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# A survey of epidermal morphology in *Ficus* Linn. (Moraceae) of Nigeria

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**Abstract.** A detailed morphological study of the leaf epidermis of the tropical genus *Ficus* Linn. in Nigeria is presented. The study revealed several interesting epidermal features that have not previously been reported in the genus. Leaf epidermal characters such as pattern of epidermal cells, type of stomata, shape of guard cell pairs, and cuticular ornamentation are constant in some species and variable in others and thus of great significance in understanding the relationships between and within species. Leaves are hypostomatic in all species except in *F. vallis-choudae* Del., which has amphistomatic leaves. Poral epidermal walls of the outer stomatal ledge are distinctly higher than the peristomatal rims in *F. cyathistipula* subsp. *cyathistipula* Warb., *F. lyrata* Warb., and *F. sagittifolia* Mildbr. & Burret.

**Keywords:** Epidermal characters; *Ficus*; Morphological survey; Scanning electron microscopy (SEM); Taxonomy.

## Introduction

Literature on the epidermal morphology of *Ficus* is relatively rare though the taxonomic value of epidermal morphology is well documented in botanical literature for several other groups of angiosperms (Stace, 1965). As an example, epidermal characters of *Euphorbiaceae* have been studied by Amelunxen et al. (1967), Kakkar and Paliwal (1974), and Raju and Rao (1977). Several reports were published on the epidermal structures and stomatal ontogeny by Karatela and Gill (1984a, b; 1985) who stressed their usefulness in plant taxonomy.

In his taxonomic study of *Jatropha* L. (Euphorbiaceae), Dehgan (1980) reported that all species, with the exception of *J. fremontioides* Standley, have paracytic stomata that are with few exceptions restricted to the abaxial surface. Wax morphology has been used extensively in taxonomic work. The classic work of Hallam and Chambers (1970) on SEM studies of the leaf of *Eucalyptus* L'Heritier has demonstrated the potential of epicuticular wax studies to aid the classification of a complex genus. Although morphological studies of the epidermis may not themselves be sufficient as taxonomic evidence, they could in conjunction with anatomical features serve as good taxonomic tools for delimiting taxa.

Stomata and associated epidermal cells are providing an increasingly important source of taxonomic characters. The taxonomic significance of stomata distribution and morphology in the Epacridaceae was surveyed by Watson (1962), who found that members of the tribe *Styphelieae* typically possess only adaxial stomata (on the sepal) while in the Epacrideae they are usually abaxial. Trichomes and hydathodes are other characters found on the epidermis and other organs of plants that can serve as good taxonomic tools. They have been employed both for classification and identification purposes by many systematists (Theobald et al., 1979; Rollins, 1993; Potgieter and van Wyk, 1999; Dickison, 2000; Batterman and Lammers, 2004). De Bary (1884) and Renner (1907) have also discussed hydathodes in *Ficus*.

Preliminary field observation of Nigerian *Ficus* populations revealed conspicuous differences in vegetative and floral features among the taxa. Previous classifications of the genus have been largely based on the systematics of pollinating wasps (Corner, 1958, 1965; Ramirez, 1977). It is imperative therefore to attempt a search for epidermal characters that may be of taxonomic utility. The main objective of this work was to survey the leaf epidermis of *Ficus* species in Nigeria in search of taxonomic characters that might assist in identification and understanding of the variations among the species.

## Materials and Methods

Plant samples were obtained from herbarium specimens or personal collections. Small pieces (c. 7 mm$^2$) of leaf from herbarium materials were dehydrated in an absolute ethanol: acetone series (90% ethanol, 30 min; absolute ethanol 30 min; 50:50 absolute ethanol:acetone, 10 min; and finally two steps of acetone, 10 min each), according to Luckow and Grimmes (1997). Dehydrated material was then critical point dried using an Oriental 100V drier and sputter coated with

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gold in a fine coat ion sputter JC 1100. Observation was done with a Jeol JSM 5200 LV scanning electron microscope with a camera (Jeol 45042) attachment. Measurements of lengths and width of guard cell pairs were made and recorded. Voucher specimens were deposited in Forest Herbarium Ibadan (FHI), Nigeria. Voucher information of the specimens examined is presented in Table 1.

