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ECO ANATOMICAL ADAPTATION OF LEAF IN SELECTED TRUE MANGROVE SPECIES IN KERALA

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ABSTRACT

This investigation was carried out with the objectives of studying the anatomical features of leaves of selected true mangrove species seen in Kerala. Based on the results, it is observed that all the selected species have some peculiar features which facilitate their growth in salty aquatic environment. *Aegiceras corniculatum*, *Acanthus ilicifolius, Acanthus ebracteatus* have numerous glandular trichomes in adaxial and abaxial epidermis. However, in *Sonneratia alba* and *Sonneratia caseolaris* including numerous large mucilage cells. *Avicennia marina* and *Avicennia officinalis* consists of glandular and non-glandular trichomes. In *Exoecaria agallocha* length of palisade layer was very extensive due to its xeromorphic nature. In rhizophoraceae, members have homogeneity in anatomical features such as presence of thick cuticle, branched sclereids, crystalliferous cells, and colorless non-assimilatory water storage tissue in hypodermis, tannin cells and terminal trachieds. In *Kandelia candel* and *Lumintzera recemosa* have isobilateral leaf but rest of them comprise dorsi-ventral leaf.
Key words: Mangroves, leaf anatomy, non-glandular trichomes, sclereids.

INTRODUCTION

Biodiversity is prevalent in the tropical estuarine system, particularly in the inter tidal forested vegetation known as Mangrove.[1] The vegetation consists of evergreen trees and shrubs belonging to several unrelated families and share similar habitats. Mangroves are the prominent component of coastal vegetation occupying flood plains, margins of bays and tidal river in addition of shores. Uniqueness of mangrove ecosystem is that the biota is constantly under physiological stress caused by extreme environmental conditions. Despite extreme conditions, mangroves have been successfully colonized by developing morphological, reproductive and physiological adaptations like pneumatophores, prop roots, stilt roots and viviparous germination which facilitates their growth in aquatic environment.[2] These plants are well adapted to changing biological, chemical and physical traits of this environment through various xeromorphic properties, including morphology, anatomy and physiology. Plants of the mangrove community belong to many different genera and families, most of which are not closely related to one another phylogenetically.[3] Anatomical modifications pertaining to specific site conditions are reported from in east coast of India and other regions of sub tropic. However no detailed studies have been reported from the intertidal zones in the Kerala coast.

MATERIALS AND METHODS

The study was conducted for characterizing anatomical features of 15 mangrove species seen in Kerala. The species are: *Aegiceras corniculata, Acanthus ilicifolius, Acanthus ebracteatus Avicennia marina, Avicennia officinalis, Bruguiera cylindrica, Bruguiera gymnorrhiza, Bruguiera sexangula, Excoecaria agallocha, Kandelia candel, Rhizophora mucronata, Rhizophora apiculata, Sonneratia alba, Sonneratia caseolaris, , Lumintzera recemosa*.

Leaf samples were collected from the intertidal zones of Kerala. The plants were identified by BSI Coimbatore. One of the healthy plants was selected and the mature leaves from fifth and sixth node were taken for anatomical studies. Sections were made at a position approximately half way between the base and apex of a sector from one side of the lamina, stained with Toluidine blue 0 and mounted in 50% glycerin. The slides analysed by trilocular compound microscope model number 10093409 and imaged by using the camera Olympus E-PL3.

RESULTS

In *L. recemosa* the leaves were isobilateral. Leaves showing adaxial and abaxial barrel shaped epidermal cells with thick cuticle. The stomata

were amphistomatic. The palisade tissue found in two layers on adaxial and abaxial sides. The mesophyll consists of water storing tissue (aqueous tissue) centrally located in between the upper and lower palisade layer. Numerous crystalliferous cells and terminal tracheids were present in spongy parenchyma. The spongy cells were appear to be very bigger in size during dry season when compared to the wet season. Vascular bundles of smaller veins present along with the mesophyll cells. (Fig.-1, Plate-1)

In *S. alba* leaves described as isobilateral, leaves showing adaxial and abaxial barrel shaped epidermal cells with thick cuticle. The stomata were amphistomatic and deeply sunken. The palisade tissue found in two-four layers on adaxial and abaxial sides. The mesophyll consists of water storing tissue (aqueous tissue) centrally located in between the upper and lower palisade layer. Frequent development of group of enlarged terminal tracheids at vein ending. (Fig.-1, Plate-2)

