MORPHOLOGICAL, ANATOMICAL AND ECOLOGICAL STUDIES OF SELECTED MANGROVES OF PADNEKAT AREA, KERALA

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ABSTRACT

The mangrove vegetation in Kerala occupies approximately 70 sq Km area and the largest mangrove vegetation in Kerala belongs to Kannur distict. The common mangroves of Padnekat are Acanthus ilicifolius, Rhizophoramucronata, R.apiculata, Kandeliacandel, Aegicerascorniculatum, Sonneratiacaseolaris, S.alba. Mangroves provide a wide range of services and benefits to the mankind. They are instrumental in providing ecological and livelihood security to coastal regions and people. Some of them have got great medicinal value. They prevent soil erosion and stabilization of coasts and beaches and also it provides an excellent home to birds and animals. Mangroves protect the land from tidal surges and cyclonic storms. Due to the growing threats by man and natural calamities, future of mangroves in Kerala can be saved by the restoration of ecosystem services of the mangroves with strong involvement of community participation to mitigate the impacts of climate change.

Keywords **:** *Mangrove, Padnekat, Ecology, Threats, Conservation.*

Introduction

Mangroves are usually trees or shrubs that grow in saline coastal habitat in the tropics and subtropics. Mangroves form a characteristic saline woodland or shrubland called mangrove or mangal. The word mangrove is formed by two words-the Portuguese ‘Mangue’ (meaning tree bush) and the English word ‘Grove’. Macnae [1] coined a new term ‘Mangal” or Mangrove community and retained the term Mangrove for individual species.In Sanskrit called ‘Vaaneerah’ and it considered as a medicinal plant as ‘Raktapittahaari’.[2] And also we can understand that this plant have great value from ancient times onwards. The famous Sanskrit poet Kalidasa also mentions about ‘Vaneerah’ in the text Rakhuvamsha Mahakavya and in the famous Sandeshakavya Mekhadutam. Here in this paper studied about Morphological, Anatomical and Ecological studies of Selected Mangroves Plants constituting the Mangrove vegetation belong to different families; it includes 16-24 families and 54-75 species. Mangroveplants are very commonly found in Bay of Bengal, Sunderban, Assam, near the coasts of Bombay, Kerala and in Andaman & Nicobar islands. The mangrove plant which tolerate high salinity environment are termed Halophytes.

Mangroves in Kerala

The Mangrove vegetation in Kerala occupies approximately 70 sq Km area and the largest mangrove vegetation in Kerala belongs to Kannur district. The common mangroves of Malabar are *Avicennia marina*, *A.officinalis, Rhizophoramucronata, R.apiculata, Kandeliacandel, Aegicerascorniculatum, Sonneratiacaseolaris, S.alba, Acanthus ilicifolius.*

Mangroves provide a wide range of services and benefits to the mankind. They are instrumental in providing ecological and livelihood security to coastal regions and people. Some of them have got great medicinal value. They prevent soil erosion and stabilization of coasts and beaches and also it provides an excellent home to birds and animals. Mangroves protect the land from tidal surges and cyclonic storms.

Mangroves are distinguished by their peculiar morphology and physiology. Mangroves are a prominent component of coastal vegetation thatoccupy flood plains, margins of bays and tidal rivers and in the shores of all these. Uniqueness of mangrove ecosystem is that its biota is constantly under physiological stress caused by extreme environmental conditions. Despite the extreme conditions prevailing, mangroves have successfully colonized their habitats by developing morphological, reproductive and physiological adaptations like pneumatophores, stilt roots, prop roots, knee roots and viviparous seed germination facilitate their growth in aquatic environment.

The coastal line in the tropical and subtropical regions is fringed with a strip of swamp land which is inundated by high tide with marine or brackish waters. They are well adapted to the salty conditions as they can prevent high concentration of salts that are entering the roots and can secrete salt from their leaves.

Mangroves develop normal shallow roots. In addition to this, they have many stilt or prop roots developing from the aerial branches of the stem for better anchorage in muddy loose soil. The soils in the coastal region are poorly aerated and it contains very low percentage of oxygen because of water looping. Under such conditions, the roots do not get sufficient aeration. In order to compensate for this, the mangroves develop special type of negatively geotropic roots called pneumatophores or breathing roots. Pneumatophores develop from the underground roots and project well above the soil surface. These pneumatophores possess numerous lenticels and pneumatothodes on their surface and prominent aerenchyma enclosing air cavities internally. In these roots, gaseous exchange takes place through the lenticels and conduct air down to the submerged roots.The stems of mangroves are in general succulent and the succulents are co-related with salt tolerance of plants. Leaves of mangroves are thick, coriaceous and succulent. Mangroves growing in the tidal marshes exhibit the phenomenon of vivipary. i.e., their seeds germinate while the fruits are still attached to the mother plants.