## Results

### *Leaf Surface*

Microcharacters of taxonomic significance obtained from selected features of the leaf surfaces, using SEM, are presented in Tables 2 and 3.

### *Hairs*

Based on the presence or absence of hairs on the leaf epidermal surfaces, the taxa studied may be divided broadly into two groups, a glabrous group consisting of taxa without hairs on either their adaxial or abaxial surfaces and a pubescent group comprising taxa with one or more hair types on their leaf surfaces.

Glabrous group: This group comprises taxa such as *F. abutilifolia* (Miq.) Miq., *F. aldofi-friderici* Mildbr., *F. artocarpoides* Warb., *F. cyathistipula* subsp. *cyathistipula* Warb., *F. elasticoides* De Wild., *F. glumosa* Del., *F. lutea* Vahl, *F. lyrata* Warb., *F. natalensis* subsp. *leprieurii* (Miq.) C.C. Berg, *F. natalensis* Hochst subsp. *natalensis*, *F. platyphylla* Del., *F. sagittifolia* Mildbr. & Burret, and *F. saussureana* DC.

Pubescent group: This consists of taxa in which hairs of different dimensions occur on either the adaxial / abaxial or both surfaces. Hairs are found on the adaxial surfaces but not on the abaxial surfaces of *F. capreifolia* Del., *F. exasperata* Vahl, *F. ovata* Vahl, *F. polita* Vahl, *F. thonningii* Blume, *F. trichopoda* Baker, and *F. umbellata* Vahl. Hairs occur on the abaxial leaf surfaces but not on the adaxial leaf surfaces of *F. ingens* Del., *F. ottoniifolia* (Miq.) Miq., *F. sansibarica* subsp. *macrosperma* (Mildbr. & Burret) C. C. Berg, *F. vallis-choudae* Del. Hairs are present on both the adaxial and abaxial leaf surfaces in *F. asperifolia* Miq., *F. mucuso* Welw. ex Ficalho, *F.* sur Forssk, and *F. variifolia* Warb. While only one type of hair is present in *F. capreifolia, F. exasperata, F. ovata, F. polita, F. sansibarica* subsp. *macrosperma, F. thonningii, F. trichopoda, F. umbellata, F. variifolia,* two or more types of hairs are found in *F. asperifolia, F. mucuso, F. ottoniifolia, F. sur*, and *F. vallis-choudae*. Unicellular, non-glandular, simple hairs with narrow apiculate tips were found on the adaxial and abaxial surfaces of *F. asperifolia*. In *F. sur*, they were only observed on the adaxial surface.