In *S. caseolaris* leaves described as isobilateral, Leaves showing adaxial and abaxial barrel shaped epidermal cells with thick cuticle. The stomata were amphistomatic. The palisade tissue found in two-four layers on adaxial and abaxial sides. The dry and wet seasons were observed with their corresponding length, width and thickness. The mesophyll consists of water storing tissue (aqueous tissue) centrally located in between the upper and lower palisade layer. Frequent development of group of enlarged terminal tracheids at vein ending. (Fig.-1, Plate-3)

In *B. cylindrica* leaves described as dorsiventral, leaves showing adaxial and abaxial barrel shaped epidermal cells with thick cuticle. Hypodermis one layer thick and uniseriate. The stomata were deeply sunken confined on abaxial side only. The palisade tissue was one to two layer in thickness. Spongy tissues were multilayered and consist of crystalliferous cells and short tracheids at vein endings, and confined to the lower epidermis. Large air cavities present in the midirib and mesophyll. The vascular bundle is medullated and collateral. (Fig.-1, Plate-4)

In *B. gymnorrhiza* leaves described as dorsiventral, leaves showing adaxial and abaxial barrel shaped epidermal cells with thick cuticle. The hypodermis is composed of six to seven layers of colourless, polygonal shaped cells below the adaxial epidermal cells. The stomata were deeply sunken confined on abaxial side only. The palisade tissue was one to two layers in thickness. Spongy tissue was multilayered and consists of crystalliferous cells, idioblasts, and air cavities confined to the lower epidermis. Vascular bundles collateral. Patches of brachy sclereids found in phloem and spongy mesophyll. (Fig.-1, Plate-5)

In *B. sexangula* leaves described as dorsiventral, leaves showing adaxial and abaxial barrel shaped epidermal cells with thick cuticle. The hypodermis is composed of one layer of colourless, polygonal shaped cells below the adaxial epidermal cells. The stomata were deeply sunken confined on abaxial side only. The palisade tissue was one to two layers in thickness Spongy tissue were one and consists of crystalliferous cells, idioblasts, and air cavities confined to the lower epidermis. Vascular bundles collateral. Patches of brachy sclereids found in phloem and spongy mesophyll. (Fig.-1, Plate-6)

In *K. candel* leaves described as isobilateral type. Leaves showing adaxial and abaxial barrel shaped two layered epidermal cells with thick cuticle. Stomata were deeply sunken amphistomatic. The palisade tissue found in one to two layers on adaxial and abaxial sides The mesophyll consists of water storing tissue (aqueous tissue) centrally located in between the upper and lower palisade layer. Numerous crystalliferous cells and terminal trachieds were present in spongy parenchyma. Vascular bundles of smaller veins present along with the mesophyll cells. (Fig.-1, Plate-7)

In *R. apiculata* leaves described as dorsiventral, leaves showing adaxial and abaxial barrel shaped epidermal cells with thick cuticle. The hypodermis is composed of seven to eight layers of colourless, polygonal shaped cells below the adaxial epidermal cells The stomata were deeply sunken confined on abaxial side only. The palisade tissue was one to two layers in thickness. Spongy tissue were one and consists of crystalliferous cells, sclereids and air cavities confined to the lower epidermis. The vascular bundle is medullated and collateral. Patches of brachy sclereids found in phloem and spongy mesophyll. (Fig.-1, Plate-8)

In *R. mucronata* leaves described as dorsiventral, leaves showing adaxial and abaxial barrel shaped epidermal cells with thick cuticle, black circular cork warts in the abaxial side of leaf. The hypodermis is composed of six to seven layers of colourless, polygonal shaped cells below the adaxial epidermal cells. The stomata were deeply sunken confined on abaxial side only. The palisade tissue was one to two layers in thickness. Spongy tissue were consists of crystalliferous cells, sclereids and air cavities confined to the lower epidermis. The vascular bundle is medullated and collateral. Patches of brachy sclereids found in phloem and spongy mesophyll. (Fig.-1, Plate-9)

In *E. agallocha* leaves described as dorsiventral, leaves showing adaxial and abaxial barrel shaped epidermal cells with thick cuticle. The hypodermis is composed of one layer of colourless, polygonal shaped cells below the adaxial epidermal cells. The stomata were confined on abaxial side only. The palisade tissue was one to two layers in thickness. The dry and wet seasons were observed with their corresponding length, width and thickness. Spongy tissues were one and consist of crystalliferous cells, confined to the lower epidermis. Vascular bundles collateral. (Fig.-1, Plate-10)

