INT J CURR SCI 2015, 18: E 125-135

RESEARCH ARTICLE ISSN 2250-1770

Leaf and petiole anatomical studies of the Genus *Rhizophora* Linn. in Nigeria

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Abstract

Leaf and petiole anatomy of the three species of *Rhizophora* L. occurring in the Mangrove forest of Nigeria was carried out to search for stable characters useful in delimiting the species. Anatomical characters that are common to the three taxa show generic affinity. The three species are also distinguished based on the number of the vascular bundles of the lamina mid rib and the petiole. The mean stomata frequency, mean stomata index and the guard cell area are distinct for each species. However, the three *Rhizophora* species occurring in Nigeria can be distinguished anatomically based on the type and pattern of distribution of foliar sclereids. Osteosclereids occur in *R. mangle*: astero sclereids line the veins and veinlets, in *R. racemosa* while asterosclereids which are randomly distributed occur in *R. harrisonii*.

Keywords: anatomical characters; anticlinal walls; *Rhizophora*; sclereids; veinlets

Received: 18th July 2015; Revised: 28thJuly; Accepted: 15thAugust;

Introduction

The genus, *Rhizophora* Linn. belongs to the family Rhizophoraceae. Members of the genus are referred to as red Mangrove and are the most abundant and important among the mangrove ecosystem of Nigeria (Adekanbi and Ogundipe, 2009). The genus, *Rhizophora* consists of seven species worldwide. In Nigeria, three species have been identified, namely, *Rhizophora racemosa* G.F.W.Meyer; *Rhizophora mangle* Linn. and *Rhizophora harrisonii* Leechmam (Savory, 1953). The three species are primarily distinguished by the number of flowers per inflorescence although this diagnostic character appears to be extremely plastic and the number of flowers varies within the species (Ceron-Souza et al., 2010). The three species are ecologically different and occupy different coastal zones (Savory, 1953; Breter, 1969; Tomlinson et al., 1979; Keay, 1989). *R. racemosa* is found as the pioneer at the edge of the alluvial salt swamp; *R. racemosa* colonises the mud on the outer most fringe of vegetation between high and low tides, the species inhibits the borders of river deltas, estuaries and lagoons. *R. harrisonii* inhabits the middle belt of the mangrove forest area occupying intermediate habitat between *R. mangle* and *R. racemosa*.

R. mangle is found on the drier inner limit of the *Rhizophora* zone and it is considered to be the most salt tolerant of the three species. According to Savory (1953) and Emerhi (2012) the three species of *Rhizophora* appear to have different requirements and tend to form separate consociations in the *Rhizophora zone.* Based on certain morphological attributes such as length of peduncle, length of pedicel apex of bud, degree of branching of inflorescence etc. Wilcox (1985) reported that the three

species are distinct taxa. Wilcox (1985) also reported that *R. harrisonii* as a hybrid between *R. racemosa* and *R. mangle* based on pollen stainability test and that *R. harrisonii* combine the attributes of *R. mangle* and *R. racemosa.* These reports showed overlaps and these have placed limitations on the use of these criteria as taxonomic tools in delimiting the species in the genus. Neyland (2000) noted that due to the morphologically similarity of the three species of *Rhizophora* and their sympatric nature the taxonomy has been problematic. There is the need to search for more stable characters in delimiting the species.

Anatomical characters have been widely used to analyse the degree of genetic diversity among plant taxa (Agbagwa and Ndukwa, 2004; Scatena et al., 2005; Saheed and Illoh, 2010). Emerhi (2012) reported on anatomical properties of *R. racemosa* and *R. harrisonii* that confers on them the ability to be used for pulp and paper production. Jayeola et al. (2001) reported on micro morphological and macro morphological characters in the West African *Rhizophora* using Scanning Elecctron microscope (SEM). Stace (1966) and Macnea (1968) reported on the epidermal characteristic of six species in the genus. Olowokudejo and Obi-Osang (1993) reported on the taxonomic significance of the epidermal morphology in the Nigerian Rhizophoraceae. Poompozhil and Kamarasamy (2014) reported on the leaf anatomy of some Mangrove plants from Thaandavarayan in Tamil Nadu, India. The information of the taxonomy of the genus in Nigeria is scarce. Therefore, the objective of this study is to search for anatomical characters using the leaf lamina and petiole that will provide additional that could be useful in delimiting the genus occurring in Nigeria.

Materials and Methods

Viviparous plants were collected from Niger Delta of Nigeria and were cultured in saline water brought from the field. Herbarium specimens from forestry herbarium Ibadan (FHI), Obafemi Awolowo University, Ile Ife (IFE) and University of Ibadan (UCI) were also used. All codes of Herbaria were according to Holmgren et al. (1990). For the epidermal studies ten sizeable portions were taken from the standard median portion of mature leaves of each species. The leaf fragments were boiled in 90% alcohol for 30 mins to remove the chlorophyll then rinsed in 4 changes of water to remove alcohol, then immersed in 5% bleaching agent parazone until the fragment were thoroughly cleaned. Materials were then rinsed in 4 changes of water to remove the bleaching.