**Table 1.** Voucher information of materials used for study.

| Taxa | Specimens used |
|---|---|
| *Ficus abutilifolia* (Miq.) Miq. | *Daramola & Okafor FHI 54648*, Nigeria (FHI) |
| *F. aldofi-friderici* Mildbr. | *Ariwaodo FHI 102105,* Nigeria (FHI) |
| *F. artocarpoides* Warb. | *Onochie FHI 19137,* Nigeria (FHI) |
| *F. asperifolia* Miq. | *Latilo & Daramola FHI 28947,* Nigeria (FHI) |
| *F. barteri* Sprague | *Keay & Okafor FHI 24602,* Nigeria (FHI) |
| *F. capreifolia* Del. | *Punt & Daramola FHI 2866,* Nigeria (FHI) |
| *F. cyathistipula* subsp. *cyathistipula* Warb. | *Lowe FHI 81966*, Nigeria (FHI) |
| *F. elasticoides* De Wild. | *Sonibare & Others FHI 106051,* Nigeria (FHI) |
| *F. exasperata* Vahl | *Sonibare & Others FHI 106046,* Nigeria (FHI) |
| *F. glumosa* Del. | *Ibharmesabhor & Others FHI 94649,* Nigeria (FHI) |
| *F. ingens* (Miq.) Miq. | *Adejimi FHI 83097,* Nigeria (FHI) |
| *F. lutea* Vahl | *Stanfield FHI 44498,* Nigeria (FHI) |
| *F. lyrata* Warb. | *Jones FHI 14523,* Nigeria (FHI) |
| *F. mucuso* Welw. ex Ficalho | *Sonibare & Others FHI 106048,* Nigeria (FHI) |
| *F. natalensis* Hochst. subsp. *leprieurii* (Miq.) C.C. Berg | *Sonibare & Others FHI 106049,* Nigeria (FHI) |
| *F. natalensis* Hochst. subsp. *natalensis* | *Jackson FHI 20942,* Nigeria (FHI) |
| *F. ottoniifolia* (Miq.) Miq. | *Onochie FHI 35273,* Nigeria (FHI) |
| *F. ovata* Vahl | *Emwiogbon FHI 71250,* Nigeria (FHI) |
| *F. platyphylla* Del. | *Latilo FHI 64747,* Nigeria (FHI) |
| *F. polita* Vahl | *Sonibare & Others FHI 106053,* Nigeria (FHI) |
| *F. sagittifolia* Mildbr. & Burret | *Sonibare & Others FHI 106056,* Nigeria (FHI) |
| *F. sansibarica* subsp. *macrosperma* (Mildbr. & Burret) C.C. Berg | *Jackson FHI 15780,* Nigeria (FHI) |
| *F. saussureana* DC. | *Emwiogbon FHI 60037*, Nigeria (FHI) |
| *F. sur* Forssk. | *Gbile & Daramola FHI 60540,* Nigeria (FHI) |
| *F. thonningii* Blume | *Sonibare & Others FHI 106045,* Nigeria (FHI) |
| *F. trichopoda* Baker | *Soladoye & Others FHI 86274,* Nigeria (FHI) |
| *F. umbellata* Vahl | *Sonibare & Others FHI 106050,* Nigeria (FHI) |
| *F. vallis-choudae* Del. | *Chapman FHI 33139,* Nigeria (FHI) |
| *F. variifolia* Warb. | *Keay & Onochie FHI 21713,* Nigeria (FHI) |

