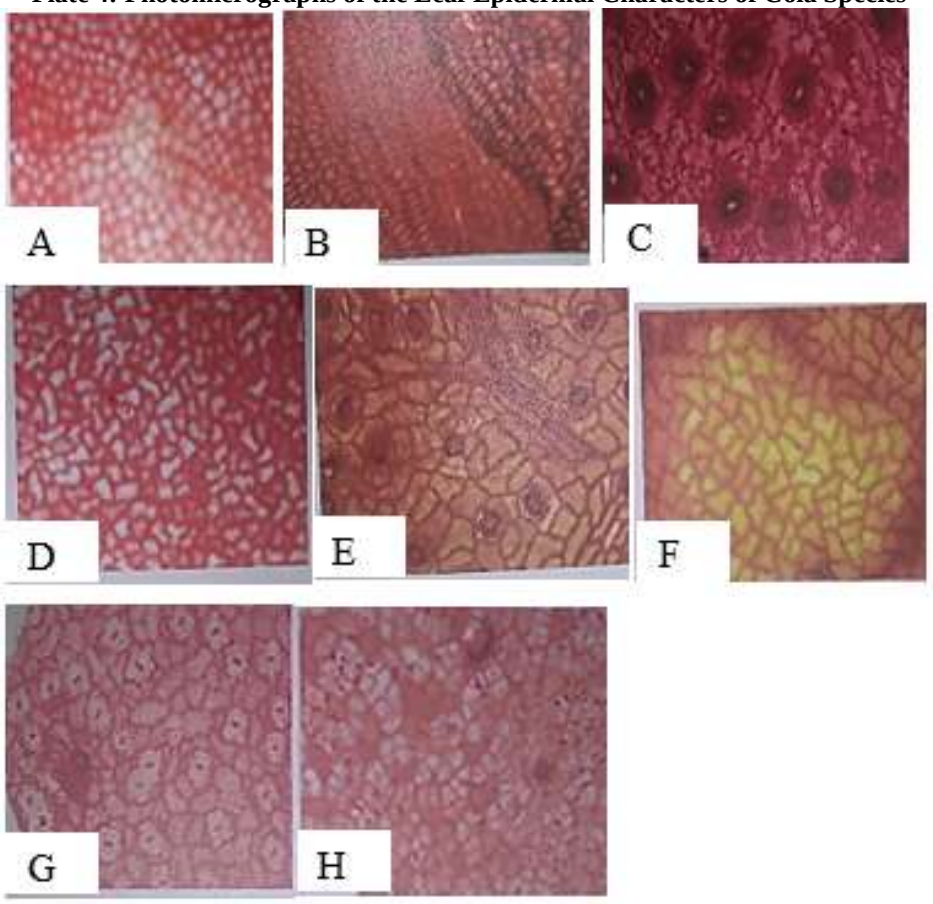
Plate 4: Photomicrographs of the Leaf Epidermal Characters of Cola Species



A. Cola nitida: abaxial surface showing polygonal cells with straight anticlinal cell walls.
B. Cola nitida: adaxial surface showing stomata along the main vein.
C. Cola pachycarpa: abaxial surface showing irregular cells with curved anticlinal cell walls, anomocytic stomata almost covered with papillate and have circular trichome bases.
D. Cola pachycarpa: adaxial surface showing irregular and polygonal cells with straight and curved anticlinal cell walls and circular trichome bases.
E. Cola rostrata: abaxial surface showing irregualar and polygonal cells with curved and straight anticlinal cell walls.
F. Cola rostrata: adaxial surface showing irregular and polygonal cells with curved and straight anticlinal cell walls and amonocytic stomata.
G. Cola verticilata: abaxial surface showing polygonal cells with straight and curved anticlinal cell walls, anomocytic stomata and circular trichome bases
H. Cola verticilata: adaxial surface showing irregular cells with straight and curved anticlinal walls, circular trichomes bases and crystal sands.