In coastal area, a natural mangrove belt exerts protection against encroachment of sea, destructive forces of tides and storms. Its ability to stabilize the coastal area against long term climatic fluctuations and sea level rise is now globally accepted. The role of mangroves in soil conservation is very important. The high nutrient status of mangrove areas resulted by the redistribution of nutrients through the incoming tidal waters and seasonal floods, make mangrove ecosystems a most fertile and productive ecosystem. As a habitat of a variety of organisms, mangroves shelter specialized group of plants and animals which cannot survive outside. Many of the commercially important fishes and crustaceans adopt mangrove ecosystems as nursery, feeding and spawning place.

The mangroves are with multiple benefits to common people. It provides a variety of products directly extracted from mangroves like timber, construction poles, firewood, charcoal, tannin, etc. Mangroves are valued greatly as cattle fodder. Seeds of some mangrove plants are edible (eg.*Avicennia*). Mangroves also provide recreational and educational values and are ideal spots for environmental education. Tourism is another area of interest.

The marshy water logged condition in the surroundings results in the development of peculiar anatomical, morphological and physiological characteristics in mangrove. Studies in such characters are very significant in present scenario since our vegetation is facing serious threats and various ecological disturbances nowadays.

So the present study is focused on anatomical studies of selected mangroves. Further, a complete study of morphological, anatomical and ecological aspects will help us to know more about the nature of mangrove vegetation.

Materials and Methods

Study Areas

Mangrove areas in the banks of Kalathera river of Padnekat12° 15' N and 75° 6' E Kasaragod district were identified.On the way to Nileshwar, patches of mangroves were seen on the banks of river. *Avicennia marina* is common in all these areas.

The plant specimens were collected from all the mangrove area. For anatomical studies leaves, stems, pneumatophores and stilt roots were collected and preserved in FAA. Mangroves and mangrove associates were identified according to “Flora of Presidency of Madras” [3] and also with the help of Plant Taxonomist Dr. Subramnaya Prasad.

Mangrove Flora

Distribution of mangroves was studied in all the study areas. The specimens collected from Padnekat premises were *Avicennia marina, Kandeliacandel, Aegicerascorniculatum, Sonneratiacaseolaris, Acanthus ilicifolius, Rhizophoramucronata* and mangrove associates include *Parsonsiainidora,*

*Acrostichumaureum, Dolichandronespathacea, Derris trifoliata, Premnaserratifolia, Lygodiumflexuosum, Calophylluminophyllum, Fimbrystylisdichotoma*etc.

Anatomical Studies

Samples for anatomical studies were collected from different areas. Leaf, stem and root (stilt root and pneumatophores) of 6 genera of mangroves belonging to 5 families were collected and fixed in FAA. Thin transverse hand sections were taken and stained with safranin. Photographs of sections were taken using photomicrography.

Leaf peeling for stomatal studies were taken and stained with safranin.Structure of salt glands was studied using the leaf peelings.Transverse sections of leaves of *Acanthus, Aegiceras* and *Avicennia* were used for the detailed study of salt glands.

Preparation of Permanent Slides

Sectioning

Sectioning of plant materials were performed on weekly basis .The sectioned material was preserved in formalin for dehydration.

Staining

Initially hand sections are taken and washed with distilled water. It is treated with safranine for 5 minutes, then it is washed with water, excess stain is removed. Then the section is passed through a series of alcohol (TBA series).Then counter stain with light green.Wash in absolute alcohol (0.5 minute), and put the section in clove oil(2.5 minute) for clearing, wash quickly with xylem.

Permanent Slide Preparation

The stained sections were mounted in DPX. The mounted slides were placed in plain area for about two weeks. The safran in stained hand sections were used to study the anatomical features of mangroves

Results

Floral Studies

During the study, a total of 6 true mangroves were recorded from the mangrove areas (Table 1.). These belonged to 6 genera and 5 families. Mangrove associates include 8 genera.

Avicenniamarina were common in almost all study areas. *Aegicerascorniculatum*was rare. Among mangrove associates *Derris trifoliata* was present in almost all study areas.

