Journal of Applied Sciences

ISSN 1812-5654

science alert

ANSInet
an open access publisher
http://ansinet.com

Journal of Applied Sciences 6 (15): 3016-3025, 2006
ISSN 1812-5654

Comparative Leaf Anatomy of *Ficus* Linn. Species (Moraceae) from Nigeria

[1]M.A. Sonibare, [2]A.A. Jayeola and [2]A. Egunyomi,
[1]Department of Maize Pathology,
International Institute of Tropical Agriculture, P.M.B. 5230, Ibadan Nigeria
[2]Department of Botany and Microbiology,University of Ibadan, Nigeria

Abstract: Studies in leaf anatomy of 25 *Ficus* species in Nigeria have been undertaken to unravel the relationship among the species with a view to providing a set of stable taxonomic characters. Anatomy of the lamina and midrib featured characters that are described in detail for the first time in the *Ficus* species of Nigeria thus providing the basis for infra-generic classification of the genus. These are multiple epidermis, two or more-layered hypodermis, one to three layers of palisade parenchyma as well as the pattern of vascular system all of which contribute to further delimitation of the genus. Heavy lignification, multiple epidermis and the presence of hypodermis in some species such as *F. abutilifolia*, *F. platyphylla* and *F. elasticoides* were probable anatomical features of adaptation to xerophytic environments.

Key words: Leaf anatomy, *Ficus*, epidermis, taxonomy, Nigeria

INTRODUCTION

Ficus Linn, the largest genus of the family Moraceae consists of about 1000 species worldwide with 105 species in the African floristic region (Berg, 1990). About 60 of the *Ficus* occur in West Africa and at least forty-four species are in Nigeria (Burkill, 1998; Keay, 1989). These species of trees, shrubs, climbers and hemi-epiphytic stranglers are recognized by a specialized inflorescence and pollination syndrome (Berg, 1990, Janzen, 1979). This genus has followed several curious lines of evolution. Seven out of the seventeen sections recognized by Corner occur in the African floristic region (Corner, 1965). The first and simple sub-division of *Ficus* was designed by Thunberg (1786) and adopted by Vahl (1805). The sub-division was based on the leaf shape lobate versus entire. Gasparrini (1844) split the genus into many genera such as *Galoglychia, Sycomorus* and *Urostigma* largely based on floral characters. Miquel (1847, 1848) increased the number of genera as with *Pharmacosycea* and *Syconia* but finally, in a worldwide survey of the genus, all these genera were united into *Ficus* again, reducing many of them to subgeneric entities (sections and subsections). It took nearly a century before a revised classification of the whole genus was presented by Corner (1958, 1960a, b, 1961, 1965).

Based on the classification of Corner (1965), the genus is divided to four subgenera, basically on the basis of breeding system, but this character appeared to be more homoplasious than morphological characters. Ramirez (1977) proposed a revised classification based on pollinator taxonomy. Classification of the genus based on anatomical studies is rare although these are being used by many systematists for both identification and classification purposes (Liao and Wu, 1996a, b; Stern and Whitten, 1999; Hussin *et al*., 2000; Wilkinson, 2000; Stern and Judd, 2001).

In an attempt to understand the relationship among the species of *Ficus* we have recently reported the chemotaxonomic significance of leaf alkanes in species of *Ficus* (Sonibare *et al*., 2005a) and a survey of epidermal morphology in *Ficus* (Sonibare *et al*., 2005b). The study reported in this paper was carried out to see if some aspects of foliar anatomy or vegetative anatomy could provide additional data of taxonomic significance aimed at further delimitation and identification of *Ficus* species. Thus we saw the need to provide anatomical information on the species of *Ficus* found in Nigeria so as to distinguish between closely related species and also to correlate anatomical features with ecology and generate a taxonomic key based on anatomical characters of the species which will enhance easy identification and classification of the genus.

MATERIALS AND METHODS

The anatomical sectioning was done by the first author in the year 2001 in the Department of Maize Pathology, International Institute of Tropical Agriculture, Ibadan, Nigeria. Twenty-five species of *Ficus* from Nigeria

Corresponding Author: M.A. Sonibare, Department of Plant Science and Applied Zoology, Olabisi Onabanjo University, P.M.B. 2002, Ago-Iwoye, Nigeria Tel: 234 803 365 9517

Table 1: Specimens examined (classification according to Corner, 1965) as summariz by Berg (1990)

Subgenus	Section	Subsection	Species
Ficus	*Sycidium* Miq.	-	*Ficus asperifolia*
	"		*Ficus capreifolia*
	"		*Ficus exasperata*
Sycomorus	*Sycomorus*(Gasp.)Miq.	-	*Ficus mucuso*
	"		*Ficus sur*
Urostigma	*Urostigma* (Gasp.) Miq.	-	*Ficus ingens*
	Galoglychia (Gasp.) Endl.	*Galoglychia*	*Ficus lutea*
	"	"	*Ficus saussureana*
	"	*Platyphyllae*	*Ficus abutilifolia*
	"	"	*Ficus platyphylla*
	"	"	*Ficus trichopoda*
	"	*Chlamydorae*	*Ficus nataleusis*
	"	"	subsp. *leprieurii*
	"	"	*Ficus thonningii*
	"	*Crassicostae*	*Ficus aldofi-friderici*
	"	"	*Ficus elasticoides*
	"	*Cyathistipulae*	*Ficus barteri*
	"	"	*Ficus cyathistipula*
	"	"	subsp. *cyathistipula*
	"	"	*Ficus lyrata*
	"	"	*Ficus sagittifolia*
	"	*Caulocarpae*	*Ficus artocarpoides*
	"	"	*Ficus polita*
	"	"	*Ficus ottoniifolia*
	"	"	*Ficus ovata*
	"	"	*Ficus sausibarica*
	"	"	subsp. *macrosperma*
	"	*Stilphnophyllum*	*Ficus elastica*

representing four subgenera (*Ficus*, *Pharmacosycea*, *Sycomorus and Urostigma*) in Corner's classification were used for the study (Table 1). The specimens used in anatomical study were obtained from living collections on the field. They were pressed and kept in the herbarium until when needed.