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Table 1: Qualitative leaf epidermal characters of genus Cola in Nigeria

Taxa	Cell shape		Anticlinal wall pattern		Stomatal type		Trichome type
	Adaxial	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial	
C. acuminata	Polygonal	Polygonal	Straight	Straight	Anomocytic	Anomocytic	Absent
C. chlamydantha	Irregular	Irregular	Undulate	Undulate	Absent	Anomocytic	Absent
C. digitata	Polygonal	Polygonal	Straight	Straight	Absent	Anisocytic	Absent
C. ficifolia	Polygonal	Irregular	Straight/Curved	Undulate	Absent	Paracytic	Absent
C. flaviflora	Polygonal	Irregular	Straight/Curved	Undulate	Absent	Paracytic	Absent
C. gigantea	Polygonal	Irregular	Straight	Undulate	Absent	Paracytic	Absent
C. glabra	Irregular	Irregular	Straight	Straight/Curved	Absent	Paracytic/Anomocytic	Absent
C. heterophylla	Polygonal	Irregular	Straight	Undulate	Absent	Anomocytic	Absent
C. lateritia	Polygonal	Polygonal	Straight	Straight/Curved	Absent	Paracytic	Absent
C. laurifolia	Polygonal	Polygonal	Straight	Straight	Absent	Anomocytic	Absent
C. Lepidota	Polygonal	Irregular	Straight	Straight	Absent	Anomocytic	Absent
C. megalophylla	Hexagonal	Polygonal	Straight	Straight/Curved	Absent	Anisocytic	Absent
C. nigerica	Irregular	Irregular	Undulate	Curved	Absent	Paracytic	Absent
C. nitida	Polygonal	Polygonal	Straight	Undulate	Anomocytic	Anomocytic	Absent
C. pachycarpa	Polygonal	Irregular	Straight/Curved	Curved	Absent	Anomocytic	Absent
C. rostrata	Polygonal	Irregular	Straight/Curved	Curved	Absent	Anomocytic	Absent
C. verticillata	Polygonal	Polygonal	Straight	Straight	Absent	Anomocytic	Absent

Table 2: Quantitative leaf epidermal characters of genus Cola in Nigeria

Taxa	No of cells/x400 area of view min. (mean±s.e) max.		Epidermal cell width min (mean±s.e) max. µm		Cell wall thickness min (mean±s.e) max. µm	
	Adaxial	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial
C. acuminata	506(588±38)700	278(412±76)506	10(18.9±4.6)27.5	15.0(27.2±)47.5	4.5(5.1±0.3)5.5	2.3(2.5±0.1)2.8
C. chlamydantha	506(624±63)728	168(215±31)306	15(21.8±4.4)30	20.0(34.4±)47.5	2.5(2.5±0)2.8	2.3(2.5±0.1)2.5
C. digitata	621(666±47)754	132(171±23)225	12.5(19.4±3.6)25.0	20.0(30.0±)37.5	2.5(2.5±0)2.5	2.5(2.5±0.0)2.5
C. ficifolia	99(121±14)156	104(141±27)208	37.5(58.9±12)77.5	40.0(71.1±)110	2.5(2.7±0.2)3.0	2.0(2.4±0.3)2.8
C. flaviflora	100(128±16)156	99(126±17)156	37.5(50.7±7.3)62.5	32.5(58.3±)72.5	2.0(2.4±0.2)2.8	2.3(2.8±0.4)2.8
C. gigantea	281(426±55)552	110(160±38)255	15(26.4±7.0)37.5	12.5(27.3±)47.5	2.3(3.5±0.1)2.5	1.5(2.8±0.4)2.8
C. glabra	378(451±58)667	144(206±34)272	20(28.1±4.7)37.5	25.0(37.5±)57.5	2.0(2.4±0.2)2.8	2.0(2.5±0.1)2.5
C. heterophylla	90(150±23)196	99(128±19)156	32.5(49.1±10.2)60.0	12.5(52.3±)80.0	1.5(2.5±0.7)4.0	1.8(2.6±0.4)3.0
C. lateritia	305(347±28)399	210(253±19)288	10(24.0±7.9)40.0	17.5(28.8±)37.5	2.5(3.6±0.7)5.0	1.8(2.6±0.4)3.0
C. laurifolia	754(837±62)960	420(502±44)575	12.5(20.7±4.1)30.0	10.0(21.0±)35.0	2.5(2.5±0)2.5	2.5(2.6±0.1)2.0
C. Lepidota	702(849±58)930	182(288±60)360	12.5(15.6±2.7)20.0	17.5(34.8±)57.5	2.5(3.0±0.3)3.8	2.8(3.4±0.4)5.5
C. megalophylla	224(258±25)306	18(117±21)156	20(32.2±5.0)40.0	35.0(51.4±)70.0	2.5(2.6±0.1)2.8	2.5(2.6±0.1)3.0
C. nigerica	399(475±50)625	210(237±24)288	12.5(24.7±5.7)35.0	17.5(29.6±)40.0	3.5(4.6±0.5)5.0	4.5(5.0±0.4)5.5
C. nitida	506(626±56)750	460(562±59)676	10.0(20.7±8.0)37.5	17.5(27.2±)50.5	2.0(2.6±0.5)4.5	1.8(2.4±0.4)3.0
C. pachycarpa	342(443±36)506	108(143±17)180	15.0(27.1±6.8)32.5	25.0(49.8±)90.0	2.5(2.9±0.3)3.3	2.0(2.4±0.2)2.5
C. rostrata	210(263±31)324	110(152±25)182	25.0(47.7±11.2)62.5	30.0(45.5±)62.5	4.5(5.0±0.1)5.0	3.0(4.4±0.7)5.0
C. verticillata	420(541±48)600	240(281±30)340	12.5(25.5±7.5)42.5	22.5(32.3±)52.5	2.5(2.6±0.2)2.8	2.5(3.0±0.7)5.0