**Table 2.** Characters of leaf epidermis of *Ficus* under electron microscope (SEM).

| Taxa | Adaxial epidermis | | | Abaxial epidermis | | | | |
|---|---|---|---|---|---|---|---|---|
| | Shape of ordinary cells | Pattern of anticlinal wall[a] | Hair dimensions[b] | Shape of ordinary cells | Pattern of anticlinal wall[a] | Hair dimensions[b] | Size of stomata µm | L / W |
| *F. abutilifolia* | Polygonal | Str-arc | - | Polygonal | Str-arc | - | 11.1 × 3.3 | 3.4 |
| *F. aldofi-friderici* | - | - | - | Polygonal | Str-arc | - | 16.4 × 16.1 | 1 |
| *F. artocarpoides* | Polygonal | Str-arc | - | Polygonal | Str-arc | - | 16.1 × 7.0 | 2.3 |
| *F. asperifolia* | Polygonal | Str-arc | U, UNG | Polygonal | Str-arc | U, UNG | 15.0 × 9.7 | 1.6 |
| *F. barteri* | Polygonal | Str-arc | - | Polygonal | Str-arc | - | 16.2 × 6.9 | 2.4 |
| *F. capreifolia* | Irregular | Rep | U | Irregular | Rep | - | 7.8 × 5.0 | 1.6 |
| *F. cyathistipula* subsp. *cyathistipula* | Polygonal | Str-arc | - | Polygonal | Str-arc | - | 8.9 × 3.3 | 2.7 |
| *F. elasticoides* | Polygonal | Str-arc | - | Polygonal | Str-arc | - | 25.0 × 10.7 | 2.3 |
| *F. exasperata* | Irregular | Rep | U | Irregular | Rep | - | 16.7 × 7.8 | 2.1 |
| *F. glumosa* | Irregular | Rep | - | Irregular | Rep | - | 12.2 × 4.7 | 2.6 |
| *F. ingens* | Polygonal | Str-arc | - | Polygonal | Str-arc | SFP | 13.9 × 9.2 | 1.5 |
| *F. lutea* | Polygonal | Str-arc | - | Polygonal | Str-arc | - | 13.6 × 7.8 | 1.7 |
| *F. lyrata* | Polygonal | Str-arc | - | Polygonal | Str-arc | - | 8.5 × 4.6 | 1.9 |
| *F. mucuso* | Irregular | Rep | U, G | Irregular | Rep | U, G | 14.5 × 6.4 | 2.3 |
| *F. natalensis* susbp. *leprieurii* | Polygonal | Str-arc | - | Irregular | Rep | - | 25.4 × 12.3 | 2.1 |
| *F. natalensis* subsp. *natalensis* | Polygonal | Str-arc | - | Polygonal | Str-arc | - | 16.4 × 6.4 | 2.6 |
| *F. ottoniifolia* | Polygonal | Str-arc | - | Not seen | Not seen | U, UNG | 20.0 × 11.1 | 1.8 |
| *F. ovata* | Irregular | Rep | SFP | Irregular | Rep | - | 15.0 × 7.3 | 2.1 |
| *F. platyphylla* | Polygonal | Str-arc | - | Irregular | Rep | - | 18.9 × 6.1 | 3.1 |
| *F. polita* | Polygonal | Str-arc | SFP | Polygonal | Str-arc | - | 16.4 × 7.5 | 2.2 |
| *F. sagittifolia* | Irregular | Rep | - | Irregular | Rep | - | 13.9 × 5.6 | 2.5 |
| *F. sansibarica* subsp. *macrosperma* | Polygonal | Str-arc | - | Polygonal | Str-arc | G | 15.3 × 7.0 | 2.2 |
| *F. saussureana* | Irregular/Polygonal | Rep/Str-arc | - | Polygonal | Str-arc | - | 16.2 × 14.2 | 1.1 |
| *F. sur* | Polygonal | Str-arc | UNG | Polygonal | Str-arc | U, SFP | 11.1 × 6.4 | 1.7 |
| *F. thonningii* | Polygonal | Str-arc | SFP | Polygonal | Str-arc | - | 20.0 × 8.9 | 2.3 |
| *F. trichopoda* | Irregular | Rep | SFP | Irregular | Rep | - | 12.5 × 4.7 | 2.7 |
| *F. umbellata* | Polygonal | Str-arc | G | Polygonal | Str-arc | - | 13.6 × 7.5 | 1.8 |
| *F. vallis-choudae* | Polygonal | Str-arc | - | Polygonal | Str-arc | U, G, SFP | 12.8 × 6.1 | 2.1 |
| *F. variifolia* | Irregular | Rep | U | Irregular | Rep | U | 18.5 × 11.2 | 1.7 |

[a]Str-arc = Straight to arched; Rep = Repand.

[b]UNG = unicellular, nonglandular; U = uniseriate; SFP = stalked + flat plate; G = glandular.

