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Research Article

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Foliar epidermal studies in the family *Sapindaceae* Juss. in South Western Nigeria

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ABSTRACT

A comparative study of leaf epidermal features of selected species of the family Sapindaceae in Nigeria was undertaken with a view to obtain additional characters for the elucidation of taxonomic relationships, delimiting species and identification of the taxa. The epidermises were separated from the mesophyll by soaking in concentrated Nitric acid. Bubble appearance on the surfaces of the leaves indicated their readiness for separation. They were then rinsed in water thrice before the layers were separated with the aid of forceps and Camel hair brush, stained with Safranin O. It was then mounted in 25% glycerol on clean glass slides, covered with cover slips. The micro morphological characters of leaf were more or less uniform in all taxa in the family. The adaxial cuticle was striated in most species. The polygonal epidermal cells with straight anticlinal walls on the adaxial surface of *Cardiosermum halicacabum* separated it from the other species with irregular shaped epidermal cells. Undulated anticlinal walls were observed on both surfaces. The leaves were hypostomatic in most species except in *C. halicacabum* where amphistomaty was observed. Stomata types included anomocytic, tetracytic and staurocytic but the anomocytic stomata were the most predominant.

KEYWORDS: Amphistomaty, Anomocytic, Epidermis, Foliar, Hypostomatic, Nigeria, Sapindaceae, Stomata

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INTRODUCTION

The family *Sapindaceae* Juss, also known as the soapberry family has about 140-150 genera with 1400-2000 species, including maple, horse chestnut and lychee (Adeyemi *et al.*, 2013). Most members are large emergent trees or erect shrubs with some tendril lianes (Acevedo-Rodriguez *et al.*, 2011). Many of these are laticiferous, and many have mildly toxic saponins in the foliage and or in the seeds, or roots (Buerki *et al.*, 2009). Leaves are usually compound, spirally alternate though sometimes opposite as in *Acer* L; *Aesculus* L; and a few other genera (Buerki *et al.*, 2009). They are most often pinnately compound, bipinnate or palmately compound, or just palmate (*Acer*, *Aesculus*); with petioles lacking stipules, but having a swollen base (Singh, 2004). Flowers are arranged in groups, usually creamy white but sometimes pinkish white as in *Dodonaea* Mill. Inflorescence is usually in the form of raceme or cyme. Most often pollination can be by wind, birds or insects (Singh, 2004). Fruits are green in colour turning orange or red as they become ripe, however, they are brown in *Dodonaea* species (Adeyemi & Ogundipe, 2012). They may also be fleshy or dry, nuts, berries, drupes, schizocarps, and capsules as in *Bridgesia* Bertero ex Cambess or samaras as in *Acer* L. often red, containing seeds (Heywood, 1978). The majority of the species are native to Asia, although there are a few in South America, Africa and Australia (APG II, 2003). Sapindaceae is represented by about 26 genera in west tropical Africa (Adeyemi & Ogundipe, 2012) and 47 species in Nigeria (Onuminya & Ogundipe, 2014). Many species in Nigeria grow in under-storey forests and are on the borderline between shrubs and trees (Keay *et al.*, 1964).

Though recent studies of Sapindaceae (Sofidiya *et al.*, 2012; Adeyemi *et al.*, 2013; Onuminya & Ogundipe, 2014) have yielded useful data concerning intra- and inter-specific variation patterns as well as the geographical relationship of the family, there is a dearth of information on the foliar epidermal morphology of the taxon in Nigeria which has been known to be of taxonomic importance in identification and delimitation of Angiosperms (Aworinde *et al.*, 2014; Shokefun *et al.*, 2014; Shah *et al.*, 2019).

Leaf extracts of members of the family are commonly used for the treatment of boils, ulcers, pain, dermatological troubles,

wound healing, diarrhea and dysentery (Iwu, 1993; Burkill, 2000; Jimoh *et al.*, 2007). *Allophylus africanus* P. Beauv. was reported not only to act as galactogogue but it possesses therapeutic potentials against *E. coli* and *K. pneumoniae* and could be used as herbal drugs for the treatment of diarrhoea and pneumonia (Gbadamosi & Okolosi, 2013). The wood of *Lecaniodiscus cupanioides* Planch ex Benth. is valued for its very hard wood used in making roof-rafters, tool-handles, morters and pestles (Butkill, 2000).

MATERIALS AND METHODS

Macromorphology

Fresh collections of *Allophylus africanus* P. Beauv; *A. spicatus* (Poir.)Radlk; *Blighia unijugata* Baker; *B. sapida* K. D. Koenig; *Cardiospermum grandiflorum* Swartz; *C. halicacabum* L; *Deinbollia pinnata* Schumach & Thonn;, *Lecaniodiscus cupanioides* Planch ex Benth; *Paullinia pinnata* L; and *Zanha golungensis* Hiern. Randomly collected from Ibadan, Oyo state, and Moro, Osun state, Nigeria were used for the work.