Internal structures of the leaves were studied from rotary microtome sections. Dried herbarium materials (median portion 7×7mm of leaves and petioles) were revived by boiling in water and dehydrated in an ethanol series (30-70%). Infiltration was done with Paraplast (soft wax) and Tissue mat (hard wax) using tertiary butyl alcohol as base for 12-24 h at 53°C (Johasen, 1940). Infiltration time depended on sample size and type of tissue. Infiltrated specimens were then transferred into the embedding liquid (melted wax poured into improvised moulds) to cast hard blocks. Trimming of the relatively hard polymerized blocks was done by first heating up the blocks to a temperature of 70°C, which softens the wax layer and thus made trimming with a razor blade easy. Transverse sections, 8-10 μm thick were made with a rotary microtome Leica D-6907 Nussloch. Using one-way disposable knife the sections were transferred into drops of warm distilled water on a clean slide on which egg adhesive had been previously rubbed. The warm distilled water served in place of water bath for stretching the sections. After drying on a slide warmer- Fisher slide warmer SE 2417, slides were transferred into xylene to dewax them. They were subsequently dehydrated through ethanol series from 95-50%. Staining was done with safranin for 10-20 min (depending on type of tissue), subsequently rinsed in distilled water and differentiated in ethanol series 30-95%. Slides were counter-stained in fastgreen for 30 sec, transferred into xylene for 5 min and mounted in DPX.

Examination of slides was done using bright field optics on a Nikon inverted photomicroscope Diaphot TMD 205939. All voucher specimens and permanent slides of all microtome sections are deposited in the University Herbarium, Department of Botany and Microbiology, University of Ibadan and slide bank, respectively. Voucher information of the specimens used are provided as Appendix A. Anatomical descriptions follow the conventions established in Tomlinson (1956) and Hussin *et al.* (2000).

RESULTS

Cuticle: The comparison of selected anatomical characters is shown in Table 2. Cuticle and outer periclinal walls are very thin in most species. Cuticle on the abaxial surface is as thick as the cuticle on the adaxial surface in more than half of the species studied. In *F. saussureana* (Fig. 1), the cuticle on the adaxial surface is very thin while the cuticle on the adaxial of *F. abutilifolia* is thick. Also the cuticle on the adaxial surface is thicker than the cuticle on the abaxial surface in *F. trichopoda* and *F. elasticoides* (Fig. 4 and 8). In the other species the cuticle on the abaxial surface is thicker than that on the adaxial surface.

Table 2: Comparison of selected anatiomical features of some *Ficus* species

Taxa	Hypodermis	Palisade No.	Mesophyll scattered	Aligned	Mid rib Protrusion	Vascular system Mid rib	Petiole
F. asperifolia	0	2		+	Distinct	I, III	I, III
F. capreifolia	2	1	+		Slight	I, III	I, II, III, IV
F. exaperata	0	2		+	Distinct	I, II, III	
F. mucuso	0	1		+	Distinct	I, III	I, III
F. sur	0	1		+	Distinct	I, III	I, III
F. ingeus	0	2-3		+	Slight	I, III	I, II, III
F. lutea	0	2	+		Distinct	I, III	I, III
F. cyathistipula subsp. *cyathistipula*	0	1		+	Slight	I, III	I, III
F. saussureana	1	2-3	+		Distinct	I, III	I, III
F. abutilifolia	1	2-3		+	Distinct	I, III	I, III
F. platyphylla	0	2-3	+		Distinct	I, III	
F. trichopoda	0	2-3	+		Distinct	I, II, III, IV	I, III
F. natalensis subsp. *leprieurii*	1	2	+		Slight	I, III	I, III
F. thonningii	2-3	1	+		Slight	I, III	I, III
F. aldofi-friderici	1-	2-3		+	Distinct	I, III	I, III
F. elasticoides	2-	2		+	Slight	I, III	
F. barteri	1-	2	+		Slight	I, III	I, III
F. lyrata	1-	2	+		Distinct	I, II, III	I, III
F. sagittifolia	1-	2	+		Distinct	I, III	
F. artocarpoides	1-	2	+		Distinct	I, III	I, II, III, IV
F. polita	0-	2	+		Slight	I, III	I, III
F. ottoniifolia	0-	1	+		Slight	I, III	I, III
F. ovata	1-	1		+	Distinct	I, III	I, III
F. sausibarica subsp. *macrosperma*	0-	1	+		Slight	I, III	I, III
F. elastica	1-	1	-	+	Slight	I, III	I

Epidermis: The general shape of the mature epidermal cells is rectangular. In species with no hypodermis, adaxial cells are wide and tall (Fig. 3 and 4) but in other species, cells are short. Multiple epidermises were observed in *F. lutea*, *F. platyphylla and F. trichopoda.* Lignification was obvious in *F. abutilifolia, F. platyphylla, F. trichopoda and F. elasticoides* (Fig. 2, 3, 4 and 8).

