OBSERVATIONS

1. *Acanthus ilicifolius* Linn.

*Acanthus ilicifolius* (Spiny Holly Mangrove) is a small shrub growing 1-2m in height with non-woody stems, smooth bark and often with a pair of spines at the leaf axils. Leaves growing in the deep shade can be totally spineless. Sometimes aerial or prop roots are present at the base of stems, especially in larger specimens. The leaves are simple, opposite, oblong to narrowly ovate in shape, shiny green and hairless with a pointed apex. They are 5.0-15cm long and 4-6cm wide. The presence of spines increases with exposure to sunlight. The petiole is 0.7-1.5 cm long. The inflorescence is a spike of purple, pale blue or white flowers. The flowers are zygomorphic with 4 calyx lobes and 4 stamens and are 3.5-4cm long. The fruit is a smooth, green, egg-shaped or oblong, 2-4 seeded capsule, which is 2-3cm long and up to 1cm wide.

**Leaf architecture**

Leaves simple, opposite, exstipulate, but often with a pair of spines from the leaves in the stipular position. Petiole 0.7-1.5cm long with swollen base. Leaves dorsiventral, dark green in colour. Leaf blade is microphyll type, oblong to narrowly ovate in shape, symmetrical. Base angle of the lamina is acute and it is decurrent in shape. Apex angle of the lamina is acute and it is convex in shape. Lamina margin rigid with sharp spinous teeth. Leaf surface is glossy and stiff with tiny crystals on the upper surface. Leaves are 5.0-15cm long and 4-6cm wide in size. Lamina length and width ratio is 3:1.
Leaf venation

The venation is weak brochidodromous type. Spacing between the secondary veins are uniform and the secondaries diverge from the primary vein at an acute angle and the divergence angle is uniform from the base to the apex of the leaf. Intersecondaries sometimes seen. Tertiary veins branch at acute angle from the sides of secondaries and they are randomly reticulate and it meet the primaries in an obtuse angle. Fourth order veins are regular polygonal reticulate typ. Areoles are poorly developed. Marginal veins ending in teeth. The leaf rank is 1r.

Leaf anatomy

Epidermis

The epidermal cells on both the lower and upper surfaces are more or less similar in size. The epidermal cells are $1136.8 \pm 6.5 \mu m$ in size. The number of epidermal cells per sq mm in the lower epidermis are $1221.3 \pm 20$, whereas the number of epidermal cells in the upper epidermis are $1750 \pm 10$. All epidermal cells are polygonal in outline with straight anticlinal wall. The cells in the midrib region are elongated.

Stomata

Stomata are confined to the lower epidermis, stomata are sunken and are not protected by hairs, always confined to non-venous areas of lower epidermis, always randomly oriented. The stomata are of the diacytic type with two subsidiary cells. Stomatal ledges are clearly seen on both out side and inside of the guard cells. Stomata are $29.2 \pm 1.4 \times 21.2 \pm 1.4 \mu m$ in size. Stomatal index is $13.6 \pm 0.5$ and the stomatal frequency is $194 \pm 7.5$ per sq mm.
**TS of lamina**

The lamina is $601.3 \pm 11 \mu m$ in thickness. The epidermis is single layered with thick cuticle. The hypodermis is one layered with colourless cells and found below the upper epidermis and it is the water storage tissue (WST). The cells of the hypodermis are polygonal in transverse section. They are larger than the epidermal cells. The mesophyll composed of thin-walled chlorenchymatous cells and it is well differentiated into one or two layers of adaxial, anticlinally-extended palisade cells and oval or round-shaped, loose, abaxial, isodiametric spongy parenchyma cells. The palisade layer is $157.6 \pm 16.5 \mu m$ in thickness and the spongy parenchyma layer is $300.6 \pm 5.5 \mu m$ in thickness. The palisade/spongy ratio is $0.5 \pm 0$. The water storage tissue occupies at least 10% of the total lamina volume. Thickness of water storage tissue is $82.5 \pm 5.5$ in $\mu m$.

The percentage of water storage tissue to the total thickness of the lamina is $13.7 \pm 1.1$. There is a thick parenchymatous bundle sheath found around the vascular bundle.

**Trichomes**

The salt secreting trichomes present on both upper and lower epidermis. But it is more frequent in the upper epidermis. These trichomes have up to four basal collecting cells, one or two stalk cells and a number of radially arranged secretory cells, which are covered with a thin cuticle layer.

**TS of petiole**

The epidermis of the petiole is single layered and it is very much similar to that of the leaf epidermis. The hypodermis consists of one or two layers of
collenchyma cells. The central ground tissue is parenchymatous with large intercellular spaces. Many tannin containing cells interspersed between the parenchyma cells and these cells are normally larger than the other adjacent parenchyma cells. Stellate idioblasts were also observed between the parenchyma cells. Vascular tissue is represented by a three or more discrete vascular bundles in the pith.

**Phytochemicals**

The phytochemicals observed in the leaves of *Acanthus ilicifolius* are alkaloids, flavonoids, glycosides, phenols, saponins, steroids, tannins and terpenoids.
2. *Aegiceras corniculatum* (Linn.) Blanco

*Aegiceras corniculatum* (River Mangrove) is a low, multi-stemmed, shrub or small tree growing to 5 m high. It has smooth, dark grey-brown bark, with small lenticels. Roots are not usually above ground. The leaves are alternate, simple, spirally arranged, leathery in texture and hairless. They are elliptic to obovate in shape, 4-8cm long, 1.8-4cm wide, with a rounded to slightly notched tip and a wedge-shaped base. They occur alternately along the stem, while the surface is covered with minute salt glands that excrete salt from the plant. The inflorescence is umbel. The flowers are fragrant, 1-2cm long with 5 white, reflexed petals fused at the base to form a short tube. The fruit capsule is horn-shaped, 3.8-8cm long, has a persisting calyx and is crypto-viviparous, enclosing one propagule, horn-shaped, pointed apically, curved, 5-8cm long, with persistent calyx. Roots along the soil surface are exposed to air at low tide and help the uptake of oxygen. Prominent lenticels at the base of each trunk also help with atmospheric gas exchange.

**Leaf architecture**

Leaves simple, opposite, exstipulate, petiole 0.5–1.0cm long. Leaves dorsiventral, succulent, crowded in terminal part of the branches. Leaf blade is microphyll type, obovate-elliptic in shape, symmetrical. Base angle of the lamina is cuneate and it is cuneate in shape. Apex angle of the lamina is acute and it is convex in shape. Lamina margin entire. Leaf surface is glabrous. Leaves are 4-8cm long and 1.8-4cm wide in size. Lamina length and width ratio is 13:5.

**Leaf venation**

Venation is weak brochidodromous type. Spacing between the secondary veins are uniform. Secondaries diverge from the primary vein at almost right angle and the divergence angle is uniform from the base. Inter secondaries are prominently seen. Tertiary veins branch at right angle from the sides of secondaries.
and it is exmedially ramified forming a random reticulum. Fourth order veins are regular polygonal reticulate type. Areoles poorly developed. Margin veins regularly looped with no teeth. The leaf rank is 1r.