Epidermal Preparation

The epidermal preparations followed the modified methods of (Ugbabe & Ayodele, 2008; Shah *et al.*, 2020; Onuminya *et al.*, 2020). About 5 mm – 1 cm^2 leaf fragments were obtained from the standard median portion of the leaf and macerated in concentrated Nitrate acid in the Petri-dish for a period of about 24h. 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 and cleaned with the Camel hair brush. These were rinsed in distilled water and preserved in 50% ethanol. They were then stained in Safranin O for 5 - 10 minutes and the excess stain was washed off in the water. They were then mounted in 25% glycerol on a slide with the edge of the cover slips sealed with nail vanish to prevent dehydration. The slides were labeled appropriately and examined under a light microscope. An accu-scope trinocular microscope (ACCU-scope 33001 LED Trinocular microscope with 3.2 MP CMOS digital camera) was used to take the photomicrographs of the prepared slides. For each species, a total of twenty-five epidermal cells and stomata were randomly selected for measurement. The stomatal index (SI) was calculated for all the species using the formulae of Salisbury (1927). The range, mean and standard error were determined for all species. Terminologies followed that of Dilcher, Metcalfe and Chalk and Stace (Dilcher, 1974; Metcalfe & Chalk, 1979; Stace, 1980).

$$\text{Stomatal Index} = S/E + S\ 100$$

Where S = Mean number of stomata per view calculated for each species.
E = Mean number of epidermal cells per view calculated for each species.

Leaf Clearing

Leaf clearing methods followed what was described by Akinnubi (2014). Sizeable portions of matured leaves of each species were taken from the standard median portion of the leaves. These samples were decolorized by boiling in absolute ethanol for 15 minutes to remove chlorophyll and treated in 5% Sodium hydroxide overnight. They were rinsed in water three times before being transferred into 5% domestic bleach until they became completely white. The cleared leaves were stained in 1% aqueous solution of Safranin O and mounted on a clean microscopic glass slide in 25% glycerol and the edges of the cover slip sealed with nail vanish to prevent dehydration.

RESULTS

Leaf Macromorphological Characters

The leaflets of the ten species ranged from ovate in *Allophylus africanus, A. spicatus, Cardiospermum grandiflorum, C. halicacabum, Paullinia pinnata and Zanha golungensis* to oblong in *Blighia sapida, B. unijugata* and *Deinbolia pinnata*. Leaf was compound paripinnate in *Blighia sapida, B. unijugata, Deinbolia pinnata, Lecaniodiscus cupanioides* and *Zanha golungensis*, trifoliate in *A. africanus and A. spicatus*, trifoliolate in *Cardiospermum grandiflorum* and *C. halicacabum* and imparipinnate in *Paullinia pinnata*. Venation in *Blighia unijugata, B. sapida, Deinbolia pinnata, Lecaniodiscus cupanioides* and *Zanha golungensis* was camptodromous-bronchidodromous; leaves had entire margin and glabrous adaxial and abaxial surfaces. Leaflet apices and bases were acute in all taxa except in *B. sapida* with obtuse apex and acute base (Table 1). The leaflet size ranged from 2.7 x 6.42 cm in *C. halicacabum* to 5.1 cm x 16.86 cm in *B. unijugata*. The lamina length ranges from 11.06 cm in *B. unijugata* to 37.3 cm in *C. halicacabum*. The shortest internode was recorded in *B. unijugata* (2.58 cm), while the longest internode of 20 cm was recorded in *A. africanus*. The mean of lateral veins ranged from 2.92 to 22.4 in *C. grandiflorum* and *B. sapida* respectively (Table 2).

Not much variation was observed in the leaf shape, leaf base, leaf apex, leaf surfaces and leaf texture within species in the family making the characters of little or no taxonomic importance above the generic level. In this study, the type of secondary vein, areole development, marginal venation pattern, type of stigma as well as margin are qualitative characters of high taxonomic importance that readily splitted the species into two groups: group A consisting of trees species (*Blighia sapida, B. unijugata, Deinbollia pinnata, Lecaniodiscus cupanioides* and *Zanha golungensis*) while group B comprised of scandent shrubs (*Allophylus africanus* and *A. spicatus*) and climbers (*Cardiospermum grandiflorum, C. halicacabum* and *Paullinia pinnata*).