Hypodermis: Hypodermis is present adaxially in *F. saussureana, F. abutilifolia, F. natalensis* subsp. *leprieurii, F. aldofi-friderici, F. elasticoides, F. barteri, F. lyrata, F. artocarpoides and F. elastica* (Fig. 1, 2, 5, 7, 8, 9, 11 and 17). In *F. capreifolia and F. elasticoides*, there are two layers of hypodermis, in *F. thonningii* (Fig. 6) a third interrupted hypodermal layer occurred. Other species have no such hypodermal layers.

Mesophyll structure: Palisade cells are in 1-2 layers in certain species (Table 2), the two layers being of equal length in *F. exasperata, F. lutea and F. artocarpoides.* The first layer is longer than the second layer in other species such as *F. natalensis* subsp. *leprieurii*, F. *barteri* and 1 *F. polita* (Fig. 5, 9 and 13). More than two layers of palisade parenchyma were observed in *F. ingens*, *F. saussureana, F. abutilifolia, F. platyphylla*, *F. trichopoda* and *F. aldofi-friderici* (Table 2). In *F. trichopoda*, the first two layers were longer than the third layer of smaller and wider mesophyll-like palisade cells sometimes making it indistinguishable. Spongy parenchyma occurred in 2-4 layers. The cells are well aligned or loosely arranged. They are well aligned in species such as *F. lutea*, *F. platyphylla*, *F. trichopoda*, *F. natalensis* subsp. *leprieurii* and *F. thonningii* while in *F. capreifolia* and *F. saussureana* the cells are loosely arranged.

Vascular bundles: The mesophyll is provided with numerous vascular bundles (Fig. 2, 6, 10, 11 and 17), collateral bundles with tracheary elements consisting of 1-2 metaxylem element and few protoxylem cells flanked by colourless parenchyma laterally. Fibre cells usually form abaxial and adaxial caps, extending to abaxial epidermis in most species (Fig. 1-17). Fibre extends as girders to the adaxial epidermis or hypodermis in species such as *F. saussureana, F. abutilifolia, F. platyphylla, F. sagittifolia* and *F. ovata* (Fig. 1, 2, 3, 10, 11 and 15). In others, fibre form adaxial caps only (Fig. 6, 16).

MIDRIB

Outline: Midrib protrusion on the abaxial surface is slight in some species but well distinct in species like *F.* asperifolia, *F. exasperata*, *F. mucuso*, *F. sur*, *F. saussureana*, *F. abutilifolia and F. platyphylla* (Fig. 18, 20, 21, 22, 27 and 28). Adaxial surface is flat to curved or convex while abaxial surface is arched to V-shaped (Fig. 18-28).

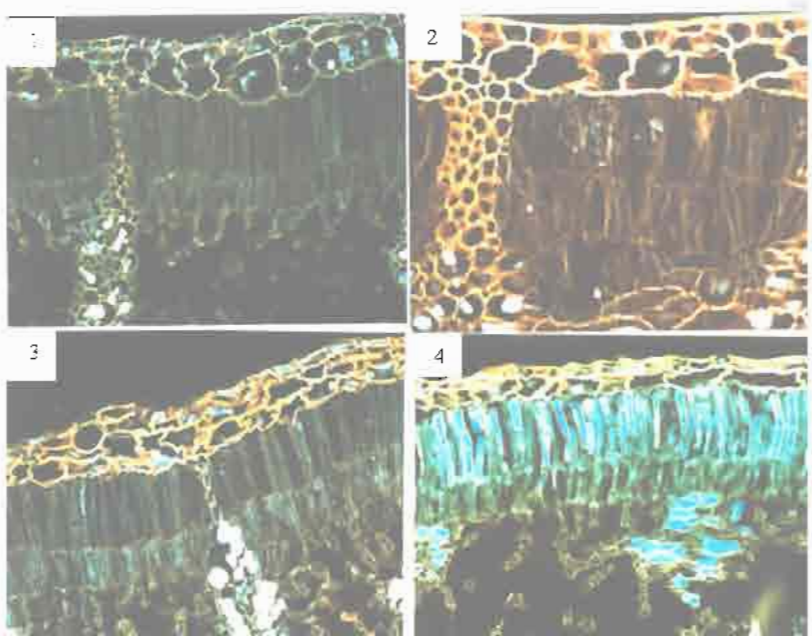

Fig. 1-4: Transverse sections of lamina of *Ficus* species (LM). Magnification ×400 Fig. 1. *F. saussureana*. **Fig. 2.** *F. abutilifolia*. **Fig. 3.** *F. platyphylla*. **Fig. 4.** *F. trichopoda*