**Leaf anatomy**

**Epidermis**

The epidermal cells on both the lower and upper surfaces are more or less similar in size. The cells are normally $521.6 \pm 3.1\mu m$ in size. The number of epidermal cells per sq mm in the lower epidermis are $1826 \pm 140$, whereas the number of epidermal cells in the upper epidermis are $2703 \pm 120$. All epidermal cells are polygonal in outline with straight anticlinal wall. The cells in the midrib region are elongated.

**Stomata**

Stomata are confined to the lower epidermis, stomata are sunken and are not protected by hairs, always confined to non-venous areas of lower epidermis, always randomly oriented. The stomata are of the anomocytic type with five to eight subsidiary cells. Stomatal ledges are not clearly seen. Stomata are $45.4 \pm 2.9$ X $23.2 \pm 0\mu m$ in size. The stomatal index is $9.3 \pm 0.6$ and the stomatal frequency is $189 \pm 8$ per sq mm.

**TS of lamina**

The lamina is $359.3 \pm 5.5\mu m$ in thickness. The epidermis is coated with thin cuticle. The epidermal cells cutinized wholly. The hypodermis is three layered with colourless cells and found below the upper epidermis and above the lower epidermis and it is the WST. The cells of the hypodermis are polygonal in transverse section. They are larger than the epidermal cells. The mesophyll composed of thin-walled chlorenchymatous cells and it is well differentiated into
one or two layers of adaxial, anticlinally-extended palisade cells and oval or round-shaped, loose abaxial, isodiametric spongy parenchyma cells. The palisade layer is 113 ± 8.2µm in thickness and the spongy parenchyma layer is 88 ± 11µm in thickness. The palisade/spongy ratio is 1.28 ± 0. The water storage tissue occupies at least 40% of the total lamina volume. Thickness of water storage tissue is 141.1 ± 8.2 in µm. The percentage of water storage tissue to the total thickness of the lamina is 39.2 ± 0.2. The vascular bundle is with distinct parenchymatous bundle sheath.

Mesophyll tissue contain dark brown coloured tanniferous cells in the lower hypodermal region. Apart from these cells many terminal tracheids are also observed in this region.

**Trichomes**

Multicellular glandular trichomes or salt glands are present both in the upper and lower epidermis. Each salt gland is composed of a stalk cell and a head comprising of variable number of cells.

**T S of petiole**

The epidermis of the petiole is single layered and it is very much similar to that of the leaf epidermis. The hypodermis consists of one or two layers of collenchyma cells. The central ground tissue is parenchymatous with large intercellular spaces. Many tannin containing cells interspersed between the parenchyma cells and these cells are normally larger than the other adjacent parenchyma cells. The vascular bundle is a medullated cylinder.

**Phytochemicals**

The phytochemicals observed in the leaves of *Aegiceras corniculatum* are alkaloids, flavonoids, glycosides, phenols, saponins, tannins and terpenoids but steroids are absent.
3. *Avicennia marina* (Forsk.) Vierh.

Evergreen shrub or small tree 1-10m high, trunk 40cm in diameter. Numerous upright pneumatophores 10-15cm high and 6mm in diameter are seen along with plants. Trunk often with masses of small air roots but no prop or stilt roots. Bark whitish to greyish or yellow-green, smooth, often powdery with raised dots, scaly, exposing greenish inner bark. Leaves opposite, ovate, lanceolate to elliptical, 3.5-12 cm long, 1.5-5cm wide, mostly acute at both ends, entire, thick leathery, shiny green and hairless upper surface, pale whitish-grey and finely hairy underneath. Petiole 5-10 mm long, hairy. Heads or cymes ball-like, upright on long stalks at ends and sides of twigs. Flowers few to many, sessile, creamy yellow, small, sweet scented, 4mm long, 5mm across. Calyx 5 lobed, green, hairy, persistent, corolla tubular, white, turning yellow or orange with 4 nearly equal, short lobes. Fruit a green, oval, two-valved capsule of 20-25 mm diameter. Seed developing on the tree, fruit usually split after falling and they are water-dispersed.

**Leaf architecture**

Leaves simple, opposite decussate, exstipulate, petiole 5-10mm long, dorsiventral, succulent. Leaf blade is microphyll type, ovate-elliptic or narrowly lanceolate in shape, symmetrical. Base angle of the lamina is acute and it is cuneate in shape. Apex angle of the lamina is acute and it is convex in shape. Lamina margin entire with shortly or bluntly pointed tip. Leaves are 3.5-12cm long and 1.5-5cm wide in size. Lamina length and width ratio is 2:1.
**Leaf venation**

The venation is weak brochidodromous type. Spacing between secondaries uniform and the angle between the primary vein and secondary vein are uniform throughout. Intersecondaries seen in some places. Tertiary veins originate almost right angles and admedially ramified forming regular polygonal domains often elongated parallel to the secondaries. Quaternary veins originate randomly forming regular well defined domains. No marginal glands were detected in the leaves. The leaf rank is \( 1_{r} \).

**Leaf anatomy**

**Epidermis**

The epidermal cells on the lower surface are generally larger than those of upper side. The cells in the lower epidermis are \( 621.6 \pm 3.1 \mu \text{m} \) in size, whereas the cells on the upper epidermis are \( 313.2 \pm 2.1 \mu \text{m} \). The number of epidermal cells per sq mm in the lower epidermis are \( 1633 \pm 50 \), whereas the number of epidermal cells in the upper epidermis are \( 3753 \pm 130 \). All epidermal cells are polygonal in outline with straight anticlinal wall. The cells in the midrib region are elongated with straight anticlinal wall. The cuticle layer is interrupted by series of uniseriate epidermal hairs. Many hydathodes like structures are present on the lower epidermis.

**Stomata**

The stomata are confined to the lower epidermis. Stomata are not sunken, always confined to non-venous areas of lower epidermis, always randomly oriented. The stomata are of the paracytic type with two subsidiary cells. These
subsidiary cells completely enclosing the guard cells with their long axis of the guard cells. Stomatal ledges are completely absent. Stomata are 23.6 ± 1.3 X 17 ± 2.5µm in size. Stomatal index is 9 ± 0.6 and the stomatal frequency is 163 ± 15 per sq mm.

**TS of lamina**

The lamina is 539 ± 11µm in thickness. The epidermis is coated with thick cuticle. The epidermis is cutinized only in the outer tangential wall. The hypodermis is two layered with colourless cells and found below the upper epidermis and it is the WST. The cells of the hypodermis are polygonal in transverse section. They are larger than the epidermal cells. The mesophyll composed of thin-walled chlorenchyma cells and it is well differentiated into one or two layers of adaxial, anticlinally-extended palisade cells and oval or round-shaped, loose, abaxial, isodiametric spongy parenchyma cells. The palisade layer is 148.5 ± 5.5µm in thickness and the spongy parenchyma layer is 129.8 ± 9.9µm in thickness. The palisade/spongy ratio is 1.13 ± 0.1. The WST occupies at least 42% (223.6 ± 5.5µm thickness) of the total lamina volume. The percentage of WST to the total thickness of the lamina is 41.4 ± 0.6µm. The vascular bundle is with distinct parenchymatous bundle sheath.

**Trichomes**

Both glandular and non-glandular trichomes are observed. Multicellular glandular trichomes are present on both lower and upper surface of the leaf whereas the non-glandular trichomes are occur only on the lower epidermis. The glandular trichomes consists of two to four collecting cells, one stalk cell and
usually eight secretary cells and they are > 50 per mm² on the lower epidermis. In
the upper epidermis these glandular trichomes are sparsely seen. The non-glandular
trichome develops a dense tomentum and found on every cells of the lower
epidermis. The distal cell of each trichome is thin walled and bladder like, while
the stalk cell is dump-bell shaped.

