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A study on morphological and anatomical features of *Acanthus ilicifolius* L. and *Excoecaria agallocha* L. selected from Ayiramthengu 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 *Acanthus ilicifolius* L. and *Excoecaria agallocha* L. selected from Ayiramthengu of Kollam District, Kerala. The study revealed that the plants growing in salt marshes of Ayiramthengu developed a number of adaptations to survive in the physiologically dry habitat. Major structural adaptations observed among these plants include, stilt roots, knee roots, thick leaves, persistent calyx, salt glands, milky latex etc. 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 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; mangroves; knotted roots; laticiferous

Introduction

Only when the last tree has died and the last river been poisoned and the last fish been caught will we realise we cannot eat money *(Cree Indian Proverb)*

We can no longer ignore the fact that since mankind walks the earth, we want to control nature and mould it to our wishes. Economical and short term profits are mostly preferred over more sustainable and ecological alternatives. All over the world, nature draws the shortest straw and a fast decline of most ecosystems is observed, many species are threatened or already extinct, leaving nothing but the shameful truth as a legacy for future generations. When we forget to think of our future generations, makes it only more certain that they will remember our actions. But the tides can still be turned to the better. Mankind has proven his intelligence and creativity many times in history. Step by step we can restore the natural order in this world so future generations will not have to carry the burden of our selfishness. Mangrove forests 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]. These plants are well adapted to changing biological, chemical and physical traits of this environment through various xeromorphic properties, including morphology and anatomy. Ayiramthengu is one of the most famous mangrove sites 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 *Acanthus ilicifolius* L. and *Excoecaria agallocha* L. selected from Ayiramthengu of Kollam District, Kerala.

Materials and Methods

A survey trip was conducted for the study of mangrove species of Ayiramthengu of Kollam District, Kerala. 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. *Acanthus ilicifolius* L. of Acanthaceae.
2. *Excoecaria agallocha* L. of Euphorbiaceae.

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 acanthus *ilicifolius* l. of acanthaceae.

Common name: Mangrove holly, sea holly

Habit: Gregarious under shrubs, usually erect, branching infrequent, stilt roots arise from lower portions.

Stem: Not woody, green in colour with speckles and a pair of spines at the leaf angles.

Leaves: Leaves are opposite decussate, oval to oblong, simple, exstipulate, nearly sessile to petiolate, spiny leaf blade, glabrous, leathery and coriaceous. Leaves are pale green above and green below, salt depositions are present on both leaf surface.

Inflorescence: Inflorescence is terminal or pseudo axillary bracteate spikes.

Flowers: Flowers are zygomorphic, sessile and ovate, pale lilac flowers. Calyx is green in colour, 4 sepals, outer 2 are elliptic rounded, inner 2 are broadly lanceolate, subacute. The corolla is bluish violet in colour, 5petals, united, 2 lipped, corolla tube short and pubescent from within which contains 4 stamens, epipetalous, didynamous, filaments stout, anthers 1 lobed, carpels 2, united, ovary 2 chambered having 2 ovules in chamber, style short stigma bifid.

Fruits: Slightly flattened, ovoid and shiny green.

Fig: 1 Flower of *Acanthuc ilicifolius* L.

Fig: 2 Inflorescence of *Acanthuc ilicifolius* L.

Fig: 3 Leaf variation in *Acanthuc ilicifolius* L.

Morphological observation of *Excoecaria agallocha* l. of euphorbiaceae

Common Name: Milky mangrove, Blinding tree.

Habit: A dioecious branched tree with greyish brown bark. Plant exudes white latex from any broken parts.

Root: Shallow, surface-running and are often knotted.

Leaves: Leaves simple, alternate, ovate-elliptic or orbicular, apex shortly acuminate, base narrowed, margin entire, glabrous, petiolate, stipules lateral and minute.

Inflorescence: Minute yellow flowers are borne on catkins at the axis.

Flowers: Unisexual, pale green, monochlamydeous.

Male flowers in axillary catkin spikes, fragrant, yellow, sessile, tepals 3, stamens 3, filaments free, anthers basifixed.