Most of the quantitative macro-morphological characters of taxa in Sapindaceae may not contribute to the separation of the taxa in the family into two groups because of the wide similarities observed

Table 1: Qualitative macro morphological features of the species of Sapindaceae

Taxa	Leaf	Type of Secondary Veins	Leaflet Apex	Leaflet Shape	Leaflet margin	Leaflet surface	Leaf arrangement
Allophylus africanus	Trifoliate	Mixed-craspedodromous	Acute	Ovate	Serrate	Glabrous	Alternate
Allophylus spicatus	Trifoliate	mixed-craspedodroous	Acute	Ovate	Serrate	Pubescent	Alternate
Blighia sapida	Paripinnate	Camptodromous-brochidodromous	Obtuse	Oblong	Entire	Glabrous	Alternate
Blighia unijugata	Paripinnate	Camptodromous-brochidodromous	Acute	Oblong	Entire	Glabrous	Alternate
Cardiospermum grandiflorum	Trifoliolate	Mixed- craspedodromous	Acute	Ovate	Serrate	Pubescent	Alternate
Cardiospermum halicacabum	Trifoliolate	Mixed- craspedodromous	Acute	Ovate	Serrate	Glabrous	Alternate
Deinbolia pinnata	Paripinnate	Camptodromous-brochidodromous	Acute	Oblong	Entire	Glabrous	Spiral
Lecaniodiscus cupanioides	Paripinnate	Camptodromous-brochidodromous	Acute	Oblong	Entire	Glabrous	Spiral
Paullinia pinnata	Imparipinnate	Mixed- craspedodromous	Acute	Ovate	Serrate	Glabrous	Spiral
Zanha golungensis	Paripinnate	Camptodromous-brochidodromous	Acute	Ovate	Entire	Glabrous	Spiral

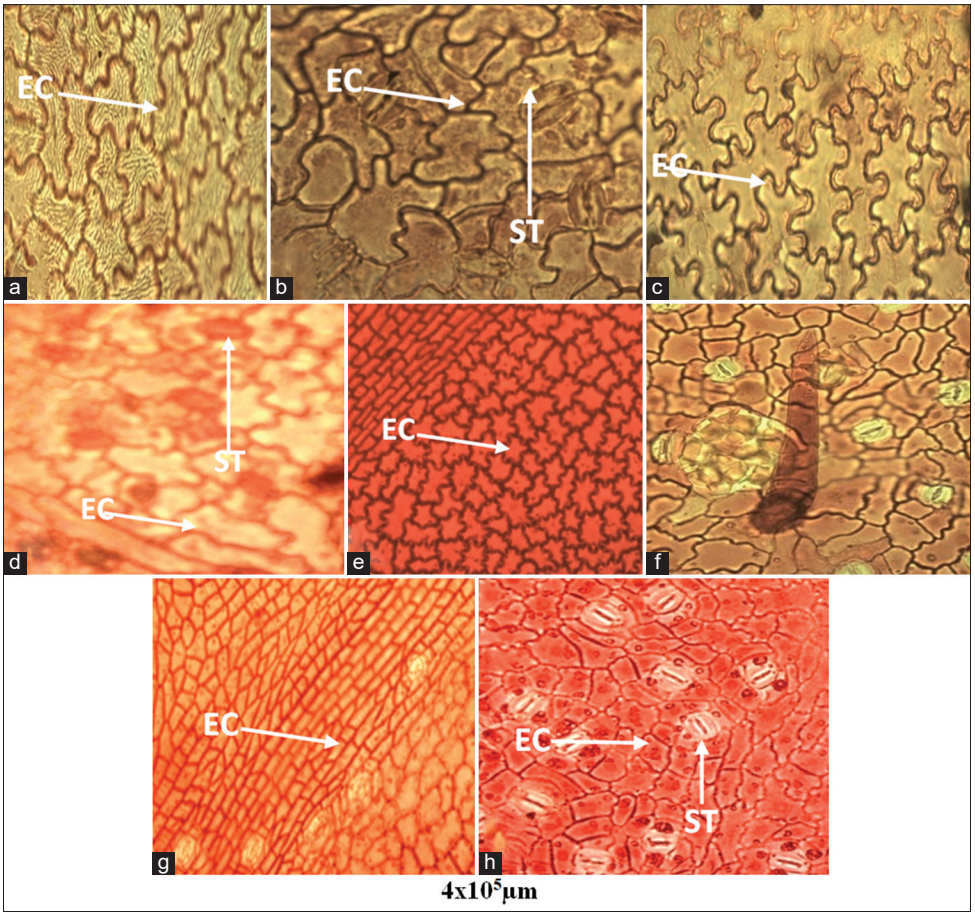

Figure 1: Leaf epidermal surfaces of species of the family Sapindaceae. a) *Allophylus africanus* - Adaxial surface, b) *Allophylus africanus* - Abaxial surface, c) *Allophylus spicatus* - Adaxial surface, d) *Allophylus spicatus* - Abaxial surface, e) *Blighia sapida* -Adaxial surface, f) *Blighia sapida* - Abaxial surface, g) *Blighia unijugata* - Adaxial surface, h) *Blighia unijugata* - Abaxial surfaces. EC - Epidermal cell, ST - Stomata

between the species. However, hairiness, leaf type, leaf size and the degree of serration of the leaf margin were stable quantitative characters of high taxonomic value that readily separate *Allophylus* from the other genera. Trifoliolate leaves in *Cardiospermum* separated them from *Paullinia*. It was evident in cluster A of the first group that the kinship between *Blighia unijugata* and *B. sapida* is very high; leaf apex is a diagnostic feature that can be employed basically to distinguish the former from the latter.