**Table 3.** Comparison of selected epidermal characters of *Ficus* under scanning electron microscope (SEM).

| Taxa | Adaxial epidermis | | Abaxial epidermis | | | |
|---|---|---|---|---|---|---|
| | Cuticular membrane | Wax ornamentation[a] | Cuticular membrane | Shape of guard cells | Outer stomatal rims | Peristomatal rims |
| *F. abutilifolia* | Smooth | F, G | Smooth | Wide Elliptic | Raised | Present |
| *F. aldofi-friderici* | Insular | C, P | Insular | Suborbiculate | Raised | Present |
| *F. artocarpoides* | Smooth | F, G | Smooth | Wide Elliptic | Raised | Present |
| *F. asperifolia* | Smooth | F, G | Smooth | Wide Elliptic | Raised | Present |
| *F. barteri* | Smooth | Rp | Smooth | Suborbiculate | Raised | Present |
| *F. capreifolia* | Striate | Fl | Striate | Wide Elliptic | Raised | Present |
| *F. cyathistipula* subsp. *cyathistipula* | Smooth | C | Smooth | Wide Elliptic | Raised | Present |
| *F. elasticoides* | Insular | F | Insular | Suborbiculate | Raised | Present |
| *F. exasperata* | Smooth | F, G, P | Smooth | Wide Elliptic | Raised | Present |
| *F. glumosa* | Smooth | F | Smooth | Wide Elliptic | Not Raised | Absent |
| *F. ingens* | Smooth | F, G | Striate | Wide Elliptic | Raised | Present |
| *F. lutea* | Smooth | F, G | Smooth | Suborbiculate | Raised | Present |
| *F. lyrata* | Smooth | F, C | Smooth | Suborbiculate | Raised | Present |
| *F. mucuso* | Smooth | F, G | Smooth | Wide Elliptic | Raised | Present |
| *F. natalensis* subsp. *leprieurii* | Striate | C | Striate | Wide Elliptic | Raised | Present |
| *F. natalensis* subsp. *natalensis* | Smooth | Mp | Smooth | Wide Elliptic | Raised | Present |
| *F. ottoniifolia* | Smooth | F, G | Smooth | Wide Elliptic | Raised | Present |
| *F. ovata* | Striate | F | Striate | Suborbiculate | Not Raised | Absent |
| *F. platyphylla* | Striate | F, G | Striate | Wide Elliptic | Not Raised | Absent |
| *F. polita* | Smooth | F, G | Smooth | Wide Elliptic | Raised | Present |
| *F. sagittifolia* | Smooth | C, L | Smooth | Suborbiculate | Raised | Present |
| *F. sansibarica* subsp. *macrosperma* | Smooth | F | Smooth | Wide Elliptic | Raised | Present |
| *F. suassureana* | Smooth | F, C | Smooth | Suborbiculate | Raised | Present |
| *F. sur* | Smooth | F, G | Smooth | Wide Elliptic | Raised | Present |
| *F. thonningii* | Smooth | F, P | Smooth | Wide Elliptic | Raised | Present |
| *F. trichopoda* | Striate | F, Fk, G | Striate | Suborbiculate | Not Raised | Absent |
| *F. umbellata* | Smooth | F, G | Smooth | Wide Elliptic | Raised | Present |
| *F. vallis-choudae* | Insular | C | Insular | Wide Elliptic | Raised | Present |
| *F. variifolia* | Striate | Fl | Striate | Wide Elliptic | Raised | Present |

[a]C = Crust; F = Film; Fk = Flakes; Fl = Fissured layer; G = Granules; L = Lumpy; Mp = Membraneous platelets; P = Platelets; Rp = Rosette of platelets.

The adaxial and abaxial surfaces of *F. mucuso* had unicellular glandular hairs that were observed only on the abaxial surface of *F. vallis-choudae*. Stalked hairs with flat plates were observed on the abaxial surfaces of *F. ingens* and *F. sur*, and also on the adaxial surfaces of *F. ovata*, *F. polita*, *F. thonningii,* and *F. trichopoda* (Table 2).

### *Epidermal Cells*

Anticlinal walls are repand in *F. capreifolia, F. exasperata, F. glumosa, F. ovata*, *F. sagittifolia, F. trichopoda, F. variifolia,* but straight to arched in all other species. Cell shape is irregular in *F. capreifollia, F. exasperata, F. glumosa, F. mucuso, F. ovata, F. sagittifolia, F. trichopoda,* and *F. variifolia* while it is polygonal in other species, except in *F. saussureana*, in which both irregular and polygonal shapes are represented.