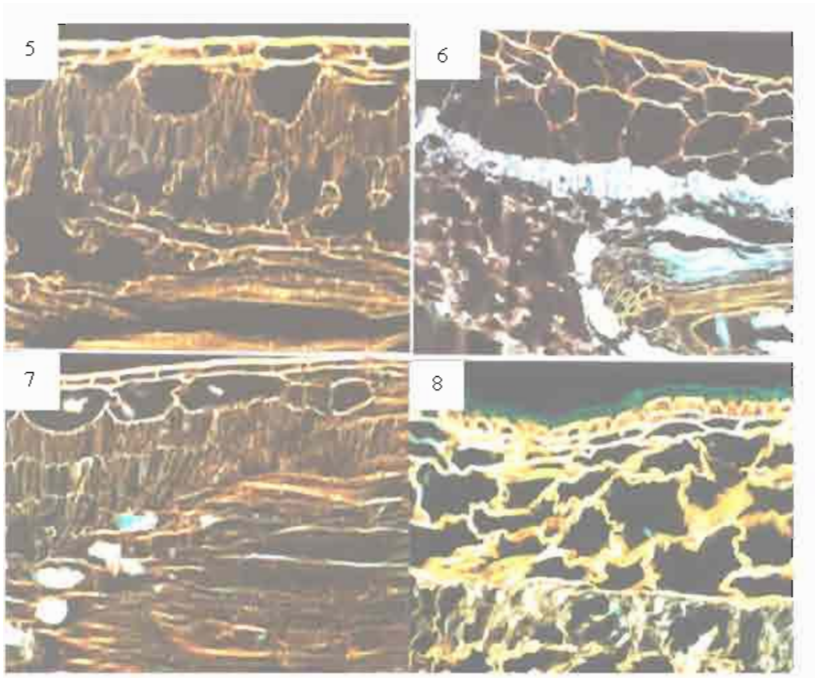

Fig. 5-8: Transverse sections of lamina of *Ficus* species (LM). Magnification ×400 Fig. 5. *F. natalensis* **subsp.** *leprieurii*. **Fig. 6.** *F. thonningii*. **Fig. 7.** *F. aldofi-friderici*. **Fig. 8.** *F. elasticoides*

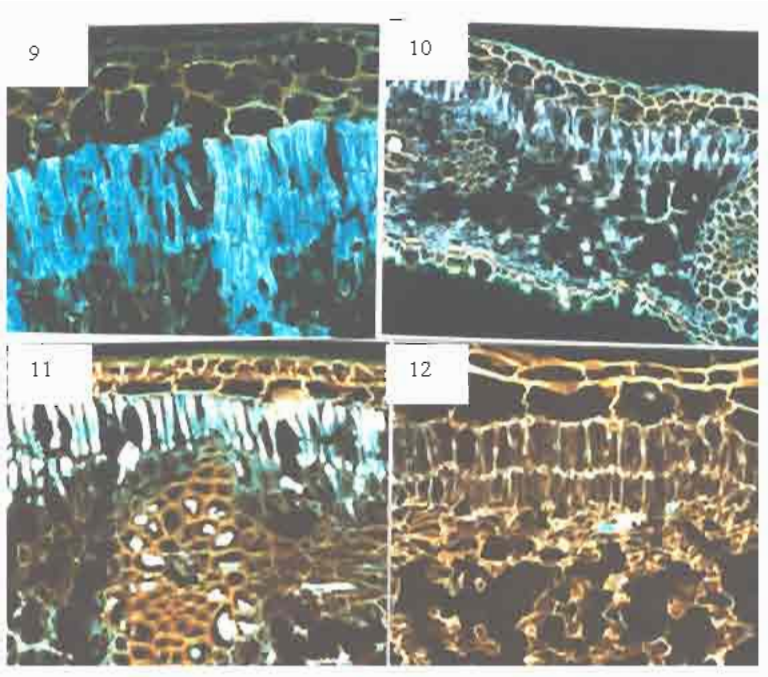

Fig. 9-12: **Transverse sections of lamina of** *Ficus* **species (LM). Magnification** ×400 **Fig. 9.** *F .barteri*. **Fig. 10.** *F. sagittifolia*. **Fig. 11.** *F. artocarpoides*, **Fig. 12.** *F. lyrata*

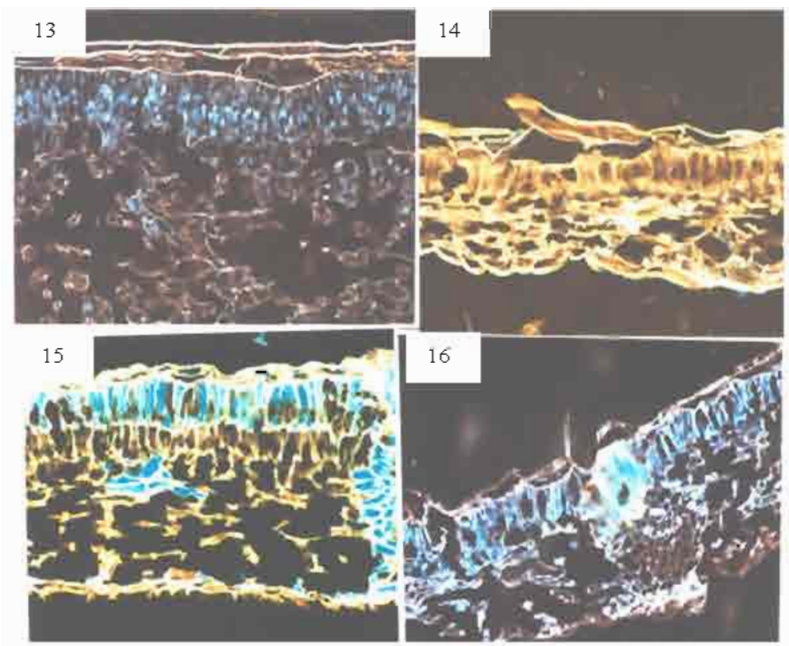

Fig. 13-16: **Transverse sections of lamina of** *Ficus* **species (LM). Magnification** × 400 **Fig. 13.** *F. polita*. **Fig. 14.** *F. ottonifolia*. **Fig. 15.** *F. ovata*. **Fig. 16.** *F. sansibarica* **subsp.** *macrosperma*

