INTERNATIONAL JOURNAL OF ADVANCED BIOLOGICAL RESEARCH

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A STUDY ON MORPHOLOGICAL AND ANATOMICAL FEATURES OF *AVICENNIA OFFICINALIS* L. AND *SONNERATIA CASEOLARIS* L. SELECTED FROM ASRAMAM OF KOLLAM DISTRICT, KERALA

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ABSTRACT
Mangroves consists of a wide variety of tropical trees or woody shrubs like plants growing at the interface between sea and land (inter-tidal) zone and form a highly productive and ecologically important ecosystem. Aim of the current work is to study various morphological and anatomical adaptations exhibited by two mangroves such as *Avicennia officinalis* L. and *Sonneratia caseolaris* L. collected from Asramam of Kollam district, Kerala. The study revealed that the plants growing in salt marshes of Asramam developed a number of adaptations to survive in the physiologically dry habitat. Major structural adaptations observed among these plants include pneumatophores, thick leaves, persistent calyx, salt glands and vivipary. The anatomy of leaves showed xerophytic characteristics such as presence of mulitilayered epidermis, sunken stomata, thick cuticle, mucilaginous cells and sclerenchymatous hypodermis. Anatomical studies on stem shows the presence of lignified cells in cortex and pith, water storing cells that are highly adapted from desiccation of tissues due to insolation. From the study it was clear that the morphological and anatomical adaptations to local conditions may allow the trees to maximize its photosynthetic efficiency.

KEY WORDS: Adaptations, Biodiversity, Coppicing, Mangrove communities, Pneumatophores.

INTRODUCTION

Mangroves are specialized ecosystems developed along estuarine sea coasts and river mouths in tropical and subtropical regions of the world, mainly in the intertidal zone. The mangroves are composed of trees and shrubs remarkably adapted to tidal and coastal land through their ability to live in poorly oxygenated sediment and can tolerate inundation by salt water through physiological chemical mechanisms (Morley, 2000). Mangroves have been successfully colonized by developing morphological, reproductive and physiological adaptations like pneumatophores, stilt roots, knee roots and viviparous germination. These plants are well adapted to changing biological, chemical and physical traits of this environment through various xeromorphic properties, including morphology and anatomy. Approximately eighty species of plants belonging to thirty genera in over twenty families (most of them belong to Rhizophoraceae) are recognized worldwide (Tomlinson, 1986). The present investigation was intended to study the morphological and anatomical features of 2 mangrove species *Avicennia officinalis* L. and *Sonneratia caseolaris* L. collected from Asramam of Kollam district.

MATERIALS AND METHODS

A survey trip was conducted for the study of mangrove species of Asramam of Kollam district. The study was based on direct observation. Even though many species were available, only two of them are selected for the present study.
Selected Mangroves and their families:

1. *Avicennia officinalis L.* of Avicenniaceae
2. *Sonneratia caseolaris L. of Lythraceae*

Morphology

Morphological studies were carried out using fresh plant specimens. The morphological identities of the collected plants were determined with the help of intended keys in 'The flora of Presidency of Madras 'by Gamble.

Anatomy

The study mainly concentrated on the anatomical peculiarities of leaf and stem of selected mangroves. Hand sections were taken, stained with safranin, sections were washed well in water. Stained sections are mounted in a mixture 1:1 glycerol and water and observed under compound microscope. The microphotographs showing the anatomical features of leaf stem and pneumatophores were taken using camera and are shown in figures.

OBSERVATION

Morphological Observations

Avicennia officinalis L.

Habit:	Shrubs or small trees, dense bushy in appearance
Roots:	Possess two types of roots, anchoring roots and cable roots, the roots are grown parallel to the surface in the mud from this arise some negatively geotropic pencil like Pneumatophores
Leaves:	Leaves are simple, exstipulate, dark green above and pale and hairy below and shortly petiolate and thick, salt depositions are present below the leaf
Inflorescence:	Terminal or axillary found in cluster of 4 or 5.
Flowers:	Flowers are small, without individual stalks, appearing in small heads on stiff angular and flowering stalks, occurring in the axils of upper leaves, or several at the end of the branch. Zygomorphic, sessile, fragrant with small bract. The calyx is green in colour, sepals 5, slightly united at base, hairy at the margins, imbricate aestivation and thin. Corolla with 4 petals, gamopetalous, yellow, glabrous within, petals fuse at base to form a short corolla tube. Stamens as many as petals and alternating with corolla lobes, epipetalous, filaments very short. Anthers basifixed, dehiscing longitudinally. Pistil long, flask shaped, ovary superior.