Venation was variable and represented by brochidodromous, craspedodromous and mixed-craspedodromous types. This was in congruence with the findings of Hickey (1979). Additionally,

Table 2: Quantitative macro morphological features of the species of Sapindaceae

Taxa	Leaflet length	Leaflet width	Petiole Length	Internode Length	Petiolule length	No of lateral nerves
Allophylus africanus	7.1 (8.34±0.35)9.2	3.6 (4.2±0.0.22)4.7	2.1 (4.1±0.56)5.3	18 (20±0.5)21	3 (4.1±0.35)5.1	18 (20±0.5)21
Allophylus spicatus	9 (11.6±1.06)14	4.6 (5.8±0.37)6.5	1.8 (5.64±1.20)7.1	10 (11.2±0.73)13	3.5 (4.2±0.52)5.5	10 (11.2±0.7)13
Blighia sapida	10.5 (12.8±0.84)15.2	5.1 (6.52±0.49)7.6	0.3 (0.38±0.2)0.4	2.9 (3.40±0.27)4.2	20 (22.4±0.93)25	20 (22.4±0.9)25
Blighia unijugata	12.9 (16.86±1.06)19.10	5.3 (6.42±0.53)7.8	2.8 (3.16±0.15)3.5	2.1 (2.58±0.19)3.1	16 (19.2±0.9)22	16 (19.2±0.9)22
Cardiospermum grandiflorum	4 (5.1±0.44)6.7	2.2 (2.7±0.18)3.2	5.3 (6.26±0.33)7	6 (7.2±0.58)9	2 (2.92±0.29)3.5	6 (7.2±0.6)9
Cardiospermum halicacabum	5 (5.32±0.19)6	2 (2.6±0.20)3	4.7 (7.22±0.82)9.7	4 (4.8±0.37)6	1.9 (3.96±0.56)5.2	4 (4.8±0.4)6
Deinbolia pinnata	12.4 (14.3±0.95)16.9	5.2 (5.88±0.29)6.7	10.9 (9.36±2.36)12.6	2.1 (2.88±0.24)3.4	15 (17.2±0.86)20	15 (17.2±0.9)20
Lecaniodiscus cupanioides	11.3 (13.9±1.02)17.6	5.6 (5.92±0.09)6.1	3.7 (5.0±0.40)5.7	2.1 (2.88±0.34)4.1	15 (19.0±1.30)23	15 (19.0±1.3)23
Paullinia pinnata	7.5 (8.06±0.15)8.4	3.6 (3.98±0.18)4.5	4.9 (6.82±0.54)7.9	10 (12.2±0.66)14	3.2 (4.9±0.49)3.7	10 (12.2±0.7)14
Zanha golungensis	4.7 (7.56±0.76)8.9	3.4 (3.18±1.30)10.2	5.0 (6.24±0.58)8.2	2.6 (3.24±0.30)4	6 (8.8±0.86)11	6 (8.8±0.9)11

Minimum-Maximum (cm) (Mean±Standard error)

the marginal venation pattern type was strongly consistent for leaves from the same or different trees (Sawangchote *et al.*, 2009). Sawangchote *et al.* (2009) found leaf architectural characters, especially marginal venation pattern types rather consistent which he used with other morphological leaf characters to identify extant *Mangifera* L. species of isolated fossil leaves of this genus. A study of the venation patterns of leaves of the ten species of Sapindaceae collected in the field (at least 30 leaves from 1 to 3 trees per species) did show differences related to their growth habit. Members of this group had camptodromous-bronchidodromous secondary veins with marginal veinlets looped and were grouped together while the shrubs and climbers formed a second group with mixed-craspedodromous secondary veins.

Leaf Micromorphological Characters

The epidermal cells had either curved or undulating anticlinal walls on both adaxial and abaxial surfaces (Table 3 and 4). All the species were hypostomatic except *Cardiospermum halicacabum* which was amphistomatic. However, cyclocytic stomata types were observed in *Blighia sapida*, *Deinbolia pinnata* and *Lecaniodiscus cupanioides* in addition to the general stomata types (anomocytic, staurocytic and tetracytic) observed in all species studied. Epidermal cells were larger on the adaxial surface than the abaxial surfaces in most taxa. *Lecaniodiscus cupanioides* had the highest number of epidermal cells on the abaxial surface (526). *Z. golungensis* had the highest number of stomata on its abaxial surface with mean value of 153.4±4.41. The lowest number of epidermal cells on the adaxial surfaces was recorded in *C. halicacabum* with a mean value of 50.6±3.42. Glandular and non-glandular trichomes were present on the adaxial and abaxial surfaces in the species studied. Trichomes which were either simple or glandular were observed on either surface of most of the species except in *L. cupanioides* and *Z. golungensis* which had none on either surface.