In *A. corniculata* leaves described as dorsiventral, leaves showing adaxial and abaxial barrel shaped epidermal cells with thick cuticle. Salt glands present in adaxial side. Each gland has a stalk cell and a head comprising of variable number of cells found on both adaxial side of leaves. The hypodermis was composed of four to five layers of colorless, polygonal shaped cells below the adaxial epidermal cells. The stomata were confined on abaxial side only. The palisade tissue has two to three layers in thickness. Tannin cells were frequently present in leaf tissue. Vascular bundles are in the form of deep arc or flat arc and collateral. (Fig.-1, Plate-11)

In *A. ebracteatus* leaves described as dorsiventral, leaves showing adaxial and abaxial barrel shaped epidermal cells with thick cuticle. Salt glands present in adaxial and abaxial sides. Each gland showed stalk cell and head comprising of variable number of cells. Below the adaxial epidermis, hypodermis composed of uni to two layers of colourless, polygonal shaped cells. The stomata were confined on abaxial side only. It showing one bigger median bundle and apart from that somewhat two smaller lateral bundles. Each bundle with sclerenchymatous sheath. The palisade tissue has two layers in thickness. Vascular bundles collateral. (Fig.-1, Plate-12)

In A. ilicifolius leaves described as dorsiventral, leaves showing adaxial and abaxial barrel shaped epidermal cells with thick cuticle. Salt glands present in adaxial side. Each gland have stalk cell and head comprising of variable number of cells. Median vein showed numerous bundles with irregular nature. The whole bundle do not shows a continuous sheath of sclerenchyma. Median vein somewhat paw shaped consists of wide parenchymatous central portion. The lateral vein bundles were somewhat near to the median bundle showing continuous layer of sclerenchyma sheath. The hypodermis is composed of two layers of colourless, polygonal shaped cells below the adaxial epidermal cells. The stomata were confined on abaxial side only. The palisade tissue was two layers in thickness. Vascular bundles collateral. (Fig.-1, Plate-13)

In *A. marina* leaves were dorsiventral, the epidermal cells were barrel shaped on adaxial and abaxial surface with thick cuticle, uniseriate epidermal hairs were present on the adaxial surface. Salt glands were frequently present on the upper side placed along with the epidermal cells. Each gland having stalk cells with variable number and with a single head cell. The hypodermis was six to seven layers of colourless, polygonal cells. The stomata were confined on abaxial side only. Presence of non-glandular uniseriate hairs, with bi seriate stalk cell and terminal awl shaped cell. Stomata were intermingled with non-glandular hairs. The vascular bundle is medullated and collateral. Lamina showing multi seriate palisade tissue and highly redused spongy parenchyma. (Fig.-1, Plate-14)

In *A. officinalis* leaves were dorsiventral, leaves showing adaxial and abaxial barrel shaped epidermal cells with thick cuticle, and its surface was not smooth, it was interrupted by uniseriate epidermal hairs. Salt glands present in adaxial side. Each gland having a stalk cell and a head comprising of variable number of cells found on both adaxial and abaxial surface of leaves. The hypodermis is composed of six to seven layers of colourless, polygonal shaped cells below the adaxial epidermal cells. The stomata were confined on abaxial side only. Presence of non-glandular uniseriate hairs, providing white velvet appearance in abaxial side and are multicellular with a stalk of 2 to three cells with an inverted pileus shaped terminal cell .Stomata were sunken in the lower epidermis. The palisade tissue was two to three layers in thickness. Vascular bundles are in the form of deep arc or flat arc and collateral, surrounded with sclerenchymatous sheath. (Fig.-1, Plate-15)

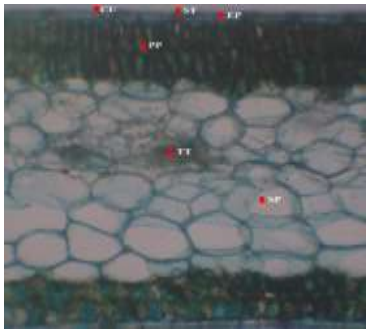

Plate-1. *Lumnitzera recemosa* Willd.

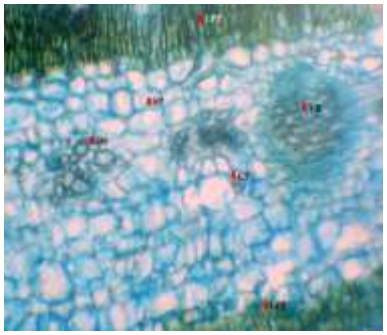

Plate-2. *Sonneratia alba* Sm.