4.2 Table 1: Distribution of true mangroves in Padnekat

Sl. No.	BOTANICAL NAME	FAMILY
1	*Acanthus ilicifolius*	Acanthaceae
2	*Aegicerascorniculatum*	Myrsinaceae
3	*Avicennia marina*	Verbenaceae
4	*Kandeliacandel*	Rhizophoraceae
5	*Rhizophoramucronata*	Rhizophoraceae
6	*Sonneratiacaseolaris*	Sonneratiaceae

4.3 Table 2: Distribution of mangrove associates in Padnekat

Sl. No.	BOTANICAL NAME	FAMILY
1	*Caesalpinia crista*	Caesalpiniaceae
2	*Calophylluminophyllum*	Clusiaceae
3	Derris trifoliata	Papilionaceae
4	*Dolichandronespathacea*	Bignoniaceae
5	*Fimbristylisdichotoma*	Cyperaceae
6	*Lygodiumflexuosum*	Lygodiaceae
7	*Parsonsiainodora*	Apocynaceae
8	*Premnaserratifolia*	Verbenaceae

Morphological Studies

Mangroves

1*Acanthus ilicifolius*

Family:Acanthaceae

Erect, littoral shrub.Leaves (15×16 cm), oblong, pinnatifid, margins with few large spines, glabrous, without cystoliths, petiolated (1 cm long) with two stipule like spines at base. Spikesupto 16 cm long. Flowers in terminal uninterrupted spikes, crowded. Bracts and bracteoles large and ovate, mucronate. Calyx 4-partite, lobes in 2 pairs, outer larger. Corolla blue (3-5 cm) tube short, ovoid, horny, limb without an upper lip, lower lip large, expanded, 3 lobed. Stamens 4, didynamous; anthers 1-celled, oblong, bearded. Disc obsolete, ovary 2 celled, ovules 2 in each cell; style slender; stigma bifid. Capsule (2.5 cm long), compressed, ovoid, 4 seeded. Seeds compressed, orbicular.

Common along the banks of estuaries to the seashore. Flowering period- March-June.

Aegicerascorniculatum

5.2.1 Family :Myrsinaceae

Black mangrove, River mangrove or Khalsi

Maritime large shrub or small tree. Leaves alternate, coriaceous, obovate, glabrous, gland dotted, petioles very short. Flowers bisexual, white, fragrant, sessile or shortly pedunculate, terminal or leaf opposite umbels; pedicels upto 1.3 cm long. Calyx lobes oblique, sepals 5, twisted to the left, corolla tube 0.5 cm long, lobe 5, white, twisted, reflexed. Stamens 5 on the corolla tube; filaments connate below the villious; anthers cordate-lanceolate, transversely septate. Ovary fusiform narrowed into a subulate style; ovules numerous, immersed in free central placenta. Fruits cylindrical; falcately curved, coriaceous, beaked, 1 seeded, dehiscent, 2.5-5 cm long. Seeds elongate, non endospermous, germination often takes place while still on the plant.

Common along the coastal areas. Flowers more or less throughout the year.

Avicennia marina

Family :Verbenaceae

Much branched evergreen trees upto 7m high, straight, pencil like, brown; bark grey, yellowish-grey or brown, smooth, occasionally flaky; branch lets more or less 4 angled, swollen at nodes. Leaves simple, opposite, decussate, estipulate; petiole 2-8 mm long, stout, yellowish green with a basal groove having a dark or black marginal hairs continuous in a line across the node; lamina 1.8-10.2 ×1-5 cm, ovate, lanceolate, narrowly elliptic- oblong or elliptic-ovate; base cuneate; apex acute; margin entire, glabrousabove,silvery white tomentose beneath, coriaceous; lateral nerves 4-7 pairs, parallel, obscure; intercoastae reticulate, faint. Flowers bisexual yellow, 5 mm long, in axillary or terminal compound spikes; peduncle to 8 cm long; flowers arranged in dense capitateunits; bracts 2×1.5 mm, small, triangular, brownish green, glabrous within, densely pubescent, bracteoles 2, similar to bracts, both persistant in fruit; calyx brownish green, sepals 5, slightly united at the base, 3×2 mm, unequal, triangular, acute, glabrous within, densely pubescent outside, persistant; corolla yellow, glabrous within, fleshy, silvery pubescent outside, corolla tube upto 1.5 mm long, lobes 4, 2.5×2.5 mm, subequal, elliptic, refluxed and blackens with maturity; stamens as many as corolla lobes, filaments very short; anthers bilobed; ovary 2.5 mm long, imperfectly unilocular; ovules 4, pendulous, attached to the tip of the central 4 winged axis; style short, solid; stigma 2 lobbed. Fruit is a capsule, greenish, 2.5×1.8 cm, more or less round, apex acute, pericarp thick, coriaceous, silvery tomentose; seed one.

Kandeliacandel

Family: Rhizophoraceae

An evergreen shrub or a small tree with aerial roots from the stem and margins.Leaves(10×5 cm), coriaceous, elliptic-oblong, obtuse at apex; petioles upto 1.2 cm long.Flowers large, white, in axillary cymes(few flowered).Bracteoles connate and round at base of calyx.Calyx (1.5-1.8 cm), 5-6 lobbed, linear, acute, tube short, adnate to the ovary.Petals 5-6, bifid, lobed multifid.Stamens many; filaments filiform.Ovary half inferior,1-celled, ovules 6 in pairs on a central column; style filiform; stigma 3-fid.Fruits 1 seeded, ovoid,upto 2.5 cm long, girt with the persistant reflexed calyx lobes.Seeds viviparous, radical (upto 37 cm long), fusiform, acuminate.