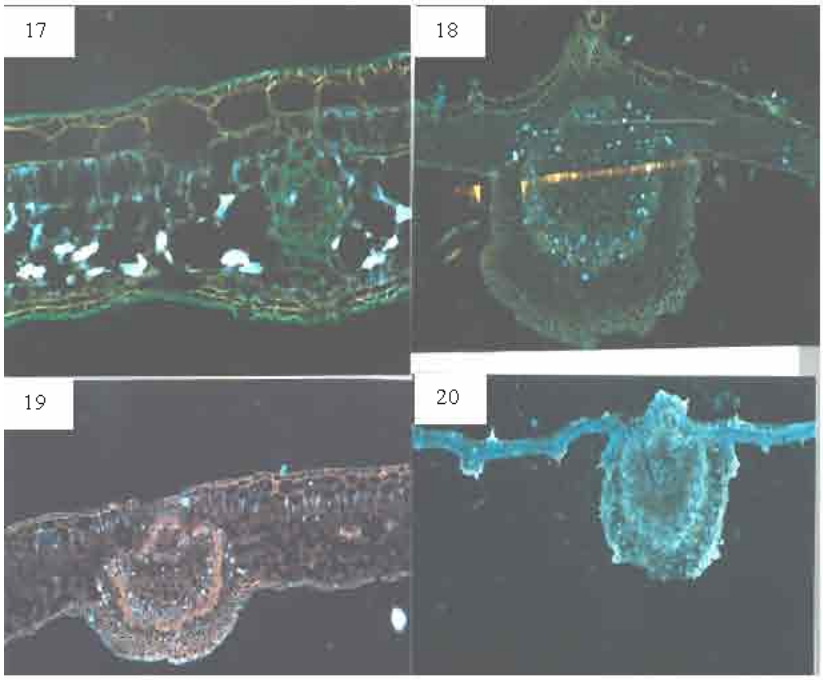

Fig. 17-20: Transverse sections of lamina (Fig. 17. *F. elastica*) and transverse sections of midrib of *Ficus* species (LM). (Fig. 18. *F. asperifolia*. Fig. 19. *F. capreifolia*. Fig. 20. *F. exasperata*). Magnification ×400

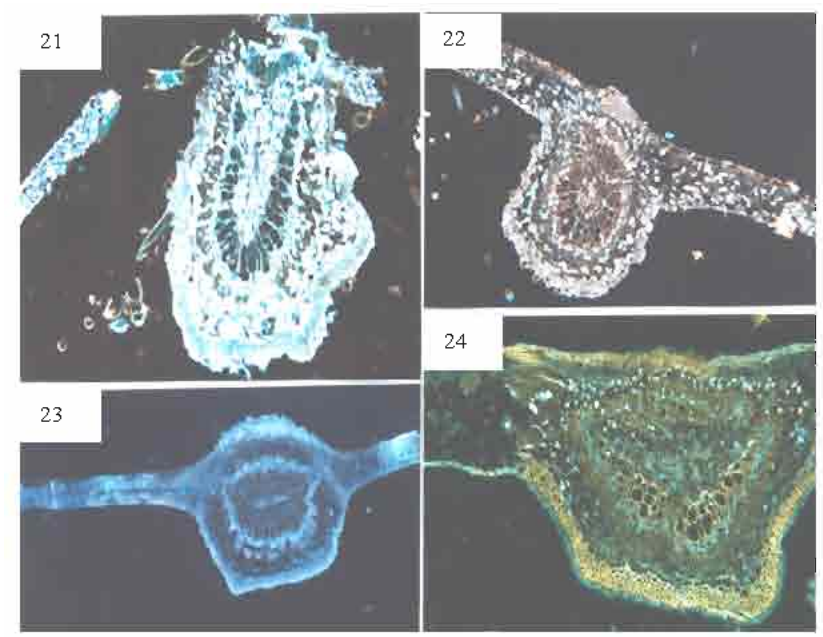

Fig 21-24: Transverse sections of midrib of *Ficus* species (LM). Magnification × 400 Fig. 21. *F. mucuso* Fig. 22. *F. sur*. Fig. 23. *F. ingens*. Fig. 24. *F. lutea*

