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A study on morphological and anatomical features of *Bruguiera cylindrica* (L.) Bl. and *Rhizophora mucronata* Lam. selected from Mundrothuruth of Kollam district, Kerala

Fouzia Hilal and Soumya Hilal

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 *Bruguiera cylindrica* and *Rhizophora mucronata* collected from Mundrothuruth of Kollam district. The study revealed that the plants growing in salt marshes of Mundrothuruth developed a number of adaptations to survive in the physiologically dry habitat. Major structural adaptations observed among these plants include pneumatophores, stilt roots, knee roots, thick leaves, persistent calyx and vivipary. The anatomy of leaves showed xerophytic characteristics such as presence of highly cuticularized epidermis, sunken stomata, mucilaginous cells and collenchymatous hypodermis. Anatomical studies on stem shows the presence of lignified cells in cortex and pith, deposition of tannins and oils, 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.

Keywords: Biodiversity, adaptations, pneumatophores, vivipary, insolation

Introduction
Mangrove forest are unique functional ecosystems having social, economical and biological importance. They are among one of the most productive ecosystems of the world as they provide important ecosystem supplies and services to human society as well as coastal and marine systems. These habitats interact with a wide array of aquatic or terrestrial flora and fauna, enabling their growth and establishment. 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 [1]. 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. Mundrothuruth is one of the most famous mangrove site in Kollam District. The uniqueness of mangrove ecosystem is that the biota is constantly under physiological stress caused by some extreme environmental conditions. Approximately eighty species of plants belonging to thirty genera in over twenty families (most of them belong to Rhizophoraceae) are recognized worldwide [2]. The present work was intended to study the morphological and anatomical features of 2 mangrove species *Bruguiera cylindrica* (L.) Bl. and *Rhizophora mucronata* Lam. belonging to family Rhizophoraceae collected from Mundrothuruth of Kollam district, Kerala.

Materials and Methods
A survey trip was conducted for the study of mangrove species of Mundrothuruth 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. *Bruguiera cylindrica* (L.) Bl. of Rhizophoraceae.
2. *Rhizophora mucronata* Lam. of Rhizophoraceae.

Morphological studies
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 [3].

Anatomical studies
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 and stem were taken using camera and are shown in figures.

Observations
Morphological observation of *Bruguiera cylindrica* (L.) BL.
Habit: Medium sized tree.
Root: Occasionally buttressed, producing numerous knee roots.

Leaves: Opposite-decussate, simple, stipules are interpetiolar, glabrous, margin entire and petiolate. Leafs are thinly fleshy, leathery and oval in shape. Upper surface is shiny green while lower surface is light green in colour.

Inflorescence: Axillary cymes, usually unbranched. Flowers are arranged in a cluster of three and rarely upto six flowers and are pendulous.

Flowers: Greenish white, usually sessile, rarely middle flower Pedicellate. Calyx greenish white, short and top shaped. It opens into 8 pointed lobes at distal end and fused basally to form a prominent calyx tube, glabrous, enclosing the ovary, persistent. Petals as many as and alternating with the calyx lobes, free, shortly stalked, greenish white, hairy with 2 to 3 bristles at their tip. Stamens 10, free, but in groups of two, inserted in the folds of each petal, anther basifixed. Ovary semi-inferior, inserted and fused with calyx cup, 2-celled, ovules 2 in each, pendulous, style long, filiform, stigma bifid.

Fig 1: Inflorescence of *Bruguiera cylindrica* (L.) Bl.

Fig 2: Flower of *Bruguiera cylindrica* (L.) Bl.

Fig 3: Persistent Calyx of *Bruguiera Cylindrica* (L.) Bl.

Morphological observation of *Rhizophora mucronata* Lam.
Habit: A glabrous, evergreen medium sized tree

Root: Often appearing buttressed by the mud being washed away from the branching aerial roots. Knee roots, stilt roots and prop roots are present.

Leaves: Simple, entire, coriaceous, glabrous, blade elliptical, slightly thick, leathery, margin entire with pointed apex and a hair at tip, dark green above and light green with numerous black dots below, stipulate and petiolate. Leaves are crowded at the end of branches.

Inflorescence: Cymes 3-7 borne on peduncles, axillary.

Flowers: Perfect, yellowish white, tetramerous; calyx green with 4 thick fleshy, valvate, deeply lobed, pale yellow and persistent in fruit. Petals 4, lanceolate with densely hairy margins and somewhat longer than the calyx lobes, Stamens 8, free, inserted at the margin of receptacular disc, filaments short; anthers linear and basifixed. Ovary half inferior, inserted within and fused with calyx cup, bicarpellary syncarpous with 2 ovules in each cell, pendulous, style short, conical, stigma bifid.

Fig 4: Inflorescence of *Rhizophora Mucronata* Lam.

Fig 5: Flower of *Rhizophora Mucronata* Lam.

Fig 6: Fruit With Persistent Calyx of *Rhizophora Mucronata* Lam.

Anatomical observations
Bruguiera cylindrica (L.) Bl.

Anatomy of Stem: Cork consists of 3-4 layers of phellogen. Cortex consists of large number of regularly arranged parenchymatous cells with large intercellular spaces. Some of these cells possess tannin deposition. Endodermis and pericycle are distinct consisting of 2 layers of sclerenchyma. Secondary xylem and phloem are well developed. Xylem region consists of highly lignified cells. Primary xylem is endarch. Medullary rays are distinct consisting of vertically elongated cells which are 1-2 cells in thickness. Pith is large and consists of large number of parenchymatous cells with oil deposits.