**T S of petiole**

The epidermis of the petiole is single layered and it is very much similar to
that of the leaf epidermis. The hypodermis consists of one or two layers of
collenchyma cells. The central ground tissue is parenchymatous with large
intercellular spaces. Many tannin containing cells interspersed between the
parenchyma cells and these cells are normally larger than the other adjacent
parenchyma cells. The vascular bundle is a medullated cylinder and the pith region
consists of thick walled parenchyma cells.

**Phytochemicals**

The phytochemicals observed in the leaves of *Avicennia marina* are
alkaloids, flavonoids, phenols, saponins, tannins and terpenoids, the glycosides
and steroids were absent.
4. *Avicennia officinalis* Linn.

Evergreen tree, sometimes to 25m, trunk to1m in diameter. Numerous upright pneumatophores rise above soil from long shallow, horizontal roots. Bark brownish-grey, thin, becoming rough and blackish, or outer bark yellowish-green and inner bark whitish. Leaves opposite obovate or broadly oblong, 4-12cm long, 2-6cm wide, rounded at tip, acute or rounded at base, thick, leathery, edges slightly rolled under, upper surfaces shiny green and hairless, underneath with fine grey-green hairs and resin dots. Cymes head like in panicles, upright near ends of twigs. Flowers many, 2-12 together, sessile, 7-10mm long, 12-15mm across. Calyx 5-lobed, hairy on edges, with resin dots; corolla bell-shaped, tubular, yellow or yellow-brown, turning orange, with 4 unequal spreading lobes, stamens 4, inserted in notches of corolla tube; ovary conical, hairy, imperfectly 4-celled with 4 ovules, style thread like; stigma 2-forked. Capsule broadly ovoid, flattened, 2.5cm long. Seed 1, large, flattened, without seed coat, germinating in water.

**Leaf architecture**

Leaves simple, opposite decussate, exstipulate, petiole 1-2cm long. Leaves dorsiventral and succulent. Leaf blade is microphyll type, ovate-lanceolate in shape, symmetrical. Base angle of the lamina is acute and it is cuneate in shape. Apex angle of the lamina is acute and it is convex in shape. Lamina margin entire. Leaves yellowish-green in colour, the margin and the midrib being yellow. The midrib is slightly raised and the margin slightly reflexed. Leaves are 4-12cm long and 2-6cm wide in size. Lamina length and width ratio is 2:1.
Leaf venation

Venation is weak brochidodromous type. Spacing between secondaries uniform and the angle between the primary vein and secondary vein is uniform throughout the leaf. Inter secondaries not prominently seen. Tertiary veins originate at obtuse or right angles, admedially ramified. Fourth order veins not distinct. The leaf rank is 1r.

Leaf anatomy

Epidermis

The epidermal cells on the lower surface are generally larger than those of upper side. The cells in the lower epidermis are $477.6 \pm 3.6\mu m$ in size, whereas the cells on the upper epidermis are $342 \pm 0.1\mu m$. In the lower epidermis the number of epidermal cells per sq mm are $2106 \pm 70$, whereas in the upper epidermis are $2780 \pm 25$. All epidermal cells are polygonal in outline with straight anticlinal wall. The cells in the midrib region are elongated with straight anticlinal wall. Many hydathodes like structures are present on the lower epidermis.

Stomata

The stomata are confined to the lower epidermis. Stomata are not sunken, always confined to non-venous areas of lower epidermis, always randomly oriented. The stomata are of the paracytic type with two subsidiary cells and they are placed right angle to guard cells. Stomatal ledges are not observed. Stomata are $26.3 \pm 1.4 \times 20.6 \pm 1.8\mu m$ in size. Stomatal index is $8 \pm 0.2$ and the stomatal frequency is $185 \pm 12$ per sq mm.
**TS of lamina**

The lamina is 489 ± 5.5µm in thickness. The epidermis is coated with thick cuticle. The epidermis is cutinized only in the outer tangential wall. The cuticle layer is interrupted due to the presence of uniseriate trichomes on the lower epidermis. The epidermal cells are single layered. The hypodermis consists of two or more layered colourless cells and it is the WST. The cells of this region are polygonal in transverse section and are larger than the epidermal cells. The mesophyll tissue composed of thin–walled chlorenchyma cells and it is well differentiated into one or two layers of adaxial, anticlinally-extended palisade cells and oval or round-shaped, loose, abaxial, isodiametric spongy parenchyma cells. The palisade layer is 155 ± 11µm in thickness and the spongy parenchyma layer is 101 ± 8.2 µm in thickness. The palisade/spongy ratio is 1.36 ± 0.2. Compared to the spongy parenchyma the development of palisade tissue is meager. Many terminal tracheids are observed in the mesophyll tissue. Thickness of water storage tissue is 202 ± 16.5 in µm. The percentage of WST to the total thickness of the lamina is 41.3 ± 0.6µm (40% of total lamina volume). The vascular bundle is with distinct parenchymatous bundle sheath.

**Trichomes**

Both glandular and non-glandular trichomes are observed. The glandular trichomes found both on the lower as well as the upper epidermis. The glandular trichomes found on the upper epidermis are few in number (5-8 per sq mm) and they are abundant (70-95 per sq mm) on the lower epidermis and it is distributed along with non glandular trichomes. The glandular trichomes found on the upper
surface are sunken and consists of a head with eight short cells and a stalk consists of single discoid cell and this is found on 4-8 small modified epidermal cells. The glandular trichomes found on the lower surface are not sunken and consists of 4-celled head and a single enlarged epidermal cell at the base. The glandular trichomes found on the lower epidermis are much shorter than the non-glandular trichomes found on the same surface. The non-glandular trichomes are found on every cell of the lower epidermis. The distal cell of these trichomes are thin walled and bladder like and the lumen of the stalk cell is dump-bell shaped.

**T S of petiole**

In TS, the petiole is semi-terete in outline with two lateral wing like projection. A triangular hairy depression occurs in the upper surface of the broadened base of the petiole. It is shallow at its apex, which is directed towards the lamina, but deepens towards the base. The epidermis of the petiole is single layered and it resembles that of the corresponding surface of the lamina except that there are no trichomes and stomata. The hypodermis consists of one or two layers of collenchyma cells. The central ground tissue is parenchymatous with large intercellular spaces. Many tannin containing cells interspersed between the parenchyma cells and these cells are normally larger than the other adjacent parenchyma cells. The vascular bundle is in the form of crescent shaped structure.