DISCUSSION

The qualitative macro-morphological characters of Sapindaceae showed variability within and between species and among genera in the family. Characters such as epidermal cell shape (adaxial), stomata type, trichome, secondary venation, leaf shape and leaf margin were of great taxonomic importance especially in the identification of the species and delimiting species boundaries while some were not useful taxonomically. Hils *et al.* (1988), Gornall (1989), Ugbabe and Ayodele (2008), Aworinde *et al.* (2014), Shah *et al.* (2020) and Akinyele *et al.* (2020), stressed the importance of the use of vegetative characters in solving taxonomic problems. Leaves of Sapindaceae were predominantly spirally arranged and variously compound, less often opposite. Compound leaves include the; bipinnate (*Blighia*, *Deinbolia*, *Lecaniodiscus*, and *Zanha*), trifoliate (*Allophylus*), (*Cardiospermum*) and imparipinnate (*Paullinia*). Leaflets were predominantly entire but some genera had serrated leaflets (*Cardiospermum* and *Paullinia*).

Most of the characters such as the type of epidermal cell, number of epidermal cells, epidermal cell width, anticlinal

Table 3: Qualitative foliar characteristics (cell shape, anticlinal wall, stomatal type) of species examined

Species	Cell shape		Anticlinal wall		Stomatal type	
	Abaxial Surface	Adaxial Surface	Abaxial surface	Adaxial surface	Abaxial surface	Adaxial surface
Allophylus africanus	Irregular	Irregular	Undulated	Undulated	Anomocytic Staurocytic Tetracytic	Absent
Allophylus spicatus	Irregular	Irregular	Undulated	Undulated	Anomocytic Tetracytic Staurocytic	Absent
Blighia sapida	Polygonal	Polygonal	Undulated	Undulated	Anomocytic Staurocytic, Cyclocytic Tetracytic	Absent
Blighia unijugata	Polygonal	Polygonal	Undulated	Undulated	Anomocytic, Staurocytic, Tetracytic	Absent
Cardiospermum grandiflorum	Irregular	Polygonal	Undulated	Straight-Curved	Anomocytic, Anomotetra-cytic Staurocytic	Absent
Cardiospermum halicacabum	Irregular	Irregular	Undulated	Undulated	Anomocytic Staurocytic Tetracytic	Anomocytic, Staucytic, Tetracytic
Deinbolia pinnata	Irregular	Polygonal	Straight	Undulated	Anomocytic Staurocytic Cyclocytic Tetracytic	Absent
Lecaniodiscus cupanioides	Polygonal	Polygonal	Undulated	Undulated	Staurocytic Cyclocytic Anisocytic Tetracytic	Absent
Paulinia pinnata	Irregular	Irregular	Undulated	Undulated	Anomocytic Staurocytic Tetracytic	Absent
Zanha golungensis	Irregular	Irregular	Straight	Straight	Anomocytic Staurocytic Tetracytic	Absent

Table 4: Qualitative foliar characteristics (trichome, ergastic substance, hydropoten) of species examined

Species	Trichome		Ergastic Substance		Hydropoten
	Abaxial surface	Adaxial surface	Abaxial surface	Adaxial surface	
Allophylus africanus	Unicellular, Glandular	Multicellular	Prismatic crystals, Crystal sands Tannins	Tannin	Present
Allophylus spicatus	Multicellular Unicellular	MulticellularGlandular	Prismatic crystals, Crystal druses, Tannin.	Starch grains, Prismatic crystals	Absent
Blighia sapida	Unicellular	Absent	Tannin, Prismnatic crystals	Absent	Present
Blighia unijugata	Unicellular	Absent	Tannin	Absent	Present
Cardiospermum grandiflorum	Glandular, Unicellular, Bicellular	Bicellular	Crystal druses, Tannin	Tannins, Crystal sands	Absent
Cardiospermum halicacabum	Unicellular, Glandular	Unicellular	Tannin	Absent	Absent
Deinbolia pinnata	Unicellular, Glandular	Absent	Tannin, Prismatic- crystals	Absent	Present
Lecaniodiscus cupanioides	Absent	Absent	Absent	Tannin	Present
Paulinia pinnata	Unicellular Glandular	Unicellular Glandular	Tannin	Prismatic crystals, Crystal sands	Present
Zanha golungensis	Absent	Absent	Tannin, Prismatic-crystals	Tannin	Present