Venation studies were carried out from ten sizeable portions taken from the standard median portion of mature leaves of each species. Leaf fragments for venation studies were first boiled in 90% alcohol for 30 mins, rinsed in 4 changes of water and to remove the alcohol, this were further boiled in 10% sodium hydroxide solution for 10 minutes, rinsed in 4 changes of water to remove the hydroxide. The partly cleared leaflets were further cleared in 5% of solution of domestic bleaching agent parazone. The cleared leaves were washed in 4 changes of water to remove the bleaching agent. Transverse section of the leaf lamina and petiole were out from median portion of the plant materials using Reichert sliding microtome at 8 µm. Epidermal cells were stained initially with Alcian blue for 3 mins, rinsed off and counter stained in Safranin O. Stained sections were mounted in serial grades of alcohol to remove water (dehydration) and excess stain

(differentiation). Portions for venations, transverse section of the leaf lamina and petiole were initially stained with Alcian blue for 3 mins, excess stained with safranin O. All sections were mounted in 25% glycerol for microscopic studies.

Microscopic Measurement was done with the aid of ocular microscope. Stomata frequency per mm^2 was determined from the average of 10 counts made on the abaxial surface of the leaves. Guard cell area was determine by measuring the length and breadth of the guard cells using ocular micrometer and multiplying by Franco's constant (L x B x 0.7854). Stomata index was determined using the method of Metcalfe and Chalk (1979).

Results

Leaf anatomy of R. mangle: Adaxial surface of the leaf

Epidermal cells are polygonal, anticlinal walls are straight and thick. Stomata, trichomes and druses were absent.

Abaxial surface of the leaf

Epidermal cells often rectangular to polygonal, anticlinal walls, straight and thick. Stomata were present and randomly distributed. Stomata were cyclocytic and sunken. The subsidiary cells more oblong than other epidermal cells, subsidiary cells 6-7 in number and raised above all other epidermal cells. Oil gland and waxy threads were present on the abaxial surface. Mean stomata frequency is $14/mm^2$, Mean stomata index is 1.61 and mean guard cell area is 676.3 μm^2.

Venation

Venation is cladodromous, secondary veins not terminating at the margin, freely ramified towards the margin. Areoles are well developed and polygonal. Veinlet endings per usually two consisting of spiral tracheids which appear swollen and are surrounded by bundle sheath cells. Osteosclereids and crystal are present.

Transverse Section of the blade

The cuticle is thick. The blade is dorsi-ventral. Adaxial and the abaxial epidermis are uniseriate. Epidermal cells rectangular to square. Hypoderm is one layered, palisade mesophylls are 3 layered, the spongy mesophyll, 10-12 layered with extensive air spaces. The vascular bundles are collateral and arranged in a ring. A sclerenchymatous tissue (cortical fibre) lines the upper part of the cortex. The druses are present.