**Phytochemicals**

The phytochemicals observed in the leaves of *Avicennia officinalis* are alkaloids, tannins, terpenoids, phenols, flavonoids, glycosides and steroids but saponin is absent.
5. *Bruguiera cylindrica* (Linn.) Blume

Tall tree, up to 25m high, perennial, evergreen, deliquescent, woody, erect, branches haphazardly arranged. Bark grey, smooth, with few lenticels. Stipules 2.5-3.5cm. The petiole is often reddish and 1-4.5cm long. The leaves are simple, opposite, thin and glossy green, elliptic in shape, 5-17cm long, 2-8cm wide, with a bluntly pointed apex. The leaves occur in clusters at the end of branches, secondary veins abaxially remote and thin, reticulate veins mostly obscure, base cuneate, apex acute. Cymes pedunculate, two or three flowered. Pedicel 1-4mm. Flowers have a pale-greenish calyx with 8 calyx lobes, 16 stamens and 8 white bi-lobed petals with 2-3 bristles on each apex and 1 conspicuous bristle in the sinus (indentation between the petal lobes) that is longer than the petal lobes. The viviparous propagule (hypocotyle) grows from within the calyx and is pencil-like and green, with a smooth surface. Fruit berry, pendulous, persistent calyx, calyx lobes bent towards pedicel, hypocotyle up to 16cm long, green slightly ridged with blunt end. Fruits up to 1.5cm, obconical, fall with the hypocotyl seedling. Seed germination epigeal.

**Leaf architecture**

Leaves simple, opposite, stipulate (stipules pale yellow or greenish), petiole 1.0-4.5cm long, dorsiventral, thin, crowded in terminal part of the branches. Leaf blade is microphyll type, narrowly elliptic in shape with pointed tips, symmetrical. Base angle of the lamina is acute and it is cuneate in shape. Apex angle of the lamina is acute and it is convex in shape. Lamina margin entire. Leaf surface is glabrous. Leaves are 5-17cm long and 2-8cm wide in size. Lamina length and width ratio is 2.5:1.
Leaf venation

The venation is weak brochidodromous type. Spacing between the secondary veins are uniform and the angle between the primary and secondary veins are uniform. Secondaries diverge from the stout middle vein at a wide-acute angle. Intersecondaries are simple, rarely composite and are often admedially ramified. Tertiaries originate from either side of the secondaries of almost right angle and may be randomly forked and may form large polygonal domains elongated parallel to the secondaries. Quaternary veins have a random polygonal relationship to the tertiaries. The margin has occasional shallow glands. The leaf rank is 1r.

Leaf anatomy

Epidermis

The epidermal cells on the lower surface are generally larger than those of upper side. The cells in the lower epidermis are 671.6 ± 2.1µm in size, whereas the cells on the upper epidermis are 405.1 ± 3.2µm. In the lower epidermis the number of epidermal cells are 1906.6 ± 50 per sq mm whereas the number of epidermal cells in the upper epidermis are 2396.6 ± 64. All epidermal cells are polygonal in outline with straight anticlinal wall. The cells in the midrib region are elongated.

Stomata

The stomata are confined to the lower epidermis and they are arranged irregularly all over the epidermis except over veins, and they are deeply sunken. The stomata are of the cyclocytic type with 4–7 subsidiary cells. Stomatal ledges
are clearly seen both inside and outside of guard cells. Stomata are $35.7 \pm 1.4 \times 26.1 \pm 1.4 \ \mu m$ in size. The stomatal index is $8 \pm 0.7$ and the stomatal frequency is $168 \pm 12.8$ per sq mm.

**TS of lamina**

The lamina is $315.3 \pm 11 \mu m$ in thickness. The epidermis is coated with thin cuticle. The epidermis is cutinized only in the outer tangential wall. The hypodermis is one layered with colourless cells and found only below the upper epidermis and it is the WST. The cells of the hypodermis are cubical or sometimes extensively vertically elongated in transverse section. They are larger than the epidermal cells. The mesophyll composed of thin- walled chlorenchyma cells and it is well differentiated into one or two layers of adaxial, anticlinally-extended palisade cells and oval or round-shaped, loose, abaxial, isodiametric spongy parenchyma cells. The palisade layer is $49.5 \pm 8.2 \mu m$ in thickness and the spongy parenchyma layer is $185.1 \pm 2.7 \mu m$ in thickness. The palisade spongy ratio is $0.26 \pm 0$. The WST occupies at least 10% ($36.6 \pm 2.7\mu m$ thickness) of the total lamina volume. The percentage of WST to the total thickness of the lamina is $11.6 \pm 0.9\mu m$. The vascular bundle is with distinct parenchymatous bundle sheath.

Mesophyll tissue contain many dark brown coloured tanniferous cells. Apart from this idioblasts, stellate sclereids and enlarged terminal tracheids were observed in the mesophyll. Large mucilage cells also observed in the hypodermal region.

**TS of petiole**

In TS, the petiole is horse shoe in outline. The epidermis of the petiole is single layered and it is very much similar to that of the leaf epidermis. The
hypodermis consists of one or two layers of collenchyma cells. The central ground tissue is parenchymatous with large intercellular spaces. Many tannin containing cells interspersed between the parenchyma cells and these cells are normally larger than the other adjacent parenchyma cells. Stellate idioblasts was also observed between the parenchyma cells. Vascular bundles found around the central pith region and they forming butterfly shaped structure. Many raphides were observed in between the parenchymatous cells of ground tissue. Large air cavities are also observed in the cortex.

**Phytochemicals**

Leaves of *Bruguiera cylindrica* contains many phytochemicals including flavonoids, saponins, tannins and terpenoids but alkaloids, steroids, phenols and glycosides are absent.
6. *Ceriops decandra* (Griff.)

Glabrous shrub1 to 2m tall, stem base pyramidal with many stilt-roots. Bark grey, red or brown, rough; exudates absent. Leaves simple and entire, opposite, elliptic oblong or obovate, apex emarginated, base cuneate, 4-10cm long, 2-6cm wide, coriaceous; petioles 1-4cm long, stipules interpetiolar, caducous. Inflorescence stalked axillary condensed cymes. Flowers small, white, regular, bisexual, long; calyx 5-6 lobed, tube adnate to ovary; petals 5-6, apex fringed with many ciliae, stamens 10 to 12, inserted between lobes of the disk, filaments, slender, anthers oblong; ovary 3 celled, style short, stigma simple. Fruit 1 celled, brown, not spiny, non–fleshy leathery, simple, indehiscent, drupe, the fruit does not fall with the often slightly ridged hypocotyls. Seed 1.

**Leaf architecture**

Leaves simple, opposite, lance–shaped, deciduous stipulate, petiole 1-4cm long. Leaves dorsiventral, succulent, crowded in terminal part of the branches. Leaf blade is microphyll type, narrowly obovate-elliptic oblong in shape with pointed tips, symmetrical. Base angle of the lamina is acute and it is cuneate in shape. Apex angle of the lamina is acute and it is convex in shape. Lamina margin entire. Leaf surface is glabrous. Leaves are 4-10cm long and 2-6cm wide in size. Lamina length and width ratio is 1.9:1.

**Leaf venation**

The venation is weak brochidodromous type. Spacing between secondaries uniform and the angle between the primary vein and secondary vein is slowly decreased towards the apex. Inter secondaries simple, equally dividing the inter
coastal areas. Tertiary veins originate at obtuse or right angles admedially and admedially ramified. Quatenary veins branch from transverse tertiaries and run parallel to the secondaries. The leaf rank is 1r.

Leaf anatomy

Epidermis

The epidermal cells on both the lower and upper surfaces are more or less similar in size. The cells are 347.6 ± 1.4 µm in size. The number of epidermal cells per sq mm in the lower epidermis are 1970 ± 65, whereas the number of epidermal cells in the upper epidermis are 2950 ± 50. The anticlinal wall of the epidermal cells are sinuous.