Common in mangrove areas.The wood is used for fuels.Flowering period June-July.

Rhizophoramucronata

Family :Rhizophoraceae

Red mangrove, Loop root mangrove or Asiatic mangrove

Evergreen medium sized tree supported on numerous aerial roots from the stem and branches. Leaves coriaceous, glabrous, entire, petiolate (1-1.5 cm long), stipulate (5 cm long), large having a size of 20×10 cm, bluntly acute at the apex and mucro-acute at the base, gland dotted with tiny red spots.Flowers are rather large, in axillary cymes, 1-1.2 cm across on short thick pedicels, 3-7 flowered, bracteoles in pairs at the base of the calyx. Calyx 4-lobed, segments oblong-lanceolate, thick , keeled within , reflexed in fruit. The tube more or less adnate to the ovary. Petals 4, entire, inserted at

the base of a fleshy disc, nearly as long as sepals, oblong, obtuse, hairy within.Stamens 8; filaments short; anthers linear. Ovary half inferior, two celled, cells 2-ovuled; style conical at the base, subulate; stigma bifid. Fruit leathery, ovate-conical, with persistant reflexed calyx lobes, indehiscent, 1-seeded.Seeds viviparous. Radicle elongated attaining a length upto 60 cm before falling from the tree. Common in tidal forest. The wood is used for fuel. Flowering period – June-August.

Sonneratiacaseolaris

Family:Sonneratiaceae

A shrub or small tree. Leavessessile, simple, entire, opposite, exstipulate, elliptic obovate to oblong, rounded or retuse at apex, cuneate at base. Flowers regular, large, terminal, solitary on short thick pedicel, usually bisexual, perigynous, solitary or in terminal cymes. Bracts and bracteoles 0, buds notribbed. Calyx tube without ribs, lobes usually 6, lanceolate, acute, longer than the tube, tinged with pinkinside. Petals dark red, linear-lanceolate. Stamens erect, red, inserted on calyx; filaments very long.Ovary superior, 4-many celled with many ovules, placentation axile; style long; stigma capitate.Fruit a capsule, 4-6 cm across, broadly ovoid or sub globose, seated on the enlarged calyx, rounded at the apex and tipped with the persistant tapering; style base.

Frequent along backwaters and mangrove swamps. Flowering period October-December.

Vivipary

In *Avicennia* and *Aegiceras* seedling does not emerge from the fruit prior to dispersal and it is called cryptovivipary. In *Avicennia sp*. the fruit coat splits shortly after the time of dispersal, releasing an embryo with two thick and fleshy cotyledons folded in opposite directions. In *Aegiceras*, the radicle and hypocotyl elongate in the fruit, and at dispersal the torpedo- shaped propagules are released.

Mangrove Associates

Caesalpinia crista

Family :Caesalpiniaceae

A large scandent shrub; stems armed with black recurved prickles. Leaves 15-30 cm long; main rachis polished and armed with recurved prickles; pinnae 2-5 pairs; leaflets 2-3 pairs, usually opposite; upto 5×2.5 cm, ovate-elliptic, acute, glabrous. Flowers scented, in long axillary or terminal racemes or panicles. Calyx glabrous; sepals 6-8 mm long, the lowest one cucullate.Petals yellow, 8-10 mm long; standard with red markings.Stamens 10, free, declinate.Ovary sessile or subsessile; ovules few; style filiform. Pod upto 7×3.5 cm, ellipsoid, glabrous, 1 seeded.

Common along coastal estuaries. Flowering period - July-January

Calophylluminophyllum

Family :Clusiaceae

Balltree, Borneo-mahagony or Indian laurel

Moderate sized tree.Leavesupto 10-15 cm, opposite, coriaceous with numerous very close parallel nerves, oblong-obovate, obtuse or retuse at apex, rounded at base; petiole upto 2 cm long.Inflorescence of axillary racemes. Flowers bisexual or polygamous in racemes or panicles, white.Sepals 4, imbricate.Petals 4, orbicular.Stamens many, free or in pahalanges; anthers 2-celled.Ovary 1-celled and 1-ovuled; ovule basal, erect; style 1, slender; stigma peltate.Drupe globose with fleshy or crustaceous pericarp.Seed ovoid or globose.

Common along the coast.Wood is useful for construction purposes.Seed oil is used in medicines. Flowering period October-April.