wall type, types of stomata, number of stomata, stomata length, stomata width, types of trichomes may not contribute to the separation of the taxa in the family because of the wide similarities observed among the species. However, hairiness, leaf type, leaf size and the degree of serration of the leaf margin were stable quantitative characters of high taxonomic value that readily separated *Allophylus* from the other genera. Trifoliolate leaves in *Cardiospermum* were very useful in separating them from *Paullinia* (biternate). It was evident that the similarity between *Blighia unijugata* and *B. sapida* was very high; leaf apex is a diagnostic feature that can be employed basically to distinguish the former (obtuse) from the latter (acute). The micro morphological characters of leaf were more or less the same in all taxa in the family. In all the assessed species cuticles of the adaxial surfaces generally were striated, and in most species, the striation radiated from the stomata (where present). This striation can be seen as a synapomorphic character in some species. Nevertheless, the polygonal epidermal cell shape in adaxial surface with a straight anticlinal on the adaxial surface of *C. halicacabum* separated it from the sister species with irregular epidermal cell shape on both surfaces with an undulated anticlinal wall. Irregular abaxial epidermal cells with curved anticlinal walls separated *Deinbolia pinnata* from its closest relative *Lecaniodiscus cupanioides* with polygonal epidermal cells and undulated walls. Epidermal cells were larger on the adaxial surfaces than the abaxial surfaces in most taxa but almost of the same size in *C. halicacabum*.

Stomata were found mostly on the lower surfaces (hypostomatic) of most of the taxa (Table 5 and 6). Solereder (1908) reported that stomata were generally confined to the lower surface of the leaves in Sapindaceae except in a few species where they were found on the upper

Table 5: Quantitative foliar epidermal characters (Stomatal index, Cell/view, Cell length, Cell width) of sapindaceae species studied

Species	Surface	Stomatal index (%)	Cell/view	Cell length (μm)	Cell width(μm)
Allophylus africanus	Adaxial	0	220(277.6±9.80)364	26(37.0±1.2)47	18(28.9±1.0)36
	Abaxial	27.74	120(145.6±8.14)34	21(30.2±1.8)61	11(21.9±0.9)34
Allophylus spicatus	Adaxial	0	09(11.9±0.3)25	32(46.4±1.5)60	25(36.9±1.3)47
	Abaxial	0	12(17.6±0.6)23	22(39.8±1.8)62	19(34.1±1.2)42
Blighia unijugata	Adaxial	0	234(278.5±8.31)314	22(33.48±1.20)42	20(29.8±1.20)41
	Abaxial	18.58	238(382.9±15.23)475	13(23.6±1.14)36	12(25±1.63)43
Blighia sapida	Adaxial	0	284(333.3±14.73)415	13(30.08±1.84)45	1.6(32.32±1.59)46
	Abaxial	25.92	283(367.5±18.50)436	11(18.92±1.13)30	11(19.52±1.08)35
Cardiospermum grandiflorum	Adaxial	0	90(130.4±6.60)157	41(58.2±1.7) 79	29(38.8±1.0)46
	Abaxial	36.71	38(65.7±7.0)109	32(50.8±2.9)91	21(35.2±1.7)59
Cardiospermum halicacabum	Adaxial	19.81	40(50.6±3.42)71	41(82.6±3.5)111	29(47.8±2.7)72
	Abaxial	21.75	43(50±1.37)58	31(52.5±2.1)71	22(36.1±2.1)64
Deinbolia pinnata	Adaxial	0	195(234.4±8.13)384	15(31.04±1.28)39	20(28.4±1.19)37
	Abaxial	15.43	301(346.5±10.03)407	15(24.24±1.41)38	10(19.04±0.97)26
Lecaniodiscus cupanioides	Adaxial	0	473(503.8±5.29)520	11(18.92±1.13)30	11(19.52±1.08)35
	Abaxial	19.39	439(526.4±16.03)610	10(16.28±0.79)25	14(19.49±0.83) 28
Paullinia pinnata	Adaxial	0	311(347.4±5.21)374	26(34.3±0.9)46	18(25.1±0.7)34
	Abaxial	35.08	130(139.7±2.33)150	19 (31.4±1.2)45	12(19.5±1.1)37
Zanha golungensis	Adaxial	0	239(311.1±14.70)387	16(25.08±0.83)34	15(24.88±1.06)38
	Abaxial	42.21	136 (210.7±19.98)387	11 (20.92±0.98)30	9 (17.32±0.86)25

Table 6: Quantitative foliar epidermal characters (Stomata/view, Stomata length, Stomata width, Trichome) of sapindaceae species studied