Stomata

The stomata are confined to the lower epidermis and they are arranged irregularly, stomata sunken with substomatal chamber. Stomatal ledges present on both sides of the stomatal pore so the subsidiary cells overlapping the guard cells. Stomata are cyclocytic type with 6-8 subsidiary cells. Stomata are 40.6 ± 0 X 18.3 ± 1.4µm in size. The stomatal index is 8.3 ± 0.6 and the stomatal frequency is 173 ± 5.5 sq mm.

TS of lamina

The lamina is 682 ± 11µm in thickness. The epidermis is coated with thick cuticle. The epidermal cells cutinized wholly. The hypodermis is one layered with colourless cells and it is found only below the upper epidermis and it is the WST. The cells of the hypodermis are polygonal in transverse section. They are larger
than the epidermal cells. The mesophyll composed of thin-walled chlorenchyma cells and it is well differentiated into one or two layers of adaxial anticlinally-extended palisade cells and oval or round-shaped, loose, abaxial, isodiametric spongy parenchyma cells. The palisade layer is $110 \pm 11\mu m$ in thickness and the spongy parenchyma layer is $440 \pm 11\mu m$ in thickness. The palisade / spongy ratio is $0.24 \pm 0$. The WST occupies at least 10% of $(81.4 \pm 5.5 \mu m$ in thickness) the total lamina thickness. The percentage of WST to the total thickness of the lamina is $11.9 \pm 0.7$. The vascular bundle is with distinct parenchymatous bundle sheath.

Mesophyll tissue contain dark brown coloured tanniferous cells. Enlarged terminal tracheids are commonly observed in the mesophyll. Apart from this many crystalliferous cells are also observed in the mesophyll tissue.

**T S of petiole**

In TS, the petiole is almost circular in outline. The epidermis of the petiole is single layered and it is very much similar to that of the leaf epidermis. The hypodermis consists of one or two layers of collenchyma cells. The central ground tissue is parenchymatous with large intercellular spaces. Many tannin containing cells interspersed between the parenchyma cells and these cells are normally larger than the other adjacent parenchyma cells. Many discrete vascular bundles are arranged in the form of a ring around the pith region.

**Phytochemicals**

The phytochemicals observed in this species are alkaloids, tannins, terpenoids, phenols, flavonoids, saponins and steroids but glycosides are absent.

Shrub or tree to 7m, occasionally to 15m, shrubby or columnar, often multi stemmed, sometimes deciduous in dry season; bark grey, smooth, vertically fissured, pustular in larger trees; stem simple to slightly flanged to form buttresses; roots serpentine at surface, knotted, lenticellate. Leaves opposite, simple, ovate to elliptic, green above and below, upper surface slightly shiny, 6.5-10.5cm long, 3.5-5.2cm wide, margin serrate but variably conspicuous to entire, apex acuminate to rounded, base cuneate, margin serrate to entire, somewhat fleshy with abundant exuding milky-white sap when broken; basal blade glands 2(-4) on each side of petiole insertion; petiole terete 2–2.5cm long, pale yellowish-green; stipules minute. Inflorescence axillary, 3-7cm long, catkins within leaf-bearing part of shoot, differ in male and female trees; male inflorescence to 11cm long, diffuse, series of spirally arranged, often glandular bracts, each subtend a flower; calyx lobes 3, narrow lacinate; sepals narrowly ovate, 1mm long, 0.5mm Wide; stamens 3, yellow, anthers 1mm long, pistillode absent, filament 2mm long; glands between stamens and inflorescence axis subglobular, sessile, 0.5mm long; female inflorescence to 3cm long; bracts glandular, basal bracteoles 2; calyx lobes 3, somewhat cupulate; staminodes absent; ovary tri-locular, styles 3, short, simple, stigma lobes 3 mm long; fruit3-lobed capsule, 1.4cm wide, becoming brown and dehiscing to release 3 seeds; pericarp somewhat but not fleshy; Seeds spherical, pepper-corn like, dark brown, streaked, 5mm wide, endosperm absent, buoyant, germination epigeal; cotyledons somewhat cuniform.
Leaf architecture

Leaves simple, alternate, stipulate, petiole 2–2.5cm long, dorsiventral. Leaves are green in young but become red and yellow tinted when mature. Leaf blade is notophyll type, ovate to elliptic in shape, symmetrical. Base angle of the lamina is acute and it is cuneate in shape. Apex angle of the lamina is acute and it is convex in shape. Lamina margin entire, slightly toothed, exudes milky-white sap when broken. Glands normally visible, one or more on each side of the leaf blade near its junction with the petiole. Leaf surface is glabrous. Leaves are 6.5-10.5cm long and 3.5-5.2cm wide in size. Lamina length and width ratio is 2:1. Leaves of female plants are larger than of the male plants and dark green in colour. Generally leaves are shed during the summer and fresh foliage can be seen during October-November.

Leaf venation

The venation is weak brochidodromous type. Spacing between secondaries uniform and the angle between the primary vein and secondary vein are uniform throughout. Intersecondaries seen in some places. Tertiary veins originate at obtuse or right angles from both sides of secondaries at right angles. Quaternary veins form irregularly polygonal domains. The leaf rank is 1r.

Leaf anatomy

Epidermis

The epidermal cells on the lower surface are generally larger than those of upper side. The cells in the lower epidermis are 1094 ± 4.3µm in size, whereas the cells on the upper epidermis are 577 ± 2.8 µm. In the lower epidermis the number
of epidermal cells per sq mm are 843 ± 17, whereas the number of epidermal cells in the upper epidermis are 1550 ± 50. All epidermal cells are irregularly arranged and their anticlinal walls are wavy.

**Stomata**

The stomata are confined to the lower epidermis and they are arranged irregularly. The stomata are not sunken. Stomata are paracytic type with two subsidiary cells. Many cuticular striations radiating from the stomata towards the walls of the subsidiary cells. Stomatal ledges are clearly seen on the out side of the stomata. Stomata are 39.6 ± 4.3 X 22.2 ± 1.4µm in size. Stomatal index is 19.3 ± 0.2 and the stomatal frequency is 203 ± 4 per sq mm.

**TS of lamina**

The lamina is 517 ± 11µm in thickness. The epidermis is coated with thick cuticle. The hypodermis is one layered with colourless cells and found only below the upper epidermis and it is the WST. The cells of the hypodermis are polygonal in transverse section. They are larger than the epidermal cells. The mesophyll composed of thin-walled chlorenchyma cells and it is well differentiated into one or two layers of adaxial, anticlinally-extended palisade cells and oval or round-shaped, loose, abaxial, isodiametric and spongy parenchyma cells. The palisade layer is 270.2 ± 5.5 µm in thickness and the spongy parenchyma layer is 177.4 ± 3.3µm in thickness. The palisade/spongy ratio is 1.51 ± 0. The WST occupies at least 6% (31.1 ± 2.7µm in thickness) of the total lamina volume. The percentage of WST to the total thickness of the lamina is 6.0 ± 0.6µm. The vascular bundle is with distinct parenchymatous bundle sheath.
Mesophyll tissue contain dark brown coloured tanniferous cells. Lacticiferous cells are common in the hypodermal region. Enlarged terminal tracheids and crystalliferous cells are also common in the mesophyll.