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Table 3: Quantitative leaf epidermal characters of genus Cola in Nigeria

Taxa	Stomatal density/x400 Min (mean±s.e) max.		Stomatal length (µm) Min (mean±s.e) max. µm		Stomatal width (µm) Min (mean±s.e) max. µm		Stomatal Index (%)	
	Adaxial	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial
C. acuminata	0(0.1±0.3)1.0	32(34±1.2)36	23.0(23.8±1.8)25.0	17.5(20.5±1.8)17.5	10(12.5±3.5)15	12.5(15.6±1.9)17.5	0.02	8.2
C. chlamydantha	Absent	21(24.8±2.3)44	Absent	17.5(19.7±1.5)20	Absent	17.5(18.8±1.3)20	Absent	10.3
C. digitata	Absent	32(39.5±3.2)44	Absent	22.5(24.8±1.8)27.5	Absent	12.5(16.8±0.8)20	Absent	18.7
C. ficifolia	Absent	18(22.5±2.5)26	Absent	20(24±1.5)25	Absent	22.5(24.1±1.2)25	Absent	13.8
C. flaviflora	Absent	21(25.6±2.6)30.0	Absent	20(23.8±2.2)27.5	Absent	20(22.7±0.5)25.0	Absent	16.9
C. gigantea	Absent	54(67.7±6.7)81	Absent	20(24±1.8)27.5	Absent	20(22.7±2.1)27.5	Absent	29.7
C. glabra	Absent	35(41.3±4.1)47	Absent	20(20.7±1.2)22.5	Absent	20(20.4±1.8)25	Absent	16.7
C. heterophylla	Absent	17(24.3±3.3)30	Absent	17.5(19±1.5)22.5	Absent	15(18.5±2.0)22.5	Absent	16.0
C. lateritia	Absent	59(71.3±3.9)83	Absent	17.5(21.1±1.5)22.5	Absent	17.5(18.1±1.1)20	Absent	21.9
C. laurifolia	Absent	80(93.3±7.1)105	Absent	17.5(18.9±1.3)20	Absent	15(16.2±1.5)20	Absent	15.7
C. Lepidota	Absent	36(42.5±3.6)48	Absent	17.5(22.8±2.5)30	Absent	15(19±2.3)22.5	Absent	12.9
C. megalophylla	Absent	7(8.8±2.0)15	Absent	25(27.3±1.8)30	Absent	17.5(1.8±0.9)27.5	Absent	7.0
C. nigerica	Absent	36(48.5±6.7)59	Absent	17.5(19.7±1.5)20	Absent	17.5(18.8±1.3)20	Absent	17.0
C. nitida	0(0.4±0.7)2	31(39.0±3.5)45	30(34.6±4.9)37.5	17.5(20.4±1.6)22.5	10(13.3±2.6)17.5	17.5(18.3±1.2)20	0.6	6.5
C. pachycarpa	Absent	16(19±1.9)23	Absent	20(24.0±2.1)27.5	Absent	17.5(20±2)25	Absent	11.7
C. rostrata	Absent	17(19.6±1.5)24	Absent	22.5(24.8±1.5)27.5	Absent	17.5(20.6±1.3)22.5	Absent	11.4
C. verticillata	Absent	35(36.2±1.4)40	Absent	20(22.2±2.0)25	Absent	12.5(6.6±0.7)17.5	Absent	11.4