### *Stomatal Apparatus*

The stomata are restricted to the abaxial surface of lamina (hypostomatic) except in *F. vallis-choudae* (Figure 1B), in which leaves are amphistomatic, but stomata more abundant on abaxial surface. Stomata are dense or evenly scattered on the abaxial leaf surfaces in most species, but they are few in *F. abutilifolia, F. capreifolia, F. ottoniifolia, F. platyphylla, F. sansibarica* subsp. *macrosperma*. Stomata are mostly of a paracytic type. The outlines of the pair of guard cells are usually suborbiculate to wide elliptical as seen in the surface view (Figures 1-3), as summarized in Table 3. The highest and lowest stomata length/width (L/W) ratios of 1 and 3.4 are found among the glabrous species. The outer stomatal rims are raised in all species except in *F. glumosa, F. ovata*, *F. platyphylla,* and *F. trichopoda*, in which the outer stomatal rims are flat.

In *F. cyathistipula* subsp. *cyathistipula* (Figure 2D), *F. lyrata* (3A) and *F. sagittifolia* (3B), the poral epidermal walls of the outer stomatal ledge are distinctly higher than the peristomatal rims while in both *F. barteri* and *F. elasticoides* the peristomatal rims overlap the outer ledge.

### *Cuticular and Wax Ornamentation*

The outer surface of the cuticle is smooth to weakly undulate in most species (Table 2), striate to wrinkled in some as in *F. capreifolia*, *F. ingens*, *F. natalensis* subsp. *leprieurii*, *F. ovata*, *F. platyphylla*, and *F. variifolia*. The striations are irregular in orientation and height or occasionally radiating from the guard cells. In *F. aldofi-friderici*, *F. elasticoides* and *F. vallis-choudae*, cuticle is divided into numerous small regions by the deep folds between them. Epicuticular waxes on adaxial epidermis as indicated in Table 3 exhibit great micromorphological diversity in all the taxa studied. Film type in *F. elasticoides, F. glumosa, F. ovata* and *F. sansibarica* subsp. *macrosperma*; Film and platelets in *F. exasperata*, film and granular waxes were observed in *F. abutilifolia, F. artocarpoides, F. asperifolia, F. ingens, F. lutea, F. mucuso, F. ottoniifolia, F. platyphylla, F. polita, F. sur, F. trichopoda, F. umbellata* (Table 2). Crust and platelets were observed in *F. aldofi-friderici*. *Ficus saussureana* had a mixture of crust and film wax ornamentation. Membraneous platelets were observed in *F. natalensis* subsp. *natalensis*. Rossettes of platelets were found in *F. barteri* Sprague while *F. capreifolia* exhibited a fissured layer (Figure 1A).

### *Hydathodes*

Hydathodes were observed on the adaxial leaf surfaces of *F. lutea* (Figure 1C)*, F. sansibarica* subsp. *macrosperma*

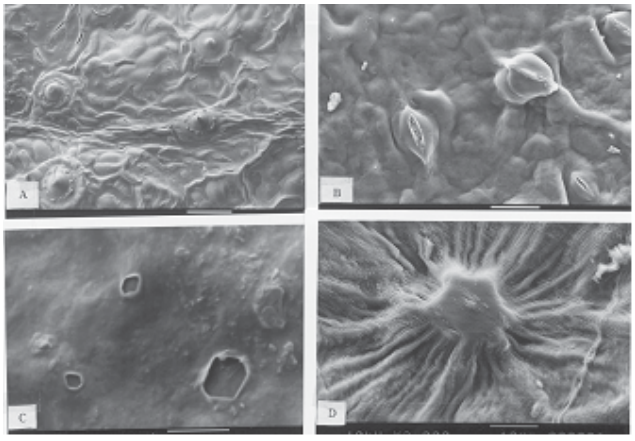

**Figure 1.** Characteristics of adaxial epidermal cells of *Ficus* (SEM). A, *Punt & Daramola 78407* (FHI) *F. capreifolia* (Scale bar: 100 μm), wax ornamentation showing fissured layer. B, *Wit & Daramola 79243* (FHI) *F. vallis-choudae* (Scale bar: 10 μm), note the presence of adaxial stomata. C, *Sonibare & Others 22254* (UIH) *F. lutea* (Scale bar: 50 μm), note the presence of hydathodes on adaxial epidermis. D, *Domen 32431* (FHI) *F. ovata* (Scale bar: 10 μm), showing stalked hair with flat plate.