Derris trifoliata

Family :Papilionaceae

A scandent or climbing shrub. Leaves upto 20 cm long; leaflets 3-7, upto 13×6.4 cm, ovate or oblong-ovate, rounded at the base, shortly acuminate at apex.Racemesauxillary, upto 25 cm long; nodes tumid, bearing one or more flowers. Flowers 1-1,2 cm long. Calyx truncate.Corolla rose-pink. Pod 2-5.2×2.5-3.8 cm, obliquely rounded, glabrous, distinctly winged along the upper suture, 1-2 seeded.

Common along estuaries and also in mangrove swamps. Flowering period April-July.

Dolichandronespathacea

Family :Bignoniaceae

Mangrove trumpet tree

Moderate sized decidous trees, to 18 m high; bark greyish brown; bole smooth. Leaves compound, imparipinnate opposite, estipulate; rachis 23-30 cm long, stout, glabrous; leaflets 5-9, opposite; petiole upto 6 mm, stot, glabrous; lamina 7.5-15.2×2.5-7.5, rhomboid or ovate, elliptic, ovate-lanceolate; base oblique; apex acuminate; margin entire, glabrous and shiny. Flowers bisexual, white, 3-4 together on terminal short erect corymbs; calyx spathaceous, cleft to the base on one side; spathe acuminate at tip; corolla 10-18 cm long, slender below, widening halfway to a funnel; lobes 5-10 cm, spreading, crisped; stamens 4 didynamous, included; disc annular; ovary sessile; ovules many; style long; stigma 2 lobbed. Fruit a capsule to 45×2.5 cm, purplish-brown; seeds winged, flat, rectangular, 1.6 cm across.

Fimbristylisdichotoma

Family :Cyperaceae

Forked fimbry

A perennial, rhizomatous or tufted herb.Stems upto 60 cm high, trigonous. Leaves shorter or longer than stem, flat, ligulate; sheaths hairy, brown spotted. Inflorescence a terminal simple or compound umbel; rays few, upto 4 cm long, bracts few, shorter or longer than umbel. Glumes broadly ovate, spirally imbricate or distichous, decidous, brown, apiculate, 2.5 mm long, lowest 1-3 empty, several succeeing bisexual, uppermost few sterile or empty. Hypogynous bristles absent. Stamens 1-3; anthers linear, oblong, muticous. Style 2-3fid, viliousorglabrous; style-base dilated. Achene 0.9 -1.2 mm long, broadly obovoid, biconvex, pale brown, striate with 7-10 rows of thick walled concave cells, style bifid, vilous.

Lygodiumflexuosum

Family :Lygodiaceae (Schizaeaceae)

Climbing fern

Terrestrial herbs with long creeping rhizome, 5-8 mm thick, with fibrous root at base; densely dark brown hairy, hairs 1 mm long, multicellualar, uniseriate, tubular. Fronds pale green, 4-5 mm long, climbing, tripinnate; stipe stout, dark brown, densely hairy at the base, straminaceous, glabrous above, wiry, 3-5 mm thick, rounded benath, flattened above; primary pinnae, alternate, stalked, forked once, with dormant bud on axis' each forked branch with 2-3 pairs of simple or forked pinnules alternately; pinnule 10-12×2.5-3 cm. oblong-lanceolate, simple or forked or auriculate, apex acute, subacute or acuminate, base cuneate in simple pinnules, subtruncate or cordate in branched or forked pinnules; margin regularly or irregularly serrulate in sterile pinnules; costa raised above and below; veins distinct above and below, forked twice or thrice, free, reaching the margin, axis of main branches and costa pubescent; sporangia yellowish-brown, crowded on finger like lobes of fertile lobes of fertile pinnae, lobes 3×1.5 mm, sporangia in 5 pairs, alternate, indusiate. Spores 48µm in diameter, yellowish-green.

Parsonsiainodora

Family :Apocynaceae

Twining shrubs, young shoots glabrous. Leaves 9-13 × 4-6 cm, oblong-lanceolate, apex acuminate, base rounded or subcordate, glabrous, subcoriaceous, lateral nerves 6-8 pairs; petiole to 2 cm long. Flowers in axillary corymbose cymes; calyx 5-partite, glandular within; corolla greenish yellow, tube 5 mm long, campanulate, mouth with aring of hairs, lobes 6 mm long: stamens attached the base of corolla tube, filaments twisted, anthers sagitate, arranged around and adnate to the stigma; ovary 2 celled, stigma columnar; disc triangular. Follicles separate on maturity.