Female flowers in axillary catkin, smaller, pale green, Pedicellate, tepals 3, calyx 3- lobed; ovary superior, 3-celled, trifid style, simple, stout, stigma 3.

Fruits: Capsule, depressed globose and 3 seeded.

Fig 4: Catkin inflorescence showing male flowers of *Excoecaria agallocha* L.

Fig 5: Milky latex of *Excoecaria agallocha* L.

Fig 6: Female flower of *Excoecaria agallocha* L.

Anatomical Observations

***Acanthus ilicifolius* L.**

Anatomy of stem: Stem is covered by a single layered epidermis with thin layer of cuticle. Epidermis is followed by sclerenchymatous hypodermis. Cortex consist of cholrenchyma followed by inner parenchyma cells containing deposits of tannin. Inner cortical cells contain large mucilage cells here and there. Vascular bundles are conjoint, collateral and open. Pith consists of small parenchymatous cells containing numerous calcium oxalate crystals. Large parenchymatous cells which are water storing are present here and there in pith.

Anatomy of leaf: A transverse section of acanthus leaf shows a thick cuticle over the epidermis which consist of 2-3 layers of parenchymatous cells, salt glands in adaxial side, median vein with numerous irregular bundles. Outer surface have ridges and furrows. Epidermis is provided with 2 or 3 sunken stomata. Inner to this layer, two layered palisade tissue are seen consisting of radially arranged closely packed cells with large amount of chloroplast. Three groups of vascular bundle are seen- two small bundle on the side and a large bundle almost to the centre. The vascular bundles are surrounded by multilayered sclerenchymatous bundle sheath. The two vascular bundle consist of a single group of xylem and the xylem is surrounded by phloem. The large central vascular bundle consists of 4 groups of xylem; in between 2 groups of xylem parenchymatous cells are seen. Below the palisade layer spongy parenchyma tissue with little intercellular space is seen. Below the vascular bundle 5 layers of parenchyma cells are present. The lower epidermis is also covered by epidermis and has sunken stomata.

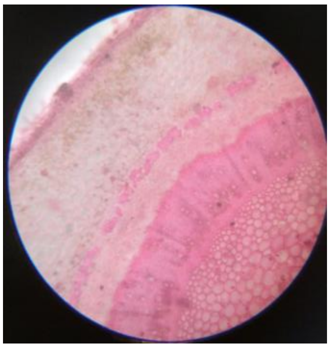
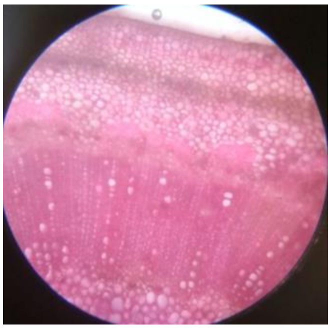


Fig 7: Anatomy of Stem **Fig 8:** Anatomy of Leaf

***Excoecaria agallocha* L.**

Anatomy of stem: Stem is covered by a single layered epidermis with thin layer of cuticle. Epidermis is followed by sclerenchymatous hypodermis. Cortex consists of cholrenchyma followed by inner parenchyma cells containing deposits of tannin. Stele is broad. Vascular bundles are conjoint, collateral and open. 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. Below the storage cells mesophyll is present which is differentiated into upper palisade and lower spongy tissue. Palisade is biseriate consisting of radially elongated compactly arranged cells containing numerous chloroplast and is dark green in colour. Spongy tissue consist of loosely arranged cells with less intercellular spaces. Vascular bundles are conjoint, collateral and closed. Bundle sheath is sclerenchymatous and xylem is well developed. The lower epidermis is provided with sunken stomata.