Sonneratia caseolaris L.

Habit:	Medium sized tree
Root:	Underground roots and Pneumatophores present
Leaves:	Simple, opposite decussate, exstipulate, obovate, rounded to slightly, notched at tip, entire margin, glabrous , fleshy, dark green upper, pale beneath, petiole reddish green, very short, sub sessile. Salt depositions are seen on lower leaf surface.
Inflorescence	Solitary axillary
Flowers:	Large, showy, Pedicellate, red in colour. Calyx tube campanulate, green outer, pale green inner, lobe 6 lanceolate, acute at the tip, coriaceous, persistent, corolla free, 6 lobed, linear, red to reddish purple, caducous. Stamens numerous, caduceus, filiform filament, long, exerted, white upper portion, red lower portion, powder puff-like when flower opens, anther horse shoe-shaped, dorsifixed, ovary bowl-shaped, green, glabrous, style long, stout, green stigma capitates and persistent.
Fruit:	Bowl-shaped, green, berry, indehiscent.

FIGURE 1: *Avicennia* inflorescence

FIGURE 2: Single flower of Avicennia

FIGURE 3: Pneumatophores

FIGURE 4:*Sonneratia* flower

FIGURE 5: bud of sonneratia

FIGURE 6: Fruit of sonneratia

ANATOMICAL OBSERVATIONS

Avicennia officinalis L.

FIGURE 7: Anatomy of Stem

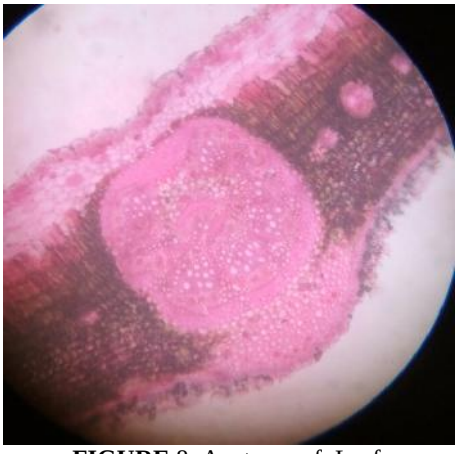

FIGURE 8: Anatomy of Leaf

The epidermis is uniseriate and thick cuticle is present above epidermis. Hypodermis is composed of three to four layers of thick walled cells. Cortex is parenchymatous consisting of radially elongated cells connected with each other and forming large number of air chambers. A well-defined endodermis of barrel shaped cells is present. Pericycle is sclerenchymatous and is made of 3-4 layers of cells. Stele is broad and vascular bundles are conjoint, collateral and open. The xylem is endarch and inner faces of xylem are composed of lignified sclerenchymatic cells. Phloem consists of thin walled smaller cells. Pith consists of large number of thick walled cells. Cells towards the periphery are smaller in size than the central region. Most of the cells are filled with tannin and oil.

Transverse section of leaf shows a thick cuticle followed by an epidermis of thick walled cells. Below the epidermis 3 or 4 layers of thin walled cells are seen which are water storing. It is multilayered epidermis modified for the purpose of water storage. The mesophyll is differentiated into palisade and spongy. Raphides are present in the mesophyll tissue. The palisade is biseriate consisting of closely packed cells rich in chloroplast. Spongy tissue is with a little intercellular space. The lower epidermis is interrupted with stomata which are sunken. There are peltate hairs on the lower epidermis except at the midrib region. Vascular bundles are surrounded by sclerenchymatous bundle sheath which is single layered. 6 xylem groups are present and phloem lies below the xylem.