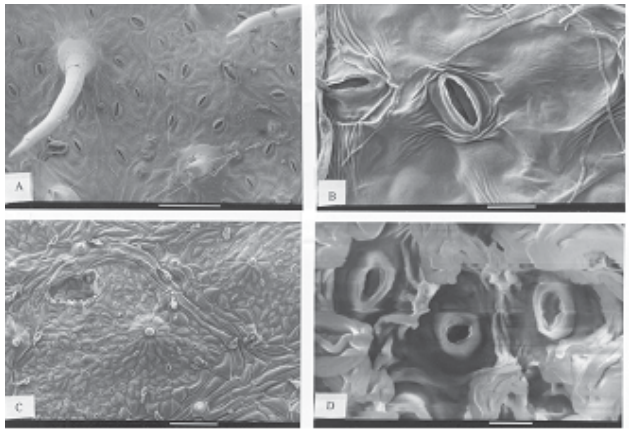

**Figure 2.** Characteristics of abaxial epidermis of *Ficus* (SEM). A, *Latilo & Daramola 28947* (FHI) *F. asperifolia* (Scale bar: 50 μm), showing long trichomes with apiculate tips and dense stomata. B, *Okeke 24695* (FHI) *F. mucuso* (Scale bar: 10 μm), with more elliptic guard cell outline. C, *Wit & Daramola 79243* (FHI) *F. vallis-choudae* (Scale bar: 100 μm), note the presence of hydathodes. D, *Lowe 81966* (FHI) *F. cyathistipula* subsp. *cyathistipula* (Scale bar: 5 μm), with poral epidermal wall higher than peristomatal rim.

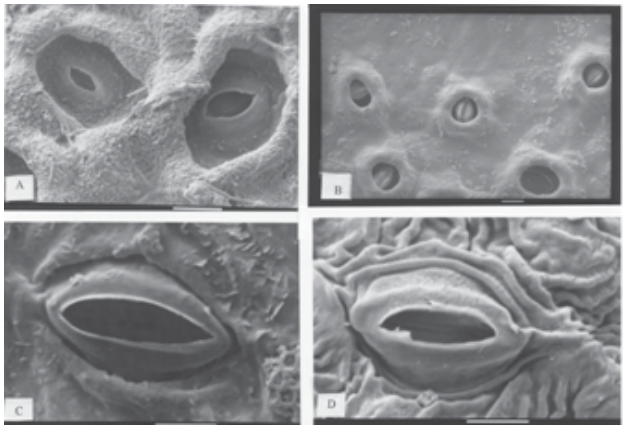

**Figure 3.** Abaxial stomatal morphology of *Ficus* (SEM). A, *Jones 14523* (FHI) *F. lyrata* (Scale bar: 10 μm), note the raised poral epidermal wall. B, *Adejimi 78819* (FHI) *F. sagittifolia* (Scale bar: 10 μm), with film type of wax ornamentation and raised poral epidermal wall. C, *Brenan 39370* (FHI) *F. artocarpoides* (Scale bar: 5 μm). D, *Keay 37245* (FHI) *F. sansibarica* subsp. *macrosperma* (Scale bar: 5 μm), note the folding.

(Figure 2C), *F. sur* and *F. vallis-choudae*, while hydathodes were absent in the other species.

## Discussion

The study of the epidermal surfaces of *Ficus* revealed a number of important micromorphological characters, and these characters exhibit interesting interspecific variations that are of significance for identification. Much variation is found in the glabrous and glabrescent species. For example, the highest and lowest stomata length / width (L/W) ratios were found among the glabrous species, indicating little or no correlation between stomata dimensions and the presence or absence of trichome.