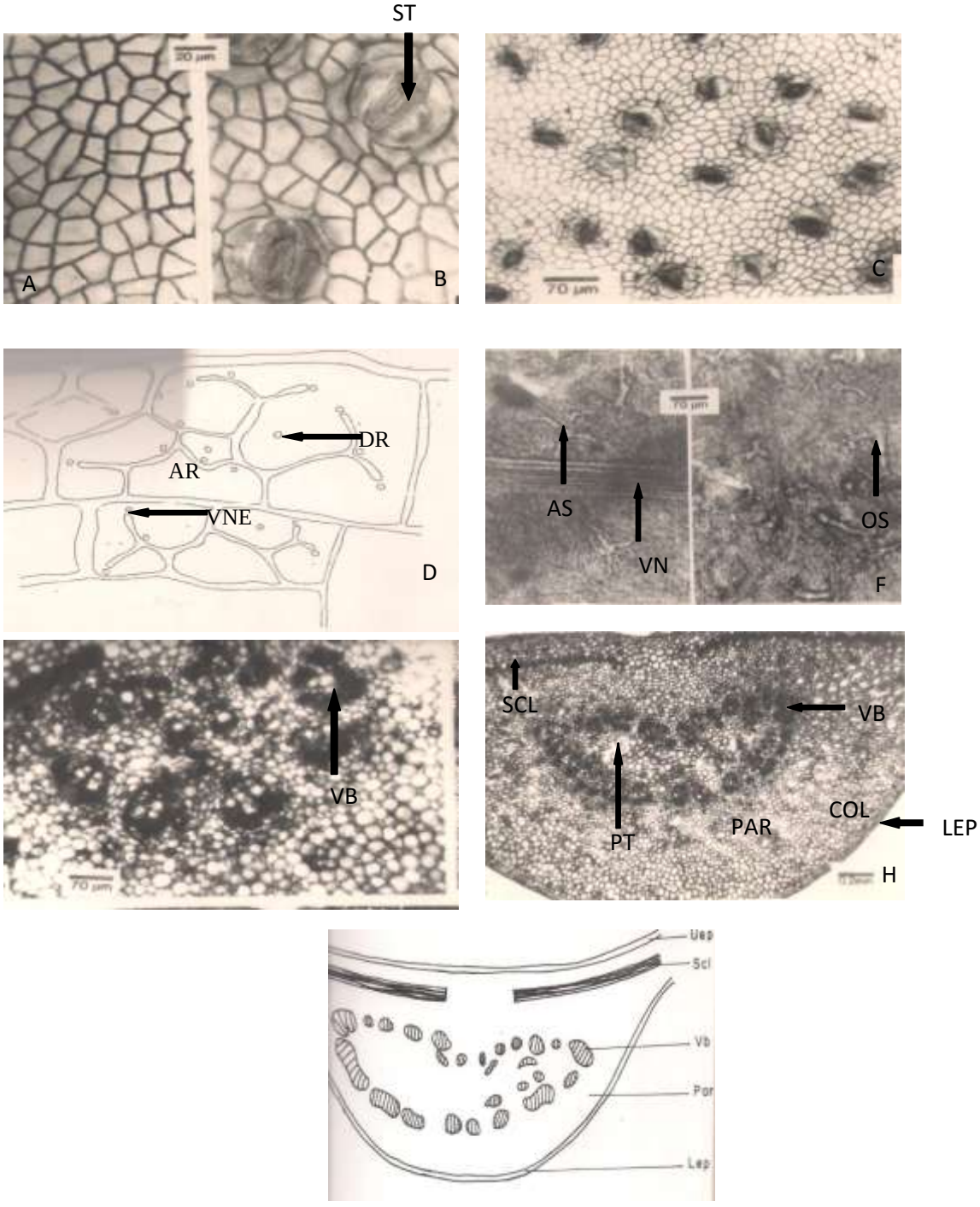
Transverse section of the mid rib

The mid rib outline is boat or saucer shaped. Adaxial outline is slightly concave while the abaxial surface is round. The epidermis is uniseriate, cells rectangular to square. The cortex are wide and consist of an outer collenchyma, vascular bundles are collateral arranged in a ring, 11-13 in number. A sclerenchymatous tissue lines the upper part of the cortex and this is interrupted at the middle above the vascular bundles. The pith occupies the centre and composed of paranchyma cells. Druses present.

Transverse section of Petiole (Median)

The cuticle is thick. The adaxial outline is more or less flattened; the abaxial surface convex. Epidermis and hypoderm are uniseriate. Epidermal cells polygonal. Cortex is wide and made of outer collenchyma, 3-5 layers and inner parenchyma cells. An H-shaped idioblast is present in the cortex. Sclerenchymatous tissue (cortical fibre) lined the upper part of the petiole and this is interrupted at the middle above the vascular bundles. Vascular bundles collateral arranged in ring 25-27, Druses present.

Fig. 1. *R. mangle*: A-Adaxial epidermal cells; B-Abaxial surface of the leaf showing cyclocytic stomata**;** C-Randomly distributed stomata; D-Venation pattern; E-Astero sclereids in *R. harrisonii*; D-Osteo sclereids in *R. mangle*; G-Lamina mid rib showing collateral bundles; H and I-Petiole outline showing vascular bundle distribution. AR-Areole, AS-Astero sclereids, COL-Collenchyma, DR-Druses, LEP-Lower epidermis OS-Osteo sclereids, PAR-Parenchyma, PT-Pith, SCL-Sclerenchymatous tissue, ST-Stomata, UEP-Upper epidermis, VB-Vascular bundle, VN-Vein, VNE-Vein ending



Leaf Anatomy of R. racemosa: Adaxial surface of the leaf

Epidermal cells rectangular to polygonal, anticlinal walls straight and thick. Stomata and trichomes were absent.

Abaxial surface of the leaf

Epidermal cells often rectangular to square. Anticlinal walls are more or less wavy. Stomata were present and sunken, randomly distributed and cyclocytic. Stomata has distinct stomata ledge. Subsidiary cells are oblong and at the same level with other epidermal cells. Subsidiary cells 5-7 in number. Mean stomata frequency, 23/mm^2, mean stomata index is 1.46 and mean guard cell area, 468.19 µm^2. Druses and oil gland present.

Venation

Venation is cladodromous, secondary veins not terminating at the margin but freely ramified towards the margin. Areoles well developed and polygonal, veinlet ends per areole usually two consisting of spiral tracheids which appear swollen being surrounded by bundle sheath cells. Asterosclereids present and this lines the veins and veinlets.