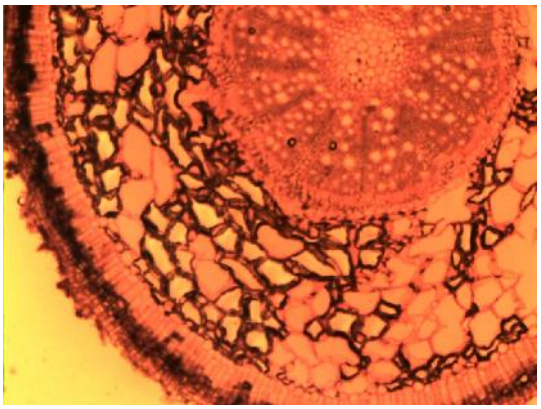

FIGURE 9: Anatomy of Pneumatophore :

The outer cork is well developed consisting of 4 to 6 layers of compactly arranged cells. Continuity of this layer is interrupted at places by Pneumatothodes. Here the cells are thin walled, loosely packed parenchyma which facilitate gaseous exchange especially absorption of oxygen for respiratory purposes. Inner to cork one or two layers of phellogen is present. Cortex is broad consisting of radially elongated cells connected with each other and forming a large number of air chambers separated by partition walls. A distinct endodermis and pericycle of sclerenchymas are seen. Stele is broad and secondary xylem and phloems are well developed. Primary xylem is exarch. Xylem elements are thick walled and lignified. Pith is well developed and possesses oil and tannin cells. It is composed of loosely arranged parenchymatous cells; the cells towards the periphery are smaller than those in the centre.

Sonneratia caseolaris L.

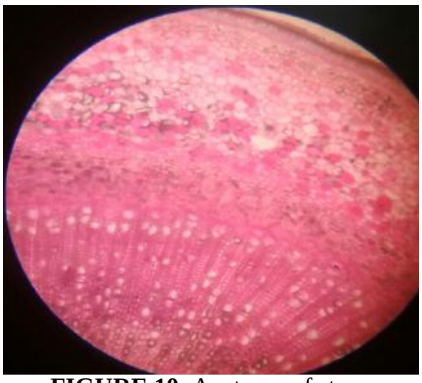

FIGURE 10: Anatomy of stem

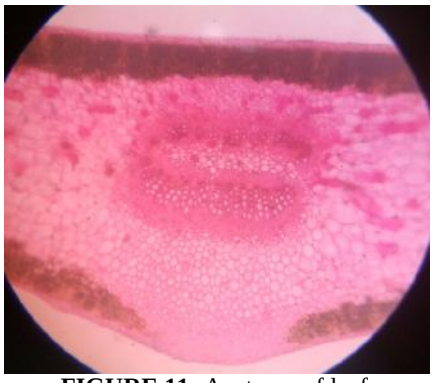

FIGURE 11: Anatomy of leaf

Transverse section of mature stem shows the following features. Cork consists of 3-4 layers of phellogen which is followed by parenchymatous cortex with tannin depositions and water storing cells. Stele is broad and vascular bundles are conjoint, collateral and open. The xylem is endarch and inner faces of xylem are composed of lignified sclerenchymatic cells. Phloem consists of thin walled smaller cells. Pith consists of large number of thick walled cells. Cells towards the periphery are smaller in size than the central region. Most of the cells are filled with tannin and oil.

Transverse section of leaf shows a thick cuticle followed by an epidermis of thick walled cells. The mesophyll is well differentiated into palisade and spongy parenchyma. The palisade is biseriate consisting of closely packed cells rich in chloroplast and is dark green in colour. Palisade layer is also seen on lower epidermis except at mid rib region. Spongy tissues are with a little intercellular space and occupy a larger area. It has tannin depositions and water storing cells. The lower epidermis is interrupted with stomata which are sunken. Vascular bundles are surrounded by parenchymatouss bundle sheath which is multilayered. Numerous xylem groups are present and phloem lies below the xylem.

RESULTS AND DISCUSSION

Mangroves are trees or shrubs that grow in shallow and muddy salt water or brackish water such as those along shorelines or in estuaries. Morphological and anatomical studies on 2 different species of mangroves reveals that the plants growing in salt marshes of Asramam of Kollam district develops a number of adaptations to survive in the physiologically dry habitat. Morphology and anatomy of halophytes has previously been reported by many botanists. According to Vasishta (1968), halophyte in general shows xerophytic characters and adaptations. Present study also revealed several morphological and anatomical adaptations similar to Xerophytes.