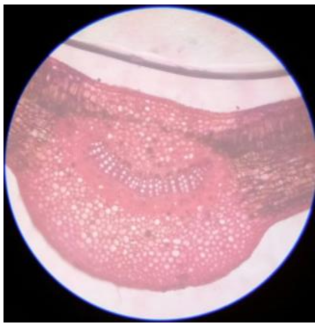


Fig 9: Anatomy of Stem Fig: 10 Anatomy of Leaf

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 Ayiramthengu 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 *Acanthus ilicifolius* is a monoecoius undershrub with indefinitely branched stem while *Excoecaria agallocha* is a dioecious tree with woody stem that branch profusely. *Acanthua ilicifolius* possess stilt roots and *Excoecaria agallocha* has knotted roots that run over the surface. Eventhough both roots 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 *Acanthus ilicifolius* were very thick and shiny due to the presence of wax coating. But the leaves *Excoecaria agallocha* is not much thick but have shiny leaves. Leaf margins were smooth and entire in Excoecaria agallocha but spiny leaf blade in *Acanthus ilicifolius* Flowers were bisexual in Acanthus while unisexual in Excoecaria. Calyx of both the species were persistent and were found attached to their fruit. The petals where thick and large in Acanthus ilicifolius and in *Excoecaria agallocha* the flowers were monochlamydeous and petals were replaced by tepals. Epipetalous stamens were found in *Acanthus ilicifolius* while free stamens were found in *Excoecaria agallocha* in male flowers. The entire palnt body of *Acanthus ilicxifolius* is mucilaginous while *Excoecaria agallocha* is lactiferous. The milky latex discharged from *Excoecaria agallocha* bark is poisonous and may cause temporary blindness and blistering of the skin [5].

Anatomically the leaves of *Acanthus ilicifolius* 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. In *Excoecaria agallocha* the epidermis is single layered. Epidermis is thick walled in both species studied and covered with thick cuticle. Presence of thick cuticle check the rate of transpiration which is an adaptation to live in scarcity of water. Another feature exhibited by the Acanthus species is the slight 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 [6]. 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 are sunken, reduced in number and restricted to upper epidermis in Acanthus 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 which increases the photosynthetic rate. Intercellular spaces between spongy tissues are very much reduced in both species studied 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 *Acanthus ilicifolius*, and *Excoecaria agallocha*. The cortical region of 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 are xerophytic adaptation. Pith region of stem are provided with some thick walled cells giving support to the pith.

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. Mangrove forests are distributed in the inter-tidal region between the sea and the land in the tropical and subtropical regions of the world between approximately 30° N and 30° S latitude. Their global distribution is believed to be delimited by major ocean currents and the 20°C isotherm of seawater in winter [7]. The forests are typically distributed from mean sea level to highest spring tide [7]. They grow in harsh environmental settings such as high salinity, high temperature, extreme tides, high sedimentation and muddy anaerobic soils. The current estimate of mangrove forests of the world is less than half of what it once was [8, 9] and much of what remains is in a degraded condition [10, 11]. Coastal habitats across the world are under heavy population and development pressures, and are subjected to frequent storms. The continued decline of the forests is caused by conversion to agriculture, aquaculture, tourism, urban development and overexploitation [12, 13]. About 35% of mangroves were lost from 1980 to 2000 [14], and the forests have been declining at a faster rate than inland tropical forests and coral reefs [15]. Relative sea-level rise could be the greatest threat to mangroves [16]. Predictions suggest that 30–40% of coastal wetlands [17] and 100% of mangrove forests [15] could be lost in the next 100 years if the present rate of loss continues. As a consequence, important ecosystem goods and services (e.g. natural barrier, carbon sequestration, biodiversity) provided by mangrove forests will be diminished or lost [15]. Mangrove forests are among of the most productive and biologically important ecosystems of the world because they provide important and unique ecosystem goods and services to human society and coastal and marine systems. The forests help stabilize shorelines and reduce the devastating impact of natural disasters such as tsunamis and hurricanes. They also provide breeding and nursing grounds for marine and pelagic species, and food, medicine, fuel and building materials for local communities. Mangroves, including associated soils, could sequester approximately 22.8 million metric tons of carbon each year. Covering only 0.1% of the earth's continental surface, the forests account for 11% of the total input of terrestrial carbon into the ocean [18] and 10% of the terrestrial dissolved organic carbon (DOC) exported to the ocean [19]. The rapid disappearance and degradation of mangroves could have negative consequences for transfer of materials into the marine systems and influence the atmospheric composition and climate.

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