Anatomy of Leaf: Epidermis is single layered with thick cuticle over it. Below the epidermis thin walled water storage cells are present. The lower epidermis is provided with sunken stomata below the storage cells mesophyll is present which is differentiated into upper palisade and lower spongy tissue. Palisade is uniseriate consisting of radially elongated compactly arranged cells containing numerous chloroplasts. Spongy tissue consists of loosely arranged cells with less intercellular spaces. Vascular bundles are conjoint, collateral and closed. Bundle sheath is sclerenchymatous and xylem is well developed.

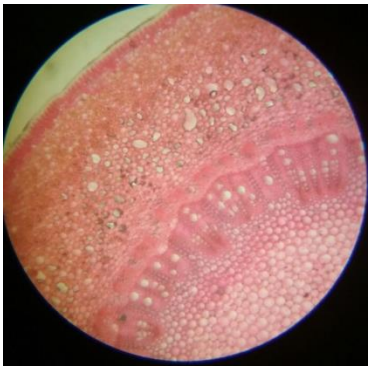

Fig 7: Anatomy of Stem

Fig 8: Anatomy of Leaf *Rhizophora mucronata* Lam.

Anatomy of Stem: Single layer of epidermis consist of thick cuticle. Hypodermis composed of 4-5 layers of collenchyma cells with tannin deposition. Outer cortex consist of regularly arranged parenchyma cells with inter cellular space, inner cortex consists of 6-7 layers of closely packed parenchyma cells, in between these cells sclerids are present and also certain chemical deposition. Endodermis and pericycle are single layered. Xylem and phloem well developed, endarch, conjoint, collateral and open. Lignified cells are seen around xylem vessels. Pith is large with water storing cells.

Anatomy of Leaf: Epidermis single layered and contains sunken stomata. Below the epidermis there is 1-2 layers of water storage cells. Lower epidermis also possesses sunken stomata. Mesophyll is differentiated into upper palisade, which is biseriate with abundant chloroplast and lower spongy parenchyma with loosely arranged cells. Vascular bundles are conjoint, collateral, endarch and open. Bundle sheath is sclerenchymatous.

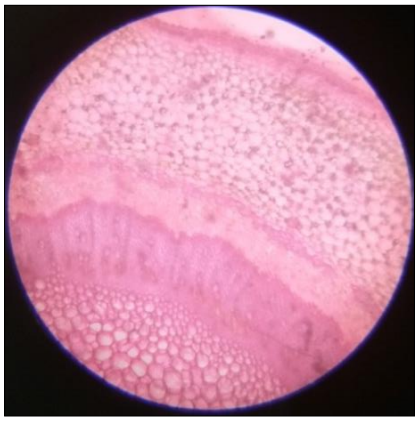

Fig 9: Anatomy of Stem

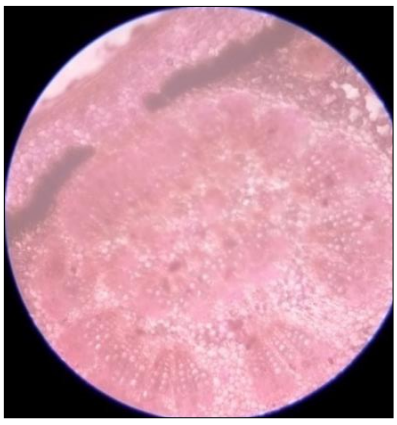

Fig 10: Anatomy of Leaf

Result 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 Mundrothuruth 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. Halophyte in general shows xerophytic characters and adaptations [4]. Present study also revealed several morphological and anatomical adaptations similar to xerophytes.

Morphologically *Bruguiera cylindrica* and *Rhizophora mucronata* were small trees with woody stem. Both of them possess pneumatophores and Knee roots for breathing. *Bruguiera cylindrica* has buttress roots that develop from substrate while *Rhizophora mucronata* has stilt roots and prop

roots that develops from lower branches even though they differ morphologically they provide an additional support to the main trunk and protect them from different calamities like erosion, cyclones, sea waves, etc. Leaves of both mangrove species *Bruguiera cylindrica* and *Rhizophora mucronata* appeared thinly succulent. This facilitates water storage in mesophylls. Leaves of the selected mangroves were leathery and shiny due to the presence of wax coating. Leaf margins were smooth and entire but a small pointed apex with a hair like tip was present in *Rhizophora mucronata.* Calyx of both the species were persistent and were found attached to their fruit. The petals where thick and fleshy in *Rhizophora mucronata*. The most distinctive and remarkable feature of Bruguiera and Rhizophora of family Rhizophoraceae was viviparous germination i.e., seed germination occurred within the fruits, while still hanging or attached to the mother plants. Hypocotyls of the viviparous germinated seedlings enlarge through the embryo development, without taking any dormancy period. This type of germination plays a significant role in the mangrove environment.

Anatomically the leaves of *Bruguiera cylindrica* and *Rhizophora mucronata* showed 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. There exists a clear relationship between the salinity of soil and the appearance of succulent features in plant growing in it [5]. 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 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 in *Rhizophora mucronata* which increases the photosynthetic rate while it is uniseriate in *Bruguiera cylindrica*. Intercellular spaces between spongy tissues are very much reduced in *Bruguiera cylindrica* 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 collenchymatous in both species. 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 *Bruguiera cylindrica* are provided with some thick walled cells giving support to the pith.

Another important adaptive feature found in both species were the possession of negatively geotropic roots called Pneumatophores and knee roots. 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.

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