Premnaserratifolia

Family :Verbenaceae

It is a small tree or shrub, upto 7m. high.Leaves simple, opposite, exstipulate, petiolate (4-14 mm) , slender, pubescent, grooved above; elliptic, elliptic-oblong, base acute, obtuse, subcordate or rounded, apex acuminate, muconate, obtuse, margin entire or subserrate, glabrous above except along the appressed midrib,chartaceous; lateral nerves 3-5 pairs, pinnate, prominent, puberulousbeneath;intercostate reticulate, obscure.Flowers bisexual, greenish white, in terminal corymbosepanicled cymes; bracts small. Calyx small, campanulate,2 lipped, 5 lobbed. Corolla tube short vilous inside 5 lobbed. Stamens 4,didynamous, inserted below

the throat of the corolla tube; anther ovate. Ovary superior, 2-4 celled, ovules 4; style linear; stigma shortly bifid.Fruit is a drupe,seated on calyx, globose, purple. Seeds oblong.It flowers and fruits between May and November.During flowering season, it attracts a large number of butterflies and bees.

Anatomical Studies

Acanthus ilicifolius

Evergreen shrub. Stem is brown in colour, smooth and fleshy with well developed aerial roots. Thorns are present in leaf. Leaf is dorsiventral and petiolate with thick cuticle.

Epidermis single layered both in upper and lower layers. Salt glands are present in both surfaces of lamina. Each salt gland is one celled, surrounded by 5-6 jacket cells. Stomata are not sunken and confined to the lower epidermis. In the lower epidermis, both salt gland and stomata are intermingled. Hypodermis or water storage tissue is two layered. Palisade and lower spongy tissue consists of loosely arranged cells. 2-3 vascular bundles are present. Xylem is endarch, surrounded by phloem.

Aegicerascorniculatum

Leaf dorsiventral and petiolate with thick cuticle. Epidermis single layered in both surfaces. Salt glands were present in both upper and lower surfaces. Each gland was composed of a large number of excretory cells and a single large basal cell. Stomata confined to the lower epidermis and sunken. In the lower epidermis both salt glands and stomata were intermingled. Hypodermis is two layered thick below the upper epidermis. Mesophyll tissue consists of upper two-layered thick palisade and lower spongy tissue with loosely arranged cells. Vascular bundles collateral and closed with sclerenchyma on the outer side.

Stem with multilayered and thick cork, covered with wax. Cortex multilayered and made up of parenchyma. Sclereids solitary and scattered in the cortex.Stelar region with secondary phloem, vascular cambium and secondary xylem.Central parenchymatous pith with sclereids and tannin cells.

Avicennia marina

Evergreen perennial tree. Smooth whitish bark and irregularly spreading branches are the characteristics of the genus. Leaves are simple, opposite, decussate and exstipulate. Well developed aerial root system with pneumatophores.

The upper epidermis is covered by thick cuticle followed by3-4 layers of thin walled compactly arranged parenchymatous cells forming the hypodermis. Below the hypodermis the mesophyll is differentiated into two layers of palisade cells and zone of spongy tissue.Thesclerenchymatous bundle sheath is surrounded by vascular bundles. Crescent shaped vascular strand and two isolated strands on both curved ends. The lower epidermis bears a uniseriate row of non-glandular hairs.

Kandeliacandel

Medium evergreen tree. Bark smooth, greyish or reddish brown. Aerial roots are normally absent. Leaves simple, opposite, decussate, stipulate, slightly fleshy and isobilateral and petiolate. Epidermis is one layer thick in both upper and lower surfaces. Cuticle is thick and waxy. Stomata are deeply sunken and confined to both epidermal layers. Hypodermis is two layered below the upper epidermis and single layered in the lower region. Mesophyll is with upper single layered palisade. Lower region is occupied by multilayered spongy tissue with loosely arranged cells.

Stele consists of ring of vascular bundles, linear medullary strand having several bundles. Vascular bundles are closed and collateral.Phloem is outer and xylem is inner.

Rhizophoramucronata

Leaf dorsiventral. Lamina with black circular spots in the lower surface, known as cork warts. Cuticle was thick and waxy. Epidermis two layered in the upper epidermis and single layered in the lower epidermis. Hypodermis multilayered. Stomata were sunken and present in the lower epidermis. Mesophyll with one layered palisade cells. Lower spongy tissue with large intercellular spaces. Sphaeraphides were present in the hypodermis.

Stilt roots with outer region protected by cork which was rupturedby lenticels. Hypodermis consists of compactly arranged parenchyma cells. Cortex was multilayered, parenchymatous and with solitary sclereids. Tannin cells were also present in the cortex. Vascular strand amphicribral in which central xylem was surrounded by phloem. Pith was parenchymatous.

Sonneratiacaseolaris

A small evergreen tree with opposite, succulent entire leaves. Wood grey and rough.Pinkpetaloid showy flowers. Leaf is isobilateral and petiolate with thick cuticle.

Epidermis is one layer thick at both upper and lower surfaces. Stomata are deeply sunken and confined to both epidermal layers. Salt glands are numerous and scattered in abaxial and adaxial surfaces. Each salt gland is multicellular and surrounded by several jacket cells. Mesophyll consists of upper and lower palisade tissue below the upper epidermis and above thelower epidermis. In between this, about six layered thick colourless water storage tissue is present. It consists of compactly arranged parenchymatous cells. Sclerenchymatous bundle sheath is present. Xylem is endarch and is surrounded by the phloem.