Transverse section of the blade

The cuticle is thick. The blade is dorsiventral. Adaxial and abaxial epidermis is uniseriate. Epidermal cells are rectangular to square. Hypoderm is uniseriate. Palisade mesophyll 4-5 layered while the spongy mesophyll is 10-12 layered with extensive air spaces. Vascular bundles, collateral, arranged in a ring. A sclerenchymatous tissue (cortical fibre) lines the upper part of the leaf and reaches to the rib of the blade.

Transverse section of the mid rib

The upper part of the mid is more or less flattened and the abaxial surface round or convex. Epidermis is uniseriate, cells rectangular to square. The cortex consists of outer 4-5 layers of collenchyma cells and inner parenchyma cells. Vascular bundles collateral, arranged in ring, 17-19 in number. A sclerenchymatous tissue lines the upper part of the cortex and this is interrupted at the middle above the vascular bundles. The pith occupies the centre and is composed of parenchyma cells. Druses present in the cortex and pith.

Transverse section of the petiole (median)

Cuticle is thick. Outline of the petiole is boat or saucer shaped. Adaxial surface is more or less flattened and the abaxial surface convex or round. Epidermis is uniseriate and the cells are rectangular to square. Hypoderm is uniseriate. The cortex is wide, made up of 4-5 layered collenchyma and inner parenchyma cells. Vascular bundles are collateral, 17-19, arranged in a ring at the centre of the cortexand one vascular bundles occurs at each end of the rib. A sclerenchymatous tissue (cortical fibre) lines the upper part of the petiole and this interrupted at the middle. Bundle sheath cells (rectangular occur at the middle of the abaxial surface. Druses occur in the cortex.

Leaf anatomy of R.harrisonii: Adaxial surface of the leaf

Epidermal cells are often rectangular to polygonal anticlinal walls straight and thick. Stomata and trichomes were absent. Druses present.