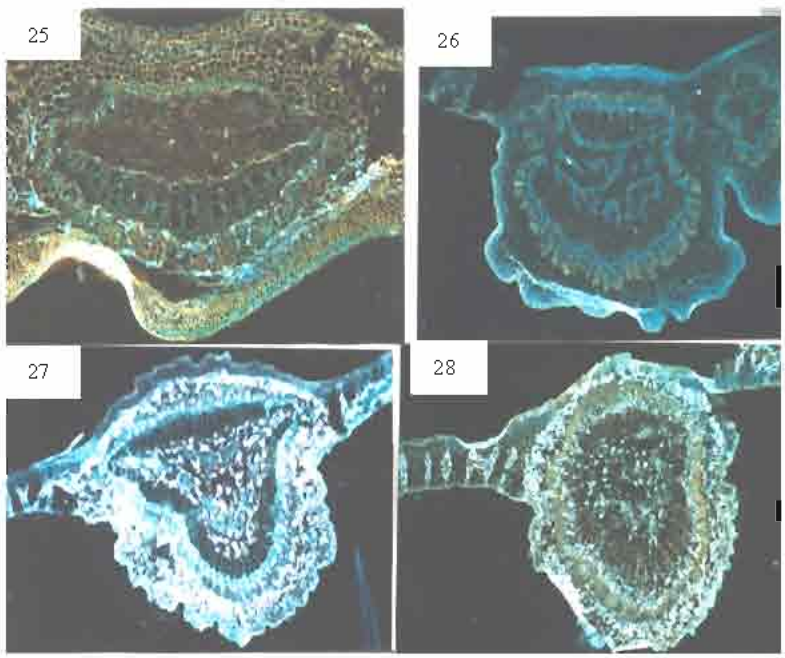

Fig. 25-28: Transverse sections of midrib of *Ficus* species (LM). Fig. 25. *F.cyathistipula subsp. cyathistipula* Fig. 26. *F. saussureana*. Fig. 27. *F. abutilifolia*. Fig. 28. *F. platyphylla*. Magnification ×400 except Fig. 25: ×100,

Trichomes: Trichomes are simple, unicellular in some species. Stalked with flat plate trichomes were observed in *F. trichopoda*, *F. thonningii*, *F. polita and F. ovata.*

Vascular tissue: Vascular bundles are arranged in several arcs, description follows Tomlinson (1956) where main arc is described as I, abaxial arc as II, adaxial arc as III and a fourth arc closer to the adaxial epidermis as IV. Arcs I, II, III, IV are present in *F. trichopoda*, I, II, III are present in *F. exasperata* and *F. lyrata* (Table 2). The other species available for transverse sectioning have only arcs I and III. The main vein is fan-shaped in all species and is built up by 11-20 rows of tracheary elements (3-6 cells high) and a more compressed phloem layer. Loosely arranged layers of large parenchymatous cells without chlorplasts surround all veins. Some species possess solitary crystals.

DISCUSSION

The observations indicate the taxonomic significance of foliar anatomical characters employed in this study. The occurrence of multiple epidermis and hypodermal walls in some species show the affinity of these taxa in the genus. Most species contain two to three layers of palisade parenchyma. Variation exists in the number of epidermal layers. The epidermis is wide and spacious in species with no hypodermis such as *F. asperifolia*, *F. exasperata*, *F. cyathistipula* subsp. *cyathistipula*. The presence of only one epidermal layer in species such as *F. mucuso*, *F. sur*, *F. ottonifolia*, *F. elastica* and *F. ingens* is noteworthy and can be used to separate these taxa from others with multiple epidermis. This character is particularly significant because the taxa are in different taxonomic ranks according to previous classifications by Thunberg (1786) and that of Corner (1958, 1960a, b, 1961, 1965). *F. mucuso* and *F. sur* which are both species of the subgenus *Sycomorus*, subsection *Sycomorus* have been separated on the basis of well aligned mesophyll, single layer of palisade parenchyma and presence of rhomboidal crystals. Bundles extension forming fibre girders was used to separate *F. ingens* from the remaining taxa with two or more palisade mesophyll. Centrally positioned large veins in *F. sagittifolia* clearly distinguish it from *F. lutea* and *F. ovata* all of which have distinctly protruding midrib. Flattened elongated epidermal cells in *F. polita* distinguish it from *F. capreifolia* with robust, spacious cells. The leaves of some of the *Ficus* species studied have been found to possess many common characters such as those mentioned by Berg (1988, 1989). Multicellular hair present on the adaxial epidermis of *F. exaperata* separates it from the heavily lignified species such as *F. thonningii* *F. lyrata*, *F. elasticoides*, *F. barteri*, *F. artocarpoides*,

F. abutilifolia, *F. trichopoda and F. platyphylla*. With the demand placed on some *Ficus* species probably due to limiting moisture and nutrient supply imposed on them by environmental stress, species of *Ficus* such as *F. abutilifolia*, *F. platyphylla* and *F. elasticoides* have developed morphological and anatomical adaptations that could act as adaptive syndrome to survive the environmental stress. Heavy lignification, multiple epidermis and the presence of hypodermis in these species are devices put in place in order to manage this stress without damage. Such xerophytic features furnish plants in this category with the capacity to survive long periods of drought and dehydration of their tissues without injury or with only slight injury. A third layer of epidermal-like cells was particularly well developed in the leaves of *F. thonningii*. This layer referred to as a hypodermis has cells with highly thickened walls and reduced cytoplasmic contents at maturity similar to the epidermal cells. Although the function of the hypodermis is apparently unknown, it may augment the protective and supportive function of the epidermis especially in a marginal environment. This role is also in keeping with plant habitat. For instance, it can be concluded from the features exhibited by *F. ingens*, *F. platyphylla* and *F. capreifolia* that they have a distribution pattern and variation, which indicate the existence of partial geographic isolation with different modal values for morphological characters. Species as normally recognized by the taxonomists are defined in terms of the mutual resemblance between the members of the populations concerned and the degree of distinctness of one set of populations from another. In summary, based on the number of species studied, a combination of characters such as number of epidermal layers, palisade parenchyma, presence of hypodermis, extension of vascular bundles to form fibre girders and the arrangement of vascular bundles is useful for the identification of *Ficus* species. Stomata type is mainly paracytic hence of no diagnostic value in the species of *Ficus*. However, level of stomata has been found useful, thus sunken stomata on the adaxial epidermis of *F. ottoniifolia* was used to separate it from *F. elastica*.