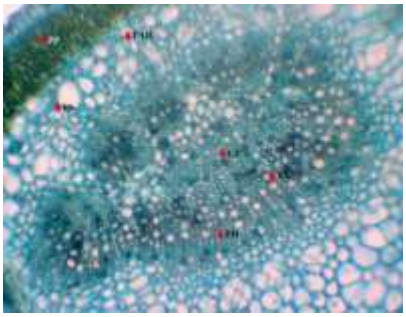

Plate-3. *Sonneratia caseolaris* (L.) Engl.

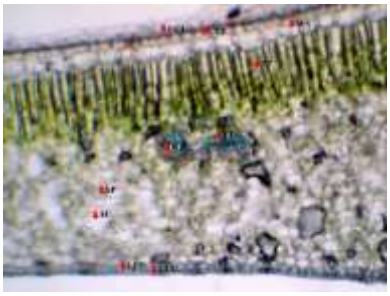

Plate-4. *Bruguiera cylindrica*(L.)Blume.

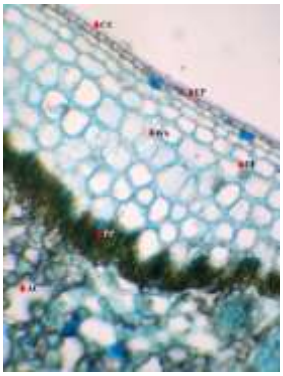

Plate-5. *Bruguiera gymnorrhiza* (L.) Lam.

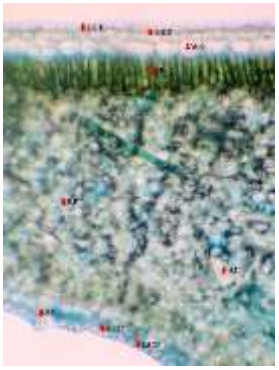

Plate-6. *Bruguiera sexangula*(Lour.)Poir.

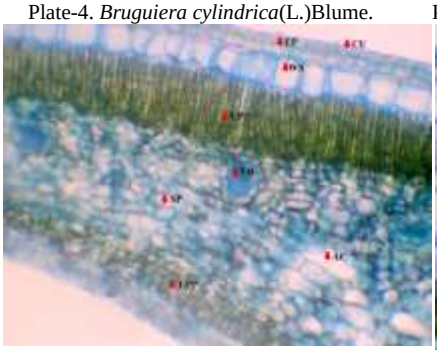

Plate-7. *Kandelia candel* (L.) Druce.

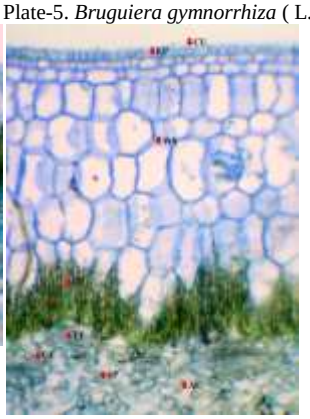

Plate-8. *Rhizophora apiculata* Blume.

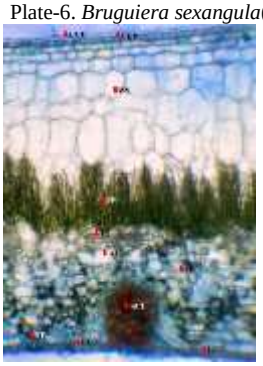

Plate-9. *Rhizophora mucronata* Lam.

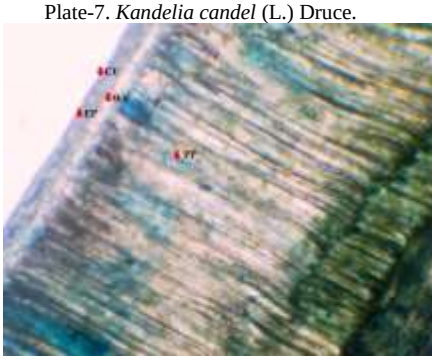

Plate-10. *Excoecaria agallocha* L.

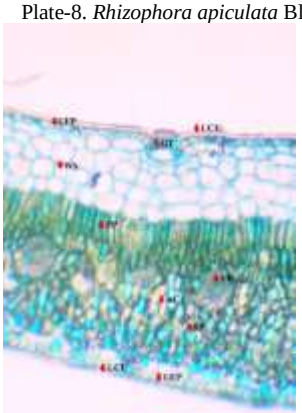

Plate-11. *Aegiceras corniculata* (L.) Blanco

Plate-12. *Acanthuus ebracteatus* Vahl.