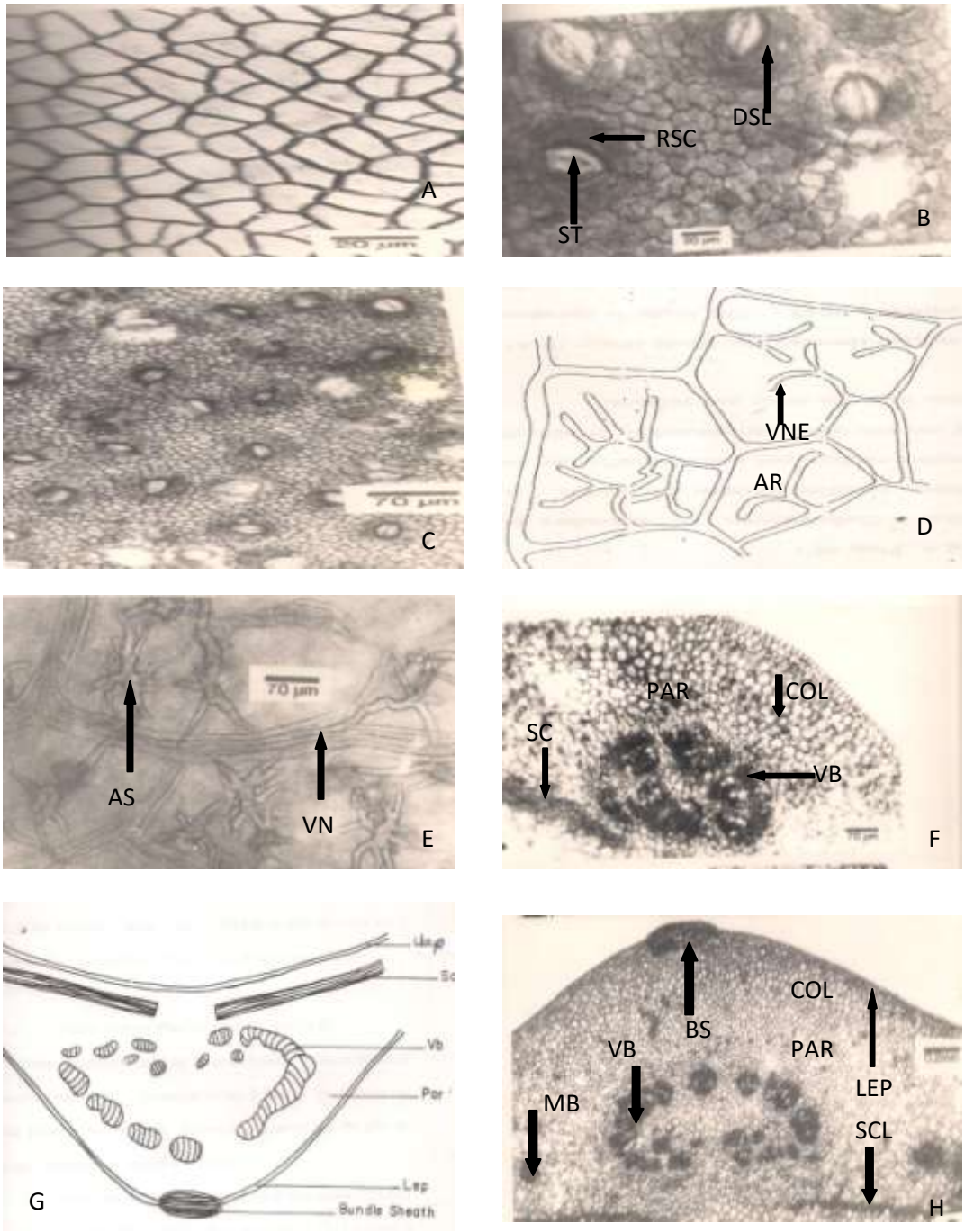
Abaxial surface of the leaf

Epidermal cells are rectangular to polygonal, anticlinal walls straight and thick. Stomata were present and randomly distributed and cyclocytic subsidiary cells, 6-8 more oblong than other epidermal cells. Stomata frequency 23/mm^2, stomata index is 2.10 and means guard cell area 419.99 µm^2.

Venation

Venation cladodromous (i.e.) secondary veins not terminating at the margin, but freely ramified towards the

Fig. 2. *R. racemosa* A-Adaxial epidermal cells; B- abaxial surface of the leaf showing wavy anticlinal wall and cyclocytic stomata; C-randomly distributed stomata; D-Venation pattern; E- Astero sclereids in *R. racemosa*; F-Lamina mid rib showing collateral bundles; G and H-Petiole outline and vascular bundle distribution. AR-Areole, AS-Astero sclereids, BS-Bundle sheath, COL-Collenchyma, DSL-Distinct stomata ledge, LEP-Lower epidermis PAR-Parenchyma, PT-Pith, SCL-Sclerenchymatous tissue, RSC-Raised subsidiary cell, ST-Stomata, UEP-Upper epidermis, VB-Vascular bundle, VN-Vein, VNE-Vein ending



margin, areoles well developed and polygonal. Veinlet endings per areole are usually two, consisting of spiral tracheids which appear swollen. Asterosclereids randomly distributed in the areole without definite pattern of arrangement.

Transverse section of the blade

The cuticle is thick. The blade is dorsiventral. Adaxial and abaxial epidermis are uniseriate epidermis are uniseriate. Epidermal cells rectangular to square. Hypoderm is uniseriate. Palisade mesophyll 3-4 layers, spongy mesophyll 10-12 layers, with extensive air spaces. A sclerenchymatous (cortical fibre) lines the upper part of the blade. Druses present.

Transverse section of the mid rib

The outline of the midrib is boat or saucer shaped. Adaxial surface more or less flattened. Abaxial surface is convex or round. Epidermis is uniseriate, cells rectangular to square. The cortex consist of 3-4 layers of outer collenchyma and inner parenchyma cells. A sclerenchymatous tissue lines the upper part of the cortex and this is interrupted at the middle above the vascular bundles. The pith occupies the centre and is composed of parenchyma cells. Druses present in the cortex and pitch.

Transverse section of the petiole (median)

Cuticle is thick. Petiole outline is boat or saucer shaped. The adaxial surface is slightly concave while the abaxial surface is convex or round. Epidermis and hypoderm are uniseriate. Epidermal cells rectangular to square. The cortex is wide, made up of 3-4 layers of collenchyma. Vascular bundles arranged in ring, 15-17 in number. A sclerenchyma tissue (cortical fibre) lines the upper part of the cortex and this is interrupted at the middle above the vascular bundles. Druses present.

Discussion

The three species of *Rhizophora* showed polygonal epidermal cells, anticlinal walls of straight and thick on the adaxial surface while on the abaxial surface the anticlinal walls are straight and thick in *R. mangle* and *R. harrisonii* but wavy in *R. racemosa*. However, Stace (1965) and (Macnae, 1968) reported that the epidermal cells in *Rhizophora* have straight anticlinal walls. Poompozhil and Kumarasamy (2014) also reported that the epidermal cells are polygonal in outline with more or less straight anticlinal walls. The species have thick cuticle over the epidermis. This was also reported by Poompozhil and Kumarasamy (2014) and Nabilah et al. (2011). The stomata are cyclocytic, found only on the adaxial surface (leaf hypostomatous) and sunken often in groove. Olowokudejo and Obi-Osang described the epidermal cells as polygonal and irregular and the anticlinal walls are straight, curved or undulate.