The parallel dichotomous key (presented as Appendix B) allows easy separation of the species based on anatomical features using light microscope.

ACKNOWLEDGMENTS

We thank Dr Kitty Cardwell, Maize Pathology Laboratory, International Institute of Tropical Agriculture, Ibadan, for providing Laboratory facilities for the microtome sections of the plants.

Appendix A: Voucher information of specimens used

Taxa	Specimens used
F. asperifolia Miq.	*Latilo* and *Daramola FHI 28947*, Nigeria (FHI)
F. capreifolia Del.	*Punt* and *Daramola FHI 2866*, Nigeria (FHI)
F. exasperata Vah	*Sonibare* and others *FHI 106046*, Nigeria (FHI)
F. mucuso Welw. ex Ficalho	*Sonibare* and others *FHI 106048*, Nigeria (FHI)
F. sur Forssk.	*Gbile* and *Daramola FHI 60540*, Nigeria (FHI)
F. ingeus (Miq.) Miq.	*Adejimi FHI 83097*, Nigeria (FHI)
F. lutea Vahl	*Stanfield FHI 44498*, Nigeria (FHI)
F. cyathistipula	
subsp. *cyathistipula* Warb	*Lowe FHI 81966*, Nigeria (FHI)
F. saussureana DC	*Emwiogbon FHI 60037*, Nigeria (FHI)
F. abutilifolia (Miq.) Miq.	*Daramola* and Okafor *FHI 54648*, Nigeria (FHI)
F. platyphlla Del.	*Latilo FHI 64747*, Nigeria (FHI)
F. trichopoda Baker	*Soladoye* and others *FHI 86274*, Nigeria (FHI)
F. natalensis	
subsp. *leprieurii* (Miq.) CC Berg	*Sonibare* and others *FHI 106049*, Nigeria (FHI)
F. thonningii Blume	*Sonibare* and others *FHI 106045*, Nigeria (FHI)
F. aldofi-friderici Mildbr.	*Ariwaodo FHI 102105*, Nigeria (FHI)
F. elasticoides De Wild.	*Sonibare* and others *FHI 106051*, Nigeria (FHI)
F. barteri Sprague	*Keay and Okafor FHI 24602*, Nigeria (FHI)
F. lyrata Warb	*Jones FHI 14523*, Nigeria (FHI)
F. sagittifolia Mildbr. and Burret	*Sonibare* and others *FHI 106056*, Nigeria (FHI)
F. artocarpoides Warb	*Onochie FHI 19137*, Nigeria (FHI)
F. polita Vahl	*Sonibare* and others *FHI 106053*, Nigeria (FHI)
F. ottoniifolia (Miq.) Miq.	*Onochie FHI 35273*, Nigeria (FHI)
F. ovata Vahl	*Emwiogbon FHI 71250*, Nigeria (FHI)
F. sausibarica	
subsp. *macrosperma* (Mildbr. and Burret)	
CC Berg	*Jackson FHI 15780*, Nigeria (FHI)
F. elastica Roxb.	*Sonibare and Others FHI 106047*, Nigeria (FHI)

Appendix B: Key to species of ficus in Nigeria

Key to species of *Ficus* in Nigeria

1. Epidermis, single layer……	2
1. Epidermis, two or more layers……..	14
2. Spongy mesophyll aligned……...	3
2. Spongy mesophyll scattered ……..	8
3. Palisade parenchyma, single layer ……	4
3. Palisade parenchyma, two or more layers ……	7
4. Crystals rhomboidal ……	5
4. Crystals not seen ……	6
5. Lamina supplied with abundant sclereids …….	*F. mucuso*
5. Lamina supplied with sparse sclereids …….	*F. sur*
6. Sunken stomata present on adaxial epidermis …..	*F. ottoniifolia*
6. Sunken stomata absent on adaxial epidermis ……	*F. elastica*
7. Bundles extend to form fibre girders ……..	*F. ingens*
7. Bundles do not extend to form fibre girders ……..	*F. asperifolia*
8. Midrib protrusion abaxially distinct ……..	9
8. Midrib protrusion abaxially not distinct ……..	11
9. Midvein large and occupy central position ……...	*F. sagittifolia*
9. Midvein small and do not occupy central position ……...	10
10. Air space big ……	*F. lutea*
10. Air space absent ……	*F. ovata*
11. Hypodermis present ……	12
11. Hypodermis absent ……..	*F. mucuso*
12. Palisade cell long ……	*F. leprieurii*
12. Palisade cells short ……..	13
13. Flattened elongated epidermal cells present ……	*F.polita*
13. Robust spacious epidermal cells …….....	*F. capreifolia*
14. Hair(multicellular) present on adaxial epidermis ..	*F. exasperata*
14. Hair absent on adaxial epidermis ……	15
15. Lamina heavily lignified ……	16
15. Lamina not lignified ……	23
16. Hypodermal cells present ……	17
16. Hypodermal cells absent ……	19
17. Third interrupted hypodermal layer present ……	*F. thonningii*
17. Third interrupted hypodermal layer absent …….	18
18. Vascular bundles in arcs I & III ouly ……..	19
18. Vascular bundles in arcs other than I & III …….	*F. lyrata*
19. Bundles form a concentric ring ……..	*F. elasticoides*
19. Bundles do not form concentric ring ……..	20
20. Flat arc bundles ……	*F. barteri*
20. Arc with dorsal plate bundles ……..	21
21. Cortical cells distinct ……..	*F. artocarpoides*
21. Cortical cells obscured ……	*F. abutilifolia*
22. Lignified palisade cells observed ……	*F. trichopoda*
22. Uulignified palisade cells observed ……	*F. platypyhlla*
23. Horizontally elongated spongy mesophyll cells present	24
23. Horizontally elongated spongy mesophyll cells absent	*F. saussureana*
24. Shape of epidermal cells, rectangular box ……..	*F. cyathistipula subsp. cyathistipula*
24. Shape of epidermal cells more or less elongated with wide hypodermis……	*F. aldofi-dericI*