Ecological values of mangroves

Mangrove ecosystems represent natural capital capable of producing a wide range of goods and services for coastal environments and communities and society as a whole. Some of these outputs, such as timber, are freely exchanged in formal markets. Value is determined in these markets through exchange and quantified in terms of price. Mangroves are important for aquatic life and home for many species of fish.

Improving Coastal Water Quality

Mangroves maintain coastal water quality by abiotic and biotic retention, removal, and cycling of nutrients, pollutants, and particulate matter from land-based sources, filtering these materials from water before they reach seaward coral reef and seagrass habitats.Mangrove root systems slow water flow, facilitating the deposition of sediment. Toxins and nutrients can be bound to sediment particles or within the molecular lattice of clay particles and are removed during sediment deposition. Compared with the expense ofconstructing a wastewater treatment plant, mangroves are commonly selected as receiving areas of effluent. Increasingly the notion of specifically constructed mangrove wetlands is being adopted and used for treatment of aquaculture and sewage effluents.

Mangroves are functionally linked to neighbouring coastal ecosystems. For instance, terrigenous sediments and nutrients carried by freshwater runoff are first filtered by coastal forests, then by mangrove wetlands, and finally by seagrass beds before reaching coral reefs. The existence and health of coral reefs are dependent on the buffering capacity of these shoreward ecosystems, which support the oligotrophic conditions needed by coral reefs to limit overgrowth by algae. Mangroves supply nutrients to adjacent coral reef and seagrass communities, sustaining these habitats' primary production and general health**.**

Endangered Mangrove Coastlines and Human Development

As a result of their intricately entangled above-ground root systems, mangrove communities protect shorelines during storm events by absorbing wave energy and reducing the velocity of water passing through the root barrier.In addition, mangroves protect intertidal sediment along coastlines from eroding away in harsh weather year-round. As new cities are developed, mangrove forests around the world have felt a great impact not only on their ecosystems health, but also their wave-attenuating capacity. Wave energy may be reduced by 75 per cent in the wave's passage through 200 meters of mangrove forests, a very substantial amount once the mangrove has been removed. Mangrove covered shorelines are less likely to erode, or will erode significantly more slowly, than unvegetated shorelines during periods of high wave energy. Other factors mangroves have an influence on, include coastal profile, water depth and bottom configuration. The mangrove population has felt both direct and indirect effects due to

coastal engineering and human development, resulting in a devastating decline in population. This decline has led to a negative chain of effects in other ecosystems that are dependent on mangrove forest for survival. Mangroves provide a number of essentials for many different ecosystems, including food and shelter for a diverse animal community, living both below and above sea level. Maintaining a healthy mangrove forest sustains natural protection and is less expensive than seawalls and similar erosion control structures, which can increase erosion in front of the structure and at adjacent properties due to coastal currents. Unless ecosystems have the space to adjust their location or elevation in the intertidal zone to the sea-level rise, they will be stressed by changed inundation periods., mangroves are a better alternative to protecting coastlines from eroding than other man made structures, such as seawalls."Mangrove forests help to build up soil along tropical coastlines, buffer from storms, and at the same time provide a habitat for many popular marine organisms such as crabs, shrimps, and oysters"[4].

The tsunami has provided an opportunity to illustrate that healthy mangroves serve as a natural barrier against massive waves – This study proves that mangroves provide a natural wall, which is necessary in high impact natural disasters areas .

Human Impacts

In addition to providing protection to the shorelines and a home for many organisms, mangroves provide many different uses for humans. For instance, mangroves are cut down to burn and produce charcoal. The charcoal is used for home cooking fuel and is also used in barbecues in the urban centres and tourist resorts. The trees are also used for construction purposes. Not only are mangroves cut down to provide land to develop along the coastline, the larger trees are used to build the buildings, and the thinner poles/branches are used for roofing purposes.

One safe use of the mangrove trees is fishing. The mangroves support the fisheries due to the many different species of fish that live within the roots of these trees. A positive feature of this use of the mangroves is that it does not require the destruction of the mangrove trees. A dangerous threat to mangroves is oil spills. Oil spills are a large cause of destruction to the many organisms that thrive in the mangroves.

Discussion

The way in which the plants function is determined by their physiology, internal structural organization and arrangement. Anatomical data are capable of predicting many of the most important physiological and ecological features of species.

The leaves and stems of coastal mangroves and associated plants are thick, succulent and coriaceous. Succulent leaves are a common feature of most mangroves.