The mean stomata frequency, mean stomata index and the mean guard cell area for the three species are distinct (Table 1). The variation in the stomata index in this study can be reasonably employed in delimiting the *Basella* forms. Olatunji (1983) reported that the stomata index is constant for any given species and the value is more uniform on the abaxial surface than the adaxial surface except in an isobilateral leaf (Adedeji and Jewoola, 2008). Venation is cladodromous, areoles are well developed, polygonal with veinlet endings more or less 2 for the genus. The epidermis is uniseriate, leaves are dorsivental having extensive air spaces. Palisade cells are predominantly 3 in *R. mangle* while predominantly 4 in *R. racemosa* and *R. harrisonii.* Sclerenchymatous tissue that lines the upper part of the adaxial portion of the mid rib

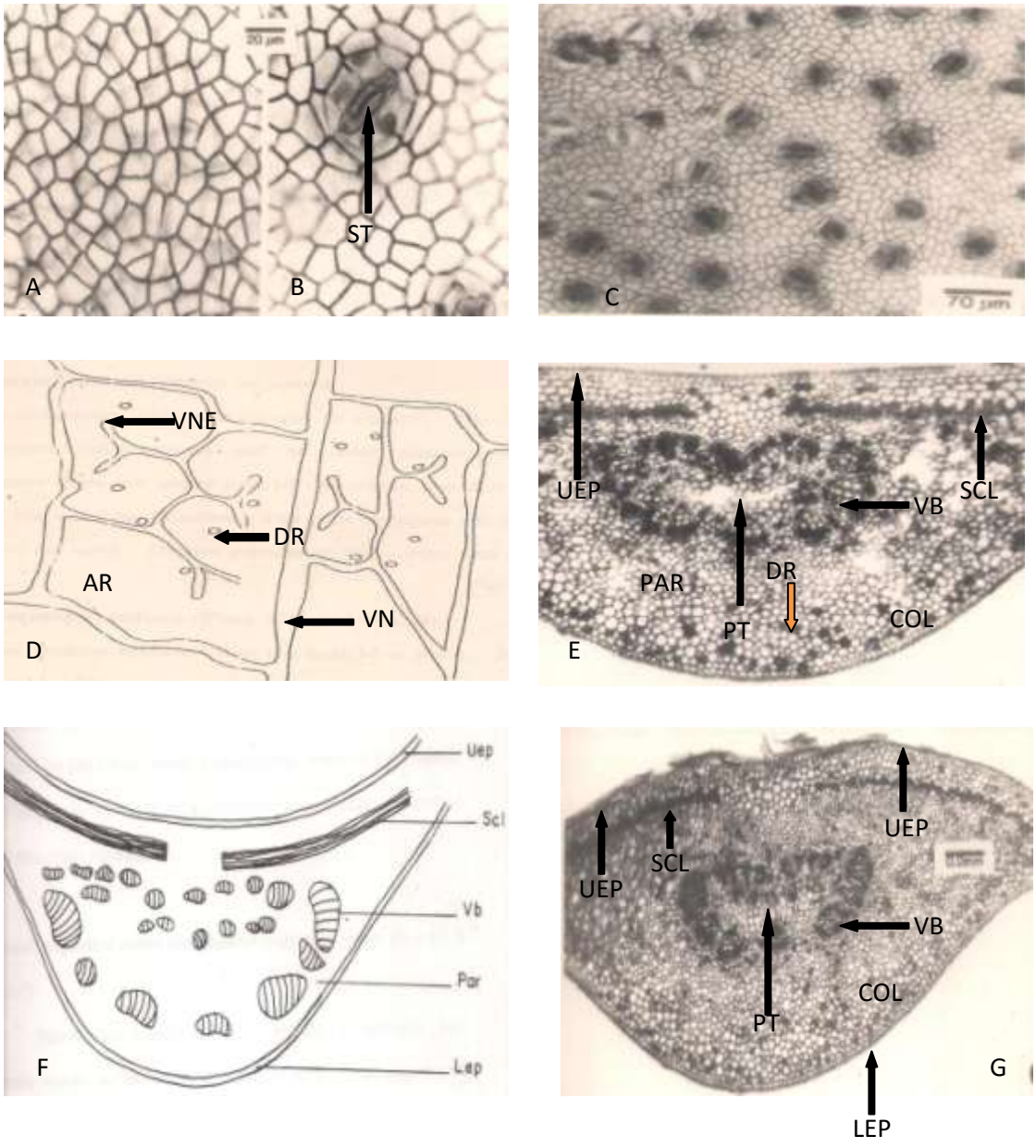
Table 1. Stomata frequency, Guard cell area, Stomata and Veinlet endings per Areole of the Species of *Rhizophora* in Nigeria