**T S of petiole**

In TS, the petiole is horse shoe in outline. The epidermis of the petiole is single layered and it is very much similar to that of the leaf epidermis. The hypodermis consists of one or two layers of collenchyma cells and it is extensively developed near middle of the upper part. The central ground tissue is parenchymatous with large intercellular spaces. Many tannin containing cells interspersed between the parenchyma cells and these cells are normally larger than the other adjacent parenchyma cells. The vascular tissue is represented by three or more discrete vascular bundles. Among these three bundles, the middle one is larger.

**Phytochemicals**

The phytochemicals observed in the leaves of *Excoecaria agallocha* are alkaloids, tannins, terpenoids, phenols and glycosides but the flavonoids, saponins and steroids are absent.
8. *Holosarica indica* (Willd.) Paul G.Wilson

Plants are small, usually less than 30cm tall. Succulent herb. Stem branched, fleshy more or less erect terete, jointed, constricted at nodes, internode narrowed below and broadened above. Leaves small and scale like and as such, so the plant appear leafless thick spongy stem. Green in colour, but their foliage turns red in autumn. Stems and branches as modified as main photosynthetic structure. Stem is jointed. In this species, the leaves are reduced and the stem is green and fleshy and take up the function of leaf. So, this species is get eliminated from further discussion.

Tree or shrub to 15m, columnar or shrubby and multi-stemmed, evergreen; twigs smooth, green becoming brown, young parts often pubescent; bark grey, fissured and flaky; stem base simple, short buttresses, if any; root knees, slender, wiry, occasionally looped above-ground, 5cm long. Leaves alternate, simple, flat and succulent, narrowly obovate-elliptic, light green, 4-6cm long, 2cm wide, entire, coriaceous when young becoming glabrous, later apex rounded and emarginate, base narrowly cuneate; petiole rounded, 3-5mm long; stipules absent. Inflorescence axillary racemes, 1-7 flowered, 2-3cm long; flowers perfect, 16-18mm long, actinomorphic, sessile with a pair of short bracteoles inserted on green calyx tube, glabrous or pubescent, 6-8mm long; calyx lobes 5, ovate, 0.5-1mm long, pointed apex; petals 5, white, glabrous, narrow elliptic or oblanceolate, reflexed, 3-5 mm long, 1mm wide; stamens 10 on inner rim of calyx cup, equal to petals; style simple, glabrous, 4-6mm long, persistent, positioned centrally in deep calyx cup filled with nectar; fruit cluster of drupes, fall as propagules. Fruit drupe 1-seeded, hard, oblong-ellipsoid, flattened, green, 1-1.5cm long, style and calyx lobes persistent, epicarp fibrous, buoyant as drupe; seed linear, germination hypogeal.

**Leaf architecture**

Leaves simple, alternate, stipules interpetiolar, petiole 3-5mm long. Leaves isobilateral, succulent, crowded in terminal part of the branches. Leaf blade is microphyll type, narrowly obovate-elliptical in shape, symmetrical. Base angle of the lamina is acute and it is decurrent in shape. Apex angle of the lamina is acute
and it is convex in shape. The leaf margin is wavy with small serrations. Leaf surface is glabrous. Leaves are 4-6cm long and 2cm wide in size. Lamina length and width ratio is 3 : 1.

**Leaf venation**

The venation is weekly brochidodromous type. Spacing between the secondary veins uniform. Secondaries diverge from the primary vein at a acute angle and the divergence angle is uniform from the base to the apex of the leaf. Inter secondaries are absent. Tertiary veins branch at acute angle form the sides of secondaries. Fourth order veins are not prominently observed. Marginal veins regularly looped with no teeth. The leaf rank is 1r.

**Leaf anatomy**

**Epidermis**

The epidermal cells on the lower surface are generally larger than those of upper side. The cells in the lower epidermis are 1336.3 ± 0.5µm in size, whereas the cells on the upper epidermis are 936.2 ± 7.5 µm. In the lower epidermis the number of epidermal cells per sq mm are 796.6 ± 30, whereas the number of epidermal cells in the upper epidermis are 1093 ± 21.5. All epidermal cells are polygonal in outline with straight anticlinal wall whereas the cells in the midrib region are elongated.

**Stomata**

Stomata are present on both the upper and lower epidermis and more frequently on upper epidermis and they are arranged irregularly all over the epidermis except over vein. Stomata are sunken and are not protected by hairs. The
stomata are of the anomocytic type with 5-6 subsidiary cells. Stomatal ledges are clearly seen over the guard cells. There is no size variation in the stomata found on both upper and lower epidermis and they are $34.8 \pm 2.9 \times 29 \pm 2.9$ in size. Stomatal index on lower epidermis is $10.3 \pm 0.9$ and that of the upper epidermis is $14.2 \pm 0.8$. The stomatal frequency on lower epidermis $110 \pm 10$ and that of the upper epidermis is $180 \pm 15$ per sq mm.

**TS of lamina**

The lamina is $1279.6 \pm 16.5\mu m$ in thickness. The epidermis is coated with thick cuticle. Only palisade tissue is observed in the mesophyll. The palisade tissue is in two layers on both sides of the epidermis and it is $350 \pm 11\mu m$ in thickness. The WST (8–12 layers) is centrally located in between the upper and lower palisade layer and it is $885.6 \pm 2.7\mu m$ in thickness. The cells of WST are polygonal in transverse section. They are larger than the epidermal cells. The percentage of WST to the total thickness of the lamina is $69.2 \pm 0\mu m$. Many idioblasts, crystalliferous cells and stellate sclereids were observed in the mesophyll. The primary vascular bundle is small with distinct parenchymatous bundle sheath.

**TS of petiole**

In TS, the petiole is almost triangular in outline. The epidermis of the petiole is single layered and it is very much similar to that of the leaf epidermis. The hypodermis consists of one or two layers of collenchyma cells. The central ground tissue is parenchymatous with large intercellular spaces. Many tannin containing cells interspersed between the parenchyma cells and these cells are
normally larger than the other adjacent parenchyma cells. Stellate idioblasts were also observed between the parenchyma cells. Vascular bundle is represented by 3 or more or sometimes only one discrete bundle forming horse–shoe shaped structure.

**Phytochemicals**

The phytochemicals observed in *Lumnitzera racemosa* are alkaloids, flavonoids, steroids, tannins, terpenoids, and phenols but saponins and glycosides are absent.
10. *Rhizophora apiculata* Blume

Tree 20-30m tall. Bark dark grey. Glossy, dark green elliptic leaves with a pointed tip. The leaves are simple, opposite, narrowly-elliptic to elliptic in shape, glossy dark green above with a distinct light green zone along the midrib and dull below, 7-19cm long and 3-9cm wide with a pointed apex and mucronate spike to 6 mm long. The petiole is 1-4cm long. Stipule is usually red. The inflorescence is axillary with 2 (occasionally up to 4) yellowish-green or cream flowers which are held below the leaf clusters. Calyx globular, hard thick, brown on the outside yellow inside. Petals yellow to white, flat membranous and hairless, falling off soon after blossoming. Fruit brown, upside-down pear-shaped, crowned by the persistent sepals. Seedling viviparous, hypocotyl about 30cm long, smooth, with somewhat rounded tip.

**Leaf architecture**

Leaves simple, opposite, stipulate, petiole 1-4cm long. Leaves dorsiventral, succulent, crowded in terminal part of the branches. Leaf blade is mesophyll type, elliptic in shape, symmetrical. Base angle of the lamina is acute and it is cuneate in shape. Apex angle of the lamina is acute and it is straight in shape. Lamina margin entire. Leaf surface is glabrous. Leaves are 7-19cm long and 3-9cm wide in size. Lamina length and width ratio is 11 : 3.