Species	Surface	Stomata/view	Stomata length (μm)	Stomata width (μm)	Trichome
Allophylus africanus	Adaxial	Absent	Absent	Absent	Absent
	Abaxial	42(55.9±2.37)67	16(19.3±0.5)29	08(10.4±0.3)13	Present
Allophylus spicatus	Adaxial	Absent	Absent	Absent	Present
	Abaxial	1(1.6±0.2)5	11(18.6±0.4)12	09(12±0.3)14	Present
Blighia unijugata	Adaxial	Absent	Absent	Absent	Absent
	Abaxial	76(87.4±2.88)103	15(19.84±0.42)23	11(13.48±0.27)15	Present
Blighia sapida	Adaxial	Absent	Absent	Absent	Absent
	Abaxial	105(128.6±4.91)157	15(17±0.26)19	13(15±0.28)18	Present
Cardiospermum grandiflorum	Adaxial	Absent	Absent	Absent	Present
	Abaxial	32(38.1±1.96)50	24(28.7±0.5)32	12(19.4±0.5)23	Present
Cardiospermum halicacabum	Adaxial	9(12.5±1.07)18	20(23.4±0.5)30	11(23.4±0.5)21	Present
	Abaxial	9(13.9±1.18)19	17(21.9±0.7)34	11(15.1±0.4)19	Present
Deinbolia pinnata	Adaxial	Absent	Absent	Absent	Absent
	Abaxial	52(63.2±1.99)70	15(17±0.27)19	11(11.8±0.18)14	Present
Lecaniodiscus cupanioides	Adaxial	Absent	Absent	Absent	Absent
	Abaxial	100(126.4±3.90)143	11(13.52±0.32)16	12(15.48±0.47)25	Absent
Paullinia pinnata	Adaxial	Absent	Absent	Absent	Present
	Abaxial	58(75.5±4.40)97	18(22.1±0.4)25	11(14.0±0.3)17	Present
Zanha golungensis	Adaxial	Absent	Absent	Absent	Absent
	Abaxial	133(153.4±4.41)174	18(20.68±0.32)25	11(12.88±0.34)20	Absent

Minimum-Maximum (Mean±Standard error)

surfaces. The hypostomatic nature of all studied species was probably an adaptation to water loss as it is expected to confer an ecological advantage on them to survive as perennial plants, (Goldschmidst, 1996). *Cardiospermum halicacabum* was the only species where amphistomatism; an infrequent character in Sapindaceae (Solereder, 1908) was observed. This character with the combination of glabrous leaf surfaces was of taxonomic importance in separating the genus *Cardiospermum* into two groups: One consisting of hypostomatic and pubescent leaves; *C. grandiflorum* and the second consisting of the sole amphistomatic with glabrous leaves; *C. halicacabum*. Anomocytic, tetracytic and staurocytic stomata types were encountered in all the species studied with anomocytic stomata being the most predominant. The presence of cyclocytic stomata separated *B. sapida*, *D. pinnata* and *L. cupanioides* from other species. The lowest number of epidermal cells on the adaxial surfaces was observed in *C. halicacabum* with a mean value of 50.6±3.42. *Zanha golungensis* had the highest number of stomata on its abaxial surface with a mean value of 153.4±4.41. The stomata qualitative characters obviously showed affinity among taxa. *Lecaniodiscus cupanioides* had the highest number of epidermal cells on the abaxial surface (526). Taxonomically, trichomes have been mostly employed to compare species within taxa (Hoot, 1991; Gonzalez & Arbo, 2004; Batterman & Lammers, 2004). Trichomes which were either simple or glandular were observed on either surface of most of the species except in *L. cupanioides* and *Z. golungensis* where none was recorded on either surface.