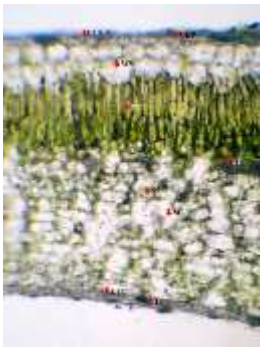

Plate-13. *Acanthuus ilicifolius* L.

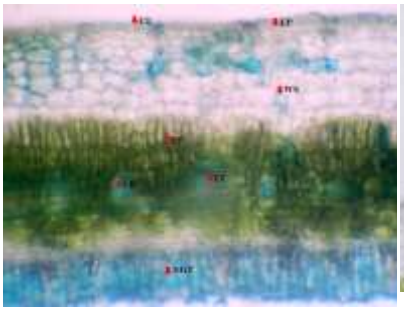

Plate-14. *Avicennia marina*(Forssk.) Vierh..

Plate-15. *Avicennia officinalis* L.

Fig-1. Leaf anatomy of mangrove species. CU- Cuticle, AC- Air cavities, EP-Epidermis, HP- Hypodermis, PP- Palisade parenchyma, CF- Crystalliferous cell, PAR-Parenchyma, PH- Phloem, BS- Brachy sclereids, SC- Subsidiary cells, SP- Stomatal parenchyma, VB- Vascular bundle, TT-Terminal tracheids, WS- Water storage tissue, XY- Xylem. NGT- Non glandular trichomes, SB- Sclerenchyma bands, GT- Glandular trichomes, UPP- Upper palisade parenchyma, LPP- Lower palisade parenchyma, UCU- Upper cuticle, LCU- Lower cuticle, ST- Stomata.

DISCUSSION

In additional to the common anatomical features of the selected species, the members of the family Rhizophoraceae (*R. mucronata, R. apiculata, K. candel, B. cylindrica, B. sexangula* and *B. gymnorrhiza)* showed distinct variations in few anatomical features. Though they showed homogeneity in anatomical features such as presence of thick cuticle, branched sclereids, crystalliferous cells, colourless non- assimilatory water storage tissue in hypodermis, tannin cells, terminal tracheids. Epidermal cells were slightly curved in all species. The water storing tissue is uniseriate in *B. cylindrica*, multiseriate in other species observed. Crystalliferous cells found in all most all species Branched idioblast found in the mesophyll region of *B. gymnorrhiza*. Few comparative studies concerning the leaf anatomy of rhizophoraceae in Port Blair region have been conducted.[5] The leaf anatomy of genus *Rhizophora* from Nigeria was also reported.[6]

In Acanthaceae both species have glandular trichomes in adaxial and abaxial region. Water storage tissue biseriate in *A. ebractatus and A. illicifolius.* three or more discrete vascular bundles were present.

In Aviceniaceae, both *A. marina* and *A. officianalis*, showed glandular and non-glandular trichomes were observed in the leaves provided experimental evidence that glandular hairs are responsible for secretary function in *Avicennia*.[7] Glandular trichomes found in adaxial region and non-glandular trichomes were found in abaxial side. Hypodermis multilayered. Both species have terminal tracheids.

Among the Combretaceae taxa, members were dorsiventral, but in *Lumintzera* the leaves were isobilateral.[8] The palisade tissue consists of two layer of cells below the upper epidermis and a broad spongy zone. So the water storage tissue placed in the middle spongy region. . But as suggested by that in their anatomical characters, the mangrove species exhibit closer affinities to non-mangrove species of their family than to mangrove of other families.[9,10]

In Myrsinaceae *A. corniculatum*, glandular trichoms were present in both upper and lower surfaces. Numerous secretary cells present in hypodermis and mesophyll region.

The two species of Sonnneratiaceae (*S. alba* and *S. caseolaris*) characterized by isobilateral leaf. Water storage tissue situated in between palisade layer including numerous large mucilage cells.

In Euphorbiaceae, mesophyll is composed of thin-walled chlorenchymatous cells and is well differentiated in the dorsiventral leaf into one or more layers of adaxial anticlinally-extended palisade cells and oval- or round-shaped compact or loose abaxial isodiametric cells.

CONCLUSION

From this study it is concluded that all the species showing xeromorphic characters like thick cuticle, water storage tissue, extensive palisade, salt glands and trichomes, terminal tracheids, branched sclereids exhibited by most of the mangrove species appears to eco anatomical adaptations. This character includes isobilateral nature of leaves in some plants like *L. recemosa* and *K. candal*. Every species showed some peculiar features which facilitates adaptation for stress environment.

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CONFLICT OF INTERESTS

The authors declare that they have no competing interests.

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