**Leaf venation**

The venation is weak brochidodromous type. Spacing between the secondary veins uniform. Secondaries diverge from the primary vein at acute angle and the divergence angle is uniform from base to the apex of the leaf.
Intersecondaries are faintly seen and are arising primary veins. Tertiaries arise at a right angle from both sides of secondaries and often admedially ramified forming a random reticulum. Fourth order veins are regular polygonal reticulate type. Fifth order veins not prominently seen, it is of dichotomizing type. Areoles not distinct. Marginal veins regularly looped with no teeth or glands. Leaf rank is 1r.

**Leaf anatomy**

**Epidermis**

The epidermal cells on the lower surface are generally larger than those of upper side. The cells in the lower epidermis are 398 ± 0.8µm in size, whereas the cells on the upper epidermis are 303 ± 1.0µm. In the lower epidermis, the number of epidermal cells per sq mm are 2730 ± 40, whereas the number of epidermal cells in the upper epidermis are 4400 ± 50. All epidermal cells are polygonal in outline with straight anticlinal wall except in midrib region, where the cells are almost rectangular in outline with straight wall. Many large conspicuous cork warts are observed on the lower epidermis, rarely on the upper epidermis also.

**Stomata**

The stomata are confined to the lower epidermis, stomata are sunken and are not protected by hairs, always confined to non–venous areas of lower epidermis, always randomly oriented. The stomata are of the cycloctic type with 4-6 subsidiary cells. Stomatal ledge is prominently seen over the epidermis. Stomata are 54.1 ± 1.4 X 32.8 ± 1.4µm in size. The stomatal index is 5 ± 0.5 and the stomatal frequency is 145 ± 12.5 per sq mm.
TS of lamina

The lamina is $535.3 \pm 5.5 \, \mu m$ in thickness. The epidermis is coated with thick cuticle. The epidermis is cutinized wholly. The hypodermis is more than two layered with colourless cells and found only below the upper epidermis and it is the WST. The cells of the hypodermis are polygonal in transverse section. They are larger than the epidermal cells. The mesophyll composed of thin-walled chlorenchyma cells and it is well differentiated into one or two layers of adaxial, anticlinally-extended palisade cells and oval or round-shaped, loose, abaxial, isodiametric spongy parenchyma cells. The palisade layer is $165 \pm 11 \, \mu m$ in thickness and the spongy parenchyma layer is $150.3 \pm 8.2 \, \mu m$ in thickness. The palisade/spongy ratio is $1 \pm 0$. The water storage tissue occupies at least 34% of the total lamina volume. Thickness of water storage tissue is $183.3 \pm 16.5 \, \mu m$. The vascular bundle is with distinct parenchymatous bundle sheath. Large mucilage cells occur in the lower hypodermal region, especially near the lower epidermis. Tannin containing cells also present in between the bundle sheath cells.

TS of petiole

In TS, the petiole is horse shoe in outline. The epidermis of the petiole is single layered and it is very much similar to that of the leaf epidermis. The hypodermis consists of two layers of collenchyma cells. The central ground tissue is parenchymatous with large intercellular spaces. Many tannin containing cells interspersed between the parenchyma cells and these cells are normally larger than the other adjacent parenchyma cells. Stellate idioblasts are also observed between the parenchyma cells. Vascular bundle is a medullated cylinder with small scattered bundles forming a circular or C shaped structure. Many large air cavities are present in the ground tissue.
Phytochemicals

The phytochemicals observed in the leaves of *Rhizophora apiculata* are alkaloids, flavonoids, steroids, terpenoids, saponins and phenols but glycosides and tannins are absent.

Evergreen tree, 25–30m high, 70cm in diameter, with numerous branching arching stilt roots. Bark brown or blackish, smoothish, with horizontal fissures. Leaves opposite, elliptical to oblong, 8–15cm long, 5–10cm wide, acute, entire, without visible veins, thick and leathery, glabrous, black-dotted beneath. Petiole 3–5 cm long. Stipules paired, leaving ring scar. Flower clusters axillary, 2–3 times forked, with 3–8 flowers and 15mm long. Bell-shaped hypanthium with 4 pale yellow, pointed leathery sepals and 4 cream-colored petals 9mm long. Stamens 8, stalkless, anthers 6–8mm long, 4 opposite sepals and 4 opposite petals. Ovary half-inferior, conical, 2-celled, with 2 ovules in each cell, 2-lobed style. Berry ovoid or conical, 5–7 cm long, brown, leathery. Seed 1, viviparous and the hypocotyl is 40cm long and 2 cm in diameter.

**Leaf architecture**

Leaves simple, opposite, stipulate, petiole 3–5cm long. Leaves dorsiventral, succulent. Leaf blade is mesophyll type, elliptic in shape, symmetrical. Base angle of the lamina is acute and it is cuneate in shape. Apex angle of the lamina is acute and it is convex in shape with mucronate tip. Lamina margin entire. Leaf surface is glabrous. Leaves are 8–15cm long and 5–10cm wide in size. Lamina length and width ratio is 5:3.

**Leaf venation**

Venation is weak brochidodermous type. Secondaries diverge from the straight primary vein at a right or acute angle. The divergence angle is uniform and
the spacing between the secondary veins are also uniform. Intersecondaries are prominently seen. Tertiary veins are arise at a acute angle from both sides of secondaries and often exmedially ramified forming a random reticulum. Fourth order veins forming regular polygonal reticulate structures. Areoles distinct. The marginal ultimate veins forming complete loops without any teeth. The leaf rank is \textbf{1r}.

\textbf{Leaf anatomy}

\textbf{Epidermis}

The epidermal cells on the lower surface are generally larger than those of upper side. The cells in the lower epidermis are $447.7 \pm 2.1\mu m$ in size, whereas the cells on the upper epidermis are $286.2 \pm 2.8\mu m$. In the lower epidermis the number of epidermal cells per sq mm are $2396.6 \pm 64$, whereas the number of epidermal cells in the upper epidermis are $4283 \pm 75$. All epidermal cells are polygonal in outline with straight anticlinal wall. The cells in the midrib region are elongated with straight anticlinal wall. Many large water–stomata are seen in some places on the upper as well as lower epidermis.

\textbf{Stomata}

Stomata are confined to the lower epidermis, stomata are sunken and are not protected by hairs, always confined to non–venous areas of lower epidermis, always randomly oriented. The stomata are of the cyclocytic type with 4–6 subsidiary cells. Stomatal ledges are clearly seen. Stomatal ledges are occur on both sides of stomatal pore and it is not prominent as in \textit{Rhizophora apiculata}. Stomata are $46.4 \pm 2.9 \times 30.9 \pm 4.3 \mu m$ in size. The stomatal index is $6 \pm 0$ and the stomatal frequency is $151.3 \pm 8$ per sq mm.
TS of lamina

The lamina is 627 ± 11µm in thickness. The epidermis is coated with thick cuticle. The epidermis is cutinized wholly. The hypodermis more than two layered with colourless cells and found only below the upper epidermis. It is the WST. The cells of the hypodermis are polygonal in transverse section. They are larger than the epidermal cells. The mesophyll composed of thin–walled chlorenchymatous cells and it is well differentiated into one or two layers of adaxial, anticlinally–extended palisade cells and oval or round–shaped, loose, abaxial, isodiametric spongy parenchyma cells. The palisade layer is 176 ± 11µm in thickness and the spongy parenchyma layer is 165 ± 11µm in thickness. The palisade/spongy ratio is 1 ± 0.2. The water storage tissue occupies at least 40% (250 ± 22µm) of the total lamina volume. The percentage of WST to the total thickness of the lamina is 40.9 ± 2.8µm. The vascular bundle is with distinct parenchymatous bundle sheath. Mesophyll tissue contain dark brown coloured tanniferous cells. Branched fibre–sclereids and stellate idioblasts are scattered in the mesophyll tissue.