IV. DISCUSSION

The leaf epidermal characters investigated in this study include the cell shape, stomata, anticlinal wall patterns, trichomes, number of cells per area of view, epidermal cell width, cell wall thickness, stomatal length, width, density and index.

The anticlinal cell wall patterns, shapes of the cells, sizes and densities varied among the Cola species. Foliar epidermal study is very important in identification of plants (kadiri, Olowokudejo and Ogundipe, 2006). The taxonomic value of epidermal morphology was also put forward by Adedeji (2004), kadiri (2006) and Khatihajh and Zaharina (1998).

The epidermal cells in different plants may vary in the number of layers, shapes, structure, stomata, trichomes and occurance of specialized cells (Fahn, 1982).

The wide range in the distribution of cells (121-950 on the adaxial and 177-562 on the abaxial surfaces) can be used to separate one taxon from the other. The heterogenus cell shapes are delimiting characters in the Cola species.

The mostly hexagonal cells on the adaxial surface of C. megalophylla made it distinct from other taxa which may have polygonal or irregular cells. The use of epidermal cell characters was used to solve some taxonomic problems by Ogundipe and Olatunji (1991), Ayodele and Olowokudejo (1993), Das and Gbose (1993), Illoh (1995), Isawumi (1996), Croxdale (2000) and Ayodele and Olowokudejo (2006).

The sinuate anticlinal cell walls in C. glabra and C. nigerica where it is found on the abaxial surface of the former and both surfaces of the later respectively are important diagnostic characters. Stace (1965) observed that the undulation of the cell wall is a mesomophic character which according to him is determined by environmental conditions such as humidity. This does not apply to the Cola species in this research because C. nigerica which has sinuate anticlinal walls on both surfaces was from the same ecological area with C megalophylla and C. digitata that have straight anticlinal walls.

Based on the stomatal types, these Cola species can be grouped into three: viz those with anomocytic, paracytic and anisocytic stomata. The amphistomatic character shown by C. nitida is also of great taxanomic importance and can be used to separate it from the other taxa. As elucidated by Krishnamurthy and Kannabiron, 1970, the number and arrangement of subsidiary cells, morphology and relationship of the stomata to neighboring cells have diagnostic importance in these taxa. Watson (1962) pointed out that the pattern of stomatal distribution and structure are important taxonomic criteria in Epacridaceae.

Nyanayo (1986) maintained that the uniformity in subsidiary cells in each species

supports its naturalness. Akhil and Subhan (1997), Rejdali (1991), Singh and Dube (1993) and Kadiri and Adesina (2008) made it clear that the taxonomic significance of stomata has been variously reported and was evident in this work because different types of stomata were observed.

Trichome bases of different types were observed on the epidermides but stellate and peltate trichomes occurred in C. gigantea and C. heterophylla respectively. These trichomes distinguished the two species from the rest. Trichomes have been used as one of the anatomical characters for systematic comparison and delimitation.

V. CONCLUSION

The epidermal characters in this study have proved to be useful in delimiting some of the Cola species from others. Although some may have similar stomatal types but they may differ in terms of subsidiary cells or the trichome bases. This showed that the characters when combined with other characters like phytochemicals can be conveniently used to distinguish one species from the other. The use of epidermal characters in plant taxonomy from what was observed in this study is well appreciated or accepted.

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