Important anatomical features of mangrove leaves are,

1. Presence of thick cuticle

2.Presence of colourless water storage tissue

3.Presence of salt excretory glands

4.Presence of glandular and non glandular hairs

The mangrove taxa possess unique anatomical features which are very much related to their adaptations, since they grow in saline environments. This is because, salinity of the water and soil has a direct influence on the leaf architecture of mangroves. These amazing structures make them different from the other terrestrial plants.

Because of the limited fresh water availability in intertidal soils, mangroves limit the amount of water that they loss through the leaves. They can restrict the opening of their stomata. Considerably, thick cuticles are present on the epidermal layers of mangrove taxa, which also restrict the non-stomatal water loss. They also vary the orientation of their leaves to avoid the harsh mild sun and so reduce evaporation from leaves.

The water storage tissue is a characteristic feature of mangrove leaves. The thick water storage tissue results in leaf succulence due to increased water content. Leaves of mangroves become thick and succulent which can be correlated with the extra water storage capacity. Succulence is one of the most

common features of halophyte, which is often considered to be an adaptation to reduce the internal salt concentration. The leaves also have loosely packed cells to store water vapour inside the leaves.

The occurrence of salt gland is inherent in many plant species adapted to marshy habitat, because salt cannot accumulate in plant tissues beyond a limit. Excretion of ions by special glands is a well known mechanism for regulating the mineral content of many halophytic plants. Studies on electrical and concentration gradient across the glands showed that the ions Na+ and Cl- are given against electrochemical gradient [5]. The cell walls of the salt glands are in by plasmodesmata. Salt solution is excreted on the leaf surface through pores in the cuticle by the cap cells of the gland [6]. Thesalt glands aremeant for excreting excess salt accumulated in the mangroves, thus maintaininga salt balance in plants.

In *Avicennia* and *Acanthes* salt excreting glands are confined either to the adaxial or to the abaxial surface. Salt is secreted by the cytoplasm of the secreting cells into the vacuole and these secretory cells dry out with aging of the leaf and salt remains on the leaf surface as a white powdery layer. This salt secretary mechanism of the above taxa and the occurrence of epidermal hairs are very much important in relation to their adaptive nature.

The glandular and non glandular hairs present in some taxa were investigated. In *Avicennia*, glandular hairs occur in both abaxial and adaxial surfaces of the leaf. In *Avicennia*, oil glandular and non glandular hairs are formed similarly upto the three celled primordial stage, but after this two types of hairs start to disappear[7]. Experimental evidence has proven that glandular hairs are responsible for secretory function in *Avicennia.*

In *Avicennia* non glandular hairs are only present on the abaxial surface of the leaf. The salt secreting mechanism of *Avicennia* and occurrence of epidermal hairs are very much important to their adaptive nature.

In *Sonnertaiacaseolaris*, mucilage cells of varying shapes were observed, which also play a significant role in water storage. In the species of *Derris*, the sclerenchymatous partition walls and the mesophyll sclereids provide mechanical support in the absence of a well developed spongy tissue.

The occurrence of salt gland in mangroves is an adaptation for marshy habitat, because salt cannot accumulate in plant tissues beyond a limit. Salt glands are found abundantly on leaves, though their number is lesser than that of stomata in the lower epidermis. The morphology of salt glands varies from the simple to multicellular structures. Gland cells differ from normal mesophyll cells in shape and arrangement. Cells are without chloroplast. The salt glands are meant for excreting excess salts accumulated in mangroves, thus maintaining a salt balance to the plants.

The mangrove associates related for the present study shows leaf anatomy similar to a dicot. No evidence of salt glands and water storage tissues are found in such plants. However they exhibit additional adaptation for better water storage.

Conclusion

Mangroves grow in achallenging environment. Plants living in marshy places have special adaptations which enablethem to survive in the environment. In most cases, the leaves posses thick cuticles and often sclerenchyma and sclereids in the mesophyll, which will greatly increase the mechanical strength of the leaves. A multilayered water storage tissue in the hypodermis and mesophyll, presence of mucilage cells etc. improve the net water storage capacity and impart a succulent nature to their leaves. The glandular and non glandular hairs associated with the leavesof *Avicennia,* the salt excreting glands found in most of the typical mangrove taxa are structural modifications and physiological adaptations associated with their growth and survival in the saline environment. Morphologically and anatomically many salt marsh plants are adapted to resist mechanical damage by water action.

In conclusion, this session demonstrate the morphological and anatomical features including special adaptation that allow the

plants to gain strength and anchorage on the ground, obtain adequate oxygen for respiration and cope with salt and desiccation stress. Mangroves protect the land from tidal surges and cyclonic storms. Due to the growing threats by man and natural calamities, future of mangroves in Kerala can be saved by the restoration of ecosystem services of the mangroves with strong involvement of community participation to mitigate the impacts of climate change.

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