Species	*R. mangle*		*R. racemosa*		*R. harrisonii*	
Characters	Range	Mean	Range	Mean	Range	Mean
Stomata frequency per mm^2	12 - 17	14	21 - 27	23	18 - 23	22
Stomata index	1.61		1.46		2.10	
Guard cell area μm^2	549.75 – 957.21	676.30	265.07 - 755.95	468.19	235.62 - 589.05	419.99
Veinlet endings per areole	2		1 - 2		2	

and the petiole is a generic attribute of the genus and confers on members of the three taxa additional strength. Mid rib and petiole outline are boat shaped. Vascular bundles are collateral and arranged in ring for the leaf mid rib and the petiole for the three species. The numbers of vascular bundles in the mid rib of the *Rhizophora* species are; *R. mangle*, 11-13, *R. racemosa*, 8-9 while that of *R. harrisonii* is 15-17. For the petioles the numbers of vascular bundles are; *R. mangle*, 25-27, *R. racemosa*, 17-19 while that of *R. harrisonii* is 15-17. Though the number of the vascular bundle is a quantitative attribute it is diagnostic for the species in the genus. The petiole anatomy of *R. racemosa* has additional one vascular bundle occurring at end of the mid rib in addition to the central rib and this makes the species to be distinct from the other two species. Another unique feature of the petiole anatomy of *R. racemosa* is the presence rectangular bundle sheath cell that occurred at the middle of the abaxial surface.

The presence of osteosclereids in *R. mangle* and asterosclereids *R. racemosa* and *R. harrisonii* was observed in this study. Asterosclereids lined the veins and veinlets in *R. racemosa* but randomly distributed without a regular pattern in *R. harrisonii*. Nabila et al. (2011) reported that it was only in *Rhizophora* that osteosclereids and asteosclereids were observed among mangrove species studied. Anatomical investigation from this study showed that *R. harrisonii* shared features of *R. mangle* and *R. racemosa* suggesting the hybrid nature of this species. This confirms the report of Jayeola et al. (2001). Olowokudejo and Obi-Osang (1993) also suggested that *R. harrisonii* is the hybrid between *R. mangle* and *R. racemosa*. Based on large ribosoma subunit 26s rRNA gene sequence Neyland (2000) suggested that *R. mangle*, *R. racemosa* and *R. harrisonii* are distinct species. Ceron-Souza et al. (2010) described *R. mangle* and *R. racemosa* as two distinct taxonomic groups that coexist. These two species experienced ancient hybridization and introgression, which continues today when they occur in sympatry (Cero´n-Souza et al., 2010). The natural hybrids are known as Rhizophora 9 harrisonii and correspond to what has been

Fig. 3. *R. harrisonii*: A-Adaxial epidermal cells; B-Abaxial surface of the leaf showing cyclocytic stomata; C-Randomly distributed stomata; D-Venation pattern; E-Lamina mid rib showing collateral bundles; F and G-Petiole outline and vascular bundle distribution. AR-Areole, COL-Collenchyma, DR-Druses, LEP-Lower epidermis, PAR-Parenchyma, PT-Pith, SCL-Sclerenchymatous tissue, ST-Stomata, UEP-Upper epidermis, VB-Vascular bundle, VN-Vein, VNE-Vein ending



considered erroneously as a third species in the red mangrove complex in the neotropics (Ceron-Souza et al., 2010; Cornejo, 2013). *R. harrisonii* was described as a morphotype produced by the ongoing hybridization and back crossing between *R. mangle* and *R. harrisonii.* Characters of *R. racemosa* and that *R. harrisonii* are close to suggest retrogressive hybridization.

This study has added to the information on the taxonomy of the genus, *Rhizophora* in Nigeria. Anatomical characters that are common to the three taxa show generic affinity. However, anatomical features that are useful as supplements to existing system of classification include presence of sclereids, type and pattern of distribution. The three *Rhizophora* species occurring in Nigeria can be distinguished anatomically based on the following features: presence of osteosclereids and palisade cells predominantly three *R. mangle*, presence of asterosclereids which lines the veins and veinlets, vascular bundle occurring at each rib of the petiole and presence of bundle sheaths at the median portion of the petiole, wavy anticlinal wall and distinct stomata ledge-*R. racemosa* and presence of asterosclereids which are randomly distributed in the leaf blade-*R. harrisonii*. The three species can also be distinguished based on the number of vascular bundles in the mid rib and petiole. Though the stomata frequency, stomata index and the guard cell areas are quantitative parameters, they are additional features useful in delimiting members of the genus in Nigeria.

References

Adedeji O, OA Jewoola (2008). Importance of leaf epidermal characters in the *Asteraceae* family. Notulae Botanicae Horti Agrobotanici Cluj-Napoca 36(2): 7-16.

Adekanmbi OH, Ogundipe O (2009) Mangrove biodiversity in the restoration and sustainability of the Nigerian natural environment. Journal of Ecology and Natural Environment 1(3): 64-72.