The taxonomic value of trichomes in angiosperm is well documented in the botanical literature (Theobald et al., 1979; Batterman and Lammers, 2004). In the present study, their presence or absence on the epidermal surfaces of *Ficus* species were found to be less informative taxonomically. The nature of the trichomes in the genus seems to be more reliable than their mere presence or absence. Three basic types of trichomes prominent in the species studied are uniseriate, stalked with flat plate, and glandular. The taxonomic value of trichomes in this work was greatly limited by their absence in 22 out of the 28 species of *Ficus* studied. Trichome type has been found to be of little diagnostic value in this genus.

The presence of a stomatal ledge in about 80% of the taxa studied is of special note. This high percentage of occurrence may be due to ecological factors in such species as *F. atocarpoides*, *F. elasticoides, F. lyrata* and *F. sagittifolia*, but further investigation is required. Another feature worthy of note is wax ornamentation. Again, the presence of waxes of various types on the leaf surfaces of *Ficus* could be related to adaptation to drought.

The absence of sufficient overlap among the character values of the taxa considered provides support for the consideration of this genus as a very diverse one. One such character is the lamina hyadathode. Metcalfe and Chalk (1950) have recorded hydathodes from thirty-four families of dicotyledons, and De Bary (1884) noted water pores in adaxial epidermal depressions in at least six species of *Ficus*: *F. neriifolia, F. deltoidea, F. callosa, F. granatum, F. saussureana*, and *F. septica*. In the present study, hydathodes were not observed in the leaves of *Ficus* species such as *F. asperifolia, F. capreifolia, F. exasperata* and *F. saussureana*. Their absence from the leaves of *F. saussureana* is in particular at variance with the observation of de Bary in 1884, who observed hydathodes on its abaxial epidermis. However, hydathodes observed on the adaxial leaf surfaces of *F. lutea, F. sansibarica* subsp. *macrosperma*, *F. sur,* and *F. vallis-choudae* fit the observations made by Lersten and Peterson (1974) on the hydathodes in leaves of *F. deltoidea*, in which hydathodes were scattered in a seemingly random pattern in the leaf, each opening on a shallow circular depression on the adaxial surface. The hydathodes may be said to fit the passive type according to the classification of Haberlandt (1914). This inference is drawn because of prominent intercellular spaces in the epithem (internal portion of the hydathodes).

Although the ecological significance of the surface features revealed in this study are not yet fully understood (Juniper and Jeffree, 1983), Jayeola (1998) opined that certain epidermal features might help to reduce wind speed on the leaf surface, thereby curtailing excessive water loss from the stomata.

Since *Ficus* species are widely distributed in Nigeria, occurring from the coastal to dry sahelian savanna, it is possible that each species responds to its environment in specific ways by modifying the basic plan of certain features to improve its adaptation.

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# 產於奈及利亞之 *Ficus* 屬(Moraceae 科)植物之表皮形態分析

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本文詳細描述產於奈及利亞之亞熱帶植物（*Ficus* 屬）葉表皮形態。本研究顯示若干此屬植物之特殊表皮性態，先前從未被報導過。葉表皮性狀例如：表皮細胞之樣式，氣孔類別，氣孔保護細胞對之形狀，以及表皮層之狀飾，在某些種是固定的而在其他種則是可變的；因此在瞭解種間及種內之親緣關係時頗具意義。除了 *F. vallis-choudae* Del. 具 amphistomatic 葉之外，所有種之葉子都是 hypostomatic。在 *F. cyathistipula* subsp. *cyathistipula* Warb., *F. lyrata* Warb. 及 *F. sagittifolia* Mildbr. & Burret，氣孔之外突出部之有孔表皮層明顯地高出氣孔周緣。

**關鍵詞：**表皮性狀；*Ficus*；形態分析；掃描電子顯微鏡技術（SEM）；分類學。