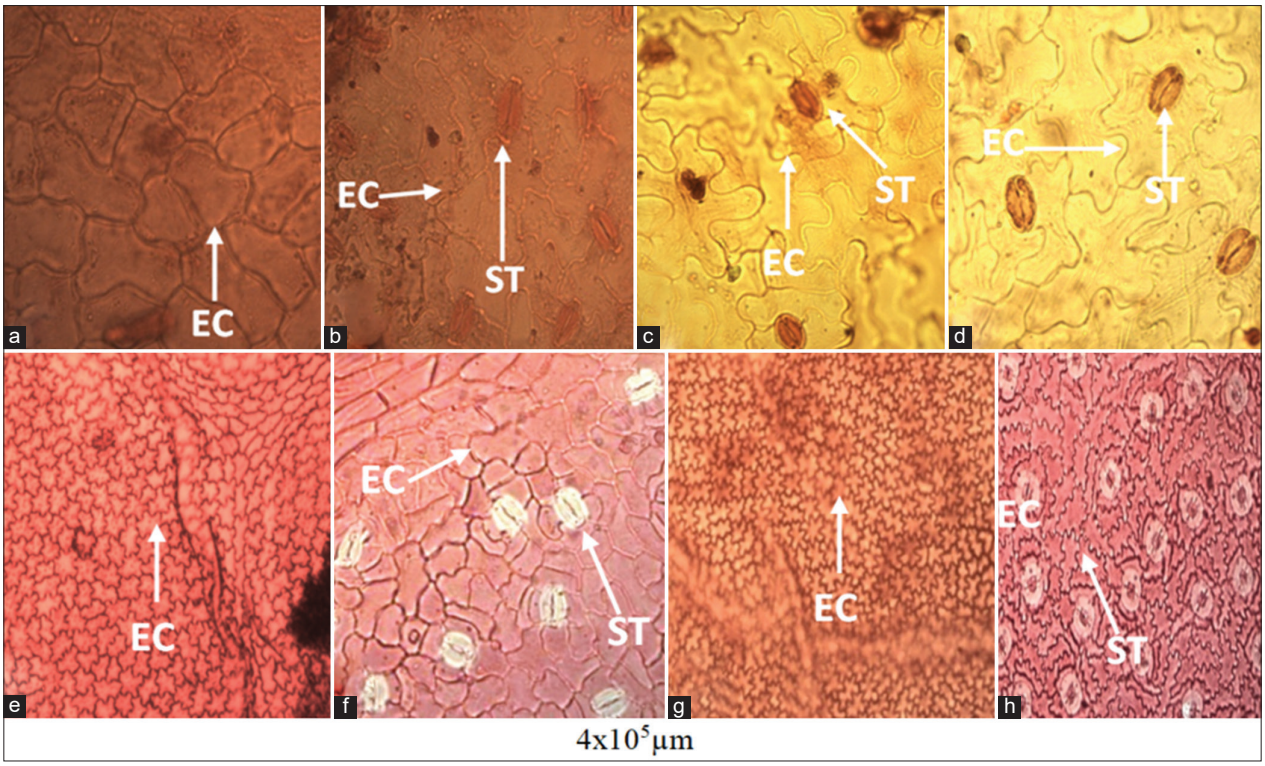

Figure 2: Leaf epidermal surfaces of species of the family Sapindaceae. a) *Cardiospermum grandiflorum* - Adaxial surface, b) *Cardiospermum grandiflorum* - Abaxial surface, c) *Cardiospermum halicacabum* - Adaxial surface, d) *Cardiospermum halicacabum* - Abaxial surface, e) *Deinbolia pinnata* - Adaxial surface, f) *Deinbolia pinnata* - Abaxial surface, g) *Lecaniodiscus cupanioides,* Adaxial surface, h) *Lecaniodiscus cupanioides* - Abaxial surfaces. EC - Epidermal cell, ST - Stomata

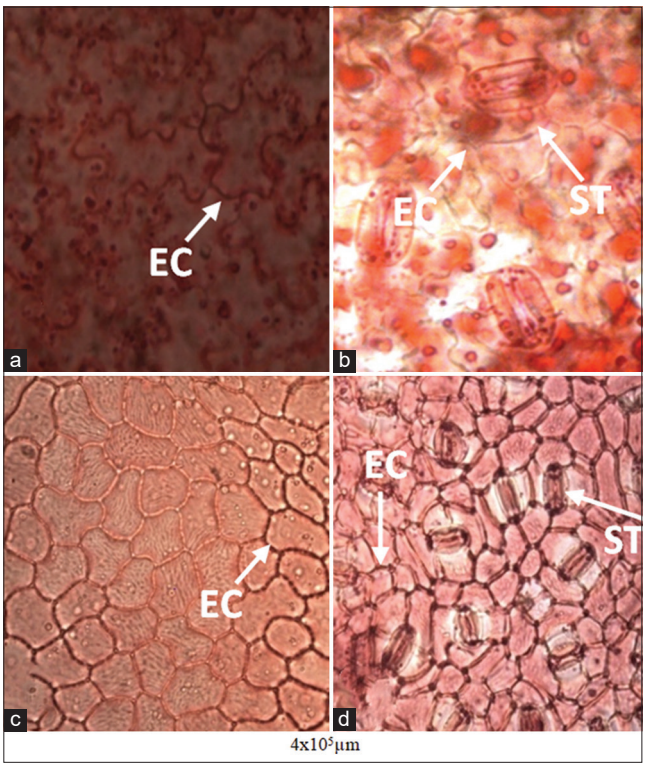

Figure 3: Leaf epidermal surfaces of species of the family Sapindaceae. a) *Paullinia pinnata* - Adaxial surface, b) *Paullinia pinnata* - Abaxial surface, c) *Zanha golungens*is - Adaxial surface, d) *Zanha golungensis* - Abaxial surface. EC - Epidermal cell, ST - Stomata

CONCLUSION

Macro and micro-morphological data obtained from the examined species delimited the taxa into two main groups; group A consisted of tree species and group B consisted of scandent shrubs species. Amphistomatism was an infrequent character in most of the examined species. It (amphistomatism) was recorded in just one of the examined species (*C. halicacabum*). This was in line with the findings of Solereder (1908) thereby making micro-morphological characters reliable, constant and dependable in taxa delimitation. *Zanha golungensis* showed little character relationship with the rest of the taxa (it may be transiting), further systematic studies (DNA sequencing, anatomical, or chemo-taxonomical screening) should be done on *Z. golungensis* to actually determine whether it should be moved from the family or to a separate tribe, ascertain its taxonomic level and ascertain to what extent the groupings in this preliminary work can be sustained. It is on this note that we have embarked on anatomical wood systematics of the family to further determine the relationship among the species in the taxa.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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