Agbagwa IO, Ndukwa BC (2004). The Value of Morpho-anatomical Features on the Systematics of *Cucurbita* species in Nigeria. African Journal of Biotechnology 3: 541-546.

Breteler FJ (1969). The Atlantic Species of *Rhizophora*. Acta-Botanica Neerlandica 18(3): 434-441.

Ceron-Souza I, Rivera-Ocasio E, Medina E, Jimenez JA, McMillan WO, Bermingham E (2010) Hybridization and introgression in New World red mangroves, *Rhizophora* (Rhizophoraceae). American Journal of Botany 97: 945-957.

Cornejo X (2013). Lectotypification and a new status for *Rhizophora* x *harrisonii* (Rhizophoraceae), a natural hybrid between *R. mangle* and *R. racemosa*. Harv Pap Bot 18: 37.

Duke NC, Allen JA (2006). *Rhizophora mangle*, *R. samoensis*, *R. racemosa*, *R. harrisonii* (Atlantic-East Pacific red mangroves), ver. 2.1. In: Elevitch, C.R. (ed) Species profiles for Pacific Island agroforestry. Permanent Agriculture Resources (PAR), Holualoa, Hawaii, USA.

Emerhi EA (2012). Variations in Anatomical Properties of *Rhizophora racemosa* (Leechman) and *Rhizophora harrisonii* (G. Meyer) in a Nigerian mangrove forest ecosystem. Int J Forest Soil and Erosion 2(2).

Holmgren PK, Keuken W, Schofied EK (1990). Index Herbariorum: Part 1. The Herbaria of the World. 8th

Ed. Reg. Veg. 120. New York, USA.

Jayeola AA, Thorpe JR, Adenegan TA (2001). MacroMorphological and Micro morphological Studies of the West African *Rhizophora* Linn. Feddes Repertorium 1: 349-356.

Keay RWJ (1989). Trees of Nigeria. Clarendon Press. 96-99.

Macnae W (1968a). A General Account of the Fauna and Flora of Mangrove Swamps and Forests in the Indo West Pacfic Region. Advances in Marine Ecology 6: 73-270.

Metcalfe CR, Chalk L (1979). Anatomy of the Dicotyledons. 2nd Edition Vol. 1. Systemic Anatomy of the Leaf and Stem. Oxford Science Publications. 63-75.

Nabilah M, Numida MK, T Noraini, AR Ruzi, MR Nurshaludah, Mohd-Airabe AB (2011). Leaf anatomical adaptation of some mangrove species (Rhizophora). http://www.umt.edu.my/document/UTMAS2011/LIFE%20SC/POSTER.LIFE_SC/LCP47%20%20Nabilah.pdf. 445-449.

Neyland R (2000). Large Ribosoma Subunit 26s rRNA Gene Sequence suggest that *Rhizophora harrisonii*, *R. mangle* and *R. racemosa* (Rhizophraceae) are distinct Species. The Proceedings of the Louisiana Academy of Science. Published by Louisiana Academy of Science, ISSN 0096-9192, USA.

Olatunji AO (1983). Practical Manual for Plant Anatomy. A Laboratory Practical Manual. Obafemi Awolowo University, Ile – Ife, Nigeria (Manuscript).

Olowokudejo JD, Obi-Osang TE (1993). Taxonomic Significance of Epidermal Morphology in Nigerian Rhizophoraceae. Acta-Botanica Neerlandica 42(1): 51-61.

Poompozhil S, Kumarasamy D (2014). Leaf Anatomical Studies on Some Mangrove Plants. Journal of Academia and Industrial Research 2(10): 583-589.

Saheed SA, Illoh HC (2010). A Taxonomic Study of some Species in *Cassiinae* (*Leguminosae*) using Leaf Epidermal Characters. Not Bot Hort Agrobot Cluj 38(1): 21-27.

Savory HJ (1953). A Note of the Ecology of *Rhizophora* in Nigeria. Kew Bulletin 1:127-128.

Scatena VL, Giuletti AM, Borba EL, van der Berge C (2005). Anatomy of the Brasilian Ericolaceae in correlation with taxonomy and habitat using multivariate analysis. Plant Syst Evol 253: 1-22.

Stace CA (1965a). Cuticular Studies as an Aid to Plant Taxonomy. Bulletin of the British Museum (Natural History) Botany 4: 1-78.

Tomlinson PB, Primade RB, Burt JB (1979). Premilinary Observation on the Floral Biology in Mangrove Rhizophoraceae. Biotropica 11(4): 256-277.

Wilcox Balagama HR (1985). Angiosperm Flora in the Mangrove Ecosystem of the Niger Delta. A Paper submitted on the Mangrove ecosystem in the Niger Delta. A workshop organized by the University of Port-Harcourt, Nigeria.