REFERENCES

Berg, C.C., 1988. New taxa and combinations in *Ficus* (Moraceae) of Africa. Kew Bull., 43: 77-97.

Berg, C.C., 1989. Classification and distribution of *Ficus*. Experientia, 45: 605-611.

Berg, C.C., 1990b. Reproduction and evolution of *Ficus* (Moraceae). Traits connected with the adequate rearing of polllinators. Mem. of the New York Bot. Gard, 55: 169-185.

Burkill, H.M., 1998. The useful plants of West Tropical Africa. 2. Vol. 4. Families M.R Kew: Ro. Bot. Gard. Kew.

Corner, E.J.H., 1958. An introduction to the distribution of *Ficus*. Reinwarditia, 4: 425-355.

Corner, E.J.H., 1960a. Taxonomic notes on *Ficus* Linn. Asia and Australasia. I- IV. Gard. Bull. Sing., 17: 368-485.

Corner, E.J.H., 1960b. Taxonomic notes on *Ficus* Linn. Asia and Australasia. Addendum Gard. Bull. Sing., 18: 1-69.

Corner, E.J.H., 1961. Taxonomic notes on *Ficus* Linn. Asia and Australasia. Addendum Gard. Bull. Sing., 18: 83-99.

Corner, E.J.G., 1965. Checklist of *Ficus* in Asia and Australasia with keys to identification. Gard. Bull. Sing., 21: 1-186.

Gasparrini, G., 1844. Nova genera quae super nonnullis *Fici* subsp. struebat. Napoli. pp: 11.

Hussin, K.H., C.T. Seng, H. Ibrahim, W.Q. Gen, L.J. Ping and L. Nian, 2000. Comparative leaf anatomy of *Alpinia* Roxb. species (Zingiberaceae) from China. Bot. J. Linn. Soc., 133: 161-180.

Janzen, D.H., 1979. How to be a fig. Ann. Rev. Ecol. Syst. 10: 13-51.

Johasen, D.A., 1940. Plant microtechnique. New York. McGraw Hill. pp: 85.

Keay, R.W.J., C.F.A. 1989. Trees of Nigeria. Clarendon Press, Oxford. pp: 288-298.

Liao, J.P. and Q.G. Wu, 1996a. Fruit anatomy of Chinese Alpinia and its taxonomic significance. Proceedings of the Second Symposium on the Family Zingiberaceae. Guangzhou, China, 9-12 May 1995. pp: 82-90.

Liao, J.P. and Q.G. Wu, 1996b. The significance of the seed anatomy of Chinese Alpinia in taxonomy and systematics. Proceedings of the Second Symposium on the Family Zingiberaceae. Guangzhou, China, 9-12 May 1995, pp: 91-106.

Miquel, F.A.G., 1847. Prodromus Monographiae *Ficuum*. Lond. J. Bot., 6: 21-23.

Miquel, F.A.G., 1848. Prodromus Monographiae *Ficuum*. Lond. J. Bot., 6: 514-588.

Ramirez, W.J., 1977. A new classification of *Ficus*. Ann. Miss. Bot. Gard., 64: 296-310.

Sonibare, M.A., A.A. Jayeola and A. Egunyomi, 2005a. Chemotaxonomic significance of leaf alkanes in species of *Ficus* (Moraceae). Biochem. Syst. Ecol., 33: 79-86.

Sonibare, M.A., A.A. Jayeola, A. Egunyomi and J. Murata, 2005b. A survey of epidermal morphology in *Ficus* Linn. (Moraceae) of Nigeria. Bot. Bull. Acad. Sin., 46: 231-238.

Stern, W.L. and W.M. Whitten, 1999. Comparative vegetative anatomy of Stanhopeinae (Orchidaceae). Bot. J. Linn. Soc. 129: 87-103.

Stern, W.L. and W.S. Judd, 2001. Comparative anatomy and systematics of Catasetinae (Orchidaceae). Bot. J. Linn. Soc., 136: 153-178.

Tomlinson, P.B., 1956. Studies in the systematic anatomy of the Zingiberaceae. J. Linn. Soc. (Bot.), 55: 547-592.

Thunberg, C.P., 1786. Dissertationes botanicae. D.d. *Ficus* genus (E. Gredner) Upsaliae., pp: 16.

Vahl, M.H., 1805. Enumeratio Plantarum 2 Hauniae. VII., pp: 181-204.

Wilkinson, H.P., 2000. A revision of the anatomy of Gunneraceae. Bot. J. Linn. Soc., 134: 233-266.