TS of petiole

The epidermis of the petiole is single layered and it is very much similar to that of the leaf epidermis. The hypodermis consists of one or two layers of collenchyma cells and it is followed by a cortex of loosely packed parenchyma cells. Many tannin containing cells and stellate idioblasts are interspersed between the parenchyma cells and these cells are normally larger than the other adjacent parenchyma cells. The vascular bundles fused to form a ring around the pith. Apart from these many discrete vascular bundles are also seen in the pith region.
Phytochemicals

Many phytochemicals were observed in the leaves of *Rhizophora mucronata* and they are alkaloids, flavonoids, steroids, tannins, terpenoids, saponins, glycosides and phenols.

Prostrate to suberect herbs, the longest branches to 1m long, commonly reddish, often rooting at nodes. Stipules 1mm long. Leaves sessile, linear-oblong, 1–7cm long, 0.2–1.5cm wide, apex blunt. Pedicels 6–17mm long. Perianth tube 2–4 mm long; lobes triangular, 6–8 mm long, outer surface green, inner surface pink or purple, margins scarious. Stamens many, free, unequal to 3mm long; anthers 0.8 mm long. Ovary ovoid; carpels 3 (4); styles to 4mm long; ovules several per locule. Capsule with the operculum 4–8mm long, smooth. Seeds subtriangular or comma-shaped in outline, longest axis 1.5 mm.

**Leaf architecture**

Leaves simple, opposite, stipulate, sessile, isobilateral and succulent. The leaves are deep purple in colour when mature. Leaf blade is nanophyll type, linear oblong in shape, symmetrical. Base angle of the lamina is acute and it is cuneate in shape. Apex angle of the lamina is obtuse and it is straight in shape. Lamina margin entire. Leaf surface is glabrous. Leaves are 1–7 cm long and 0.2–1.5 cm wide cm in size. The leaves are almost cylindrical in outline. Lamina length and width ratio is 10 : 1.

**Leaf anatomy**

**Epidermis**

The epidermal cells on the lower surface are generally larger than those of upper side. The cells in the lower epidermis are 4816 ± 6.5µm in size, whereas the cells on the upper epidermis are 4076.2 ± 7.2µm. The number of epidermal cells per sq mm are 144 ± 8. All epidermal cells are polygonal in outline with straight anticlinal wall whereas the cells in the midrib region are elongated.
Stomata

Stomata are arranged irregularly all over the surface of the leaf. The stomata are paracytic type with 2 subsidiary cells. Stomatal ledges are completely absent. Stomata are $34.8 \pm 2.9 \times 23.2 \pm 0$ µm in size. The stomatal index is $25.6 \pm 2.2$ and the stomatal frequency is $50 \pm 7.5$.

TS of lamina

The lamina is $2262.3 \pm 16.3$ µm in thickness. The epidermis is coated with thin cuticle. The mesophyll is not differentiated into palisade and spongy parenchyma. Only the spongy parenchyma is present. The spongy tissue is ranged from four to five layers found on both sides of the epidermis and it is $1210 \pm 27$ µm in thickness. The WST is centrally located in between the palisade layers and it is $851 \pm 22$ µm in thickness. The percentage of WST to the total thickness of the lamina is $37.6 \pm 2.7$ µm. The cells of the WST are polygonal in transverse section. They are larger than the epidermal cells. Smaller chloroplasts were present in the cells of WST. No bundle sheath formation was observed.

TS of petiole

In TS, the petiole is circular in outline. The epidermis of the petiole is single layered and it is very much similar to that of the leaf epidermis. The hypodermis consists of one or two layers of collenchyma cells. The central ground tissue is parenchymatous with large intercellular spaces. Vascular bundle is represented by 3 or more discrete vascular bundles in the pith.

Phytochemicals

The phytochemicals observed in the leaves of *Sesuvium portulacastrum* are alkaloids, flavonoids, tannins, glycosides, terpenoids and phenols, but the saponins and steroids were absent.

An erect or prostrate glabrous annual, pale green or bluish and often tinged with red, especially in autumn; stems 7-30cm, rarely to 60cm long. Leaves narrow or almost cylindrical, tiny, fleshy with pointed tips. Leaves 1-2.5cm long and 0.2-0.4 cm broad, subacute to acuminate, flat above, convex beneath; the lower leaves held horizontally, the upper erect. Pale green flowers gathered in groups of 2-5 or lonely at leaf axis on the upper branches of the plant. Flowers in small cymes of 1-3, more rarely 4 or 5; stigmas 2. The fruit is oval and compressed. Seeds 1-2mm diameter, compressed, shining, finely punctuate near the edges, beaked.

**Leaf architecture**

Leaves simple, alternate, exstipulate, isobilateral, succulent and sessile. Leaves green while young but become purple when mature. Leaf blade is nanophyll type, linear oblong in shape, flat above, convex beneath, the lower leaves held horizontally, the upper erect, symmetrical. Base angle of the lamina is acute and it is cuneate in shape. Apex angle of the lamina is acute and it is straight in shape. Lamina margin entire. Leaf surface is glabrous. Leaves are 1-2.5cm long and 0.2-0.4cm wide size. Lamina length and width ratio is 10:1. The leaves are almost cylindrical in outline.

**Leaf anatomy**

**Epidermis**

The epidermal cells on the lower surface are generally larger than those of upper side. The cells in the lower epidermis are $3684.6 \pm 19.5 \mu m$ in size, whereas the cells on the upper epidermis are $3014.5 \pm 14.5 \mu m$. In the lower epidermis the
number of epidermal cells per sq mm are $682.6 \pm 20$ whereas the number of epidermal cells in the upper epidermis are $898 \pm 17$. All epidermal cells are polygonal in outline with straight anticlinal wall.

**Stomata**

Stomata are present on both the upper and lower epidermis, stomata are sunken and are not protected by hairs, always confined to non–venous areas of lower epidermis, always randomly oriented. The stomata are of the paracytic type with two subsidiary cells. Stomatal ledges are completely absent. There is no size variation in the stomata found on both upper and lower epidermis and they are $32.8 \pm 2.9 \times 25.1 \pm 7.2 \, \mu m$ in size. Stomatal index is $12.7 \pm 0.9$ and the stomatal frequency is $100 \pm 10$ per sq mm.

**TS of lamina**

The lamina is $2786.6 \pm 82.5 \mu m$ in thickness. The epidermis is coated with thin cuticle. The mesophyll is not differentiated into palisade and spongy parenchyma. Only the palisade parenchyma is present. The palisade tissue is in two layers on both sides of the epidermis and it is $225.3 