Morphologically *Avicennia officinalis L.* and *Sonneratia caseolaris L.* were small trees with woody stem. Both of them possess pneumatophores. Leaves of the selected mangroves were very thick and shiny due to the presence of wax coating. Lower surface of *Avicennia officinalis L.*, *Sonneratia caseolaris L.* have salt depositions which are clearly visible. Calyx of both the species were persistent and were found attached to their fruit. The petals of Avicennia *officinalis L.* and *Sonneratia caseolaris L.* were thick and fleshy. Epipetalous stamens were found in *Avicennia officinalis L.*, while numerous long colorful stamens and horse shoe-shaped anthers were found in *Sonneratia caseolaris.* One of the important facts that we understand in this study is the presence of vivipary in *Avicennia sps.* In vivipary, seeds germinate while they are in the plant itself. This is the best adaptation of mangroves, but this adaptation is not present in *Sonneratia caseolaris L.* which possess normal indehiscent fruit.

Anatomically the leaves of *Avicennia officinalis L.* showed multilayered epidermis which usually gives rigidity to the leaf and also prevent the leaves from shrinking. Multilayered epidermis helps to reduce the rate of transpiration which is a xerophytic adaptation while in *Sonneratia caseolaris* the epidermis is single layered. In both the species epidermis is covered with thick cuticle. Presences of thick cuticle check the rate of transpiration which is an adaptation to live in scarcity of water. Another common feature exhibited by the present studied species is the succulence of leaves. The leaves showed thin walled water storing tissues in the hypodermal region. According to Mothes (1942) there exists a clear relationship between the salinity of soil and the appearance of succulent features in plant growing in it. Water storing tissues in leaf consist of large cell with large vacuoles containing a mucilaginous cell sap. These cells have a thin layer of cytoplasm lining the cell wall and scattered chloroplast are also found in these cells. The osmotic pressure in photosynthesizing cells is higher than in the non photosynthesizing cells ones and when water is lacking they obtain the water from the water storing tissue. The stomata is sunken, reduced in number and restricted to lower epidermis in both species .Sunken stomata prevent direct exposure to light thereby reducing the rate of transpiration. In *Avicennia officinalis* the lower epidermis except the midrib shows the presence of tuft of hairs. These hairs functions as salt gland which excrete excess of salt present in the absorbed water to the exterior. In leaf, the mesophyll is differentiated in the palisade and spongy in both the species studied. Palisades are well developed, compactly arranged, bi-seriated and possess abundant chloroplast which increases the photosynthetic rate. Intercellular spaces between spongy tissues are very much reduced in *Avicennia officinalis L.* and *Sonneratia caseolaris L.* by which the rate diffusion is minimized.

Anatomical studies of stem shows a single layered epidermis in both species selected for study. The hypodermis is sclerenchymatous in *Avicennia officinalis L.* and *Sonneratia caseolaris L.* The cortical region of the stem of both the species showed the presence of secondary metabolite like tannin and oil filled cells. Tannin and oil deposition enables to reduce insulation which saves the tissue from desiccation. The pericycle region of most of the stem studied is provided with sclerenchyma which gives additional support. Vasular bundles are open, conjoint and collateral, well developed with radially elongated medullary rays. Stele is lignified in both the studied mangroves which is a xerophytic adaptation. Pith region of stem of *Avicennia officinalis L.* and *Sonneratia caseolaris L.* are provided with some thick walled cells giving support to the pith.

Another important adaptive feature shown by *Avicennia officinalis L.* is the possession of negatively geotropic roots called Pneumatophores. They are respiratory in function. In salt marshes since the soil is water logged the roots cannot get oxygen. In such condition the plants develop pneumatophores that grow above the surface of soil.

Even though these plants are well adapted to the saline habitat, the number of plants in the study area is very much reduced. One of the reasons for the thin population of mangroves may be due to the difficulty faced with seed germination as reported previously by a number of scientists. Major part of salt marshes of Asramam coast of Kollam district is occupied by *Avicennia officinalis L.* This may be due to the coppicing capacity exhibited by *Avivennia officinalis* in addition to normal vegetative reproduction through rhizomes. Coppicing capacity is the capacity to produce numerous branches from the cutting area.

ACKNOWLEDGEMENT

We sincerely thank all Faculty members of Dept of Botany, MSM College, Kayamkulam and Dept of Zoology, Govt. College Elanthoor for their support for the successful completion of our work.

FUNDING

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors and the authors declare no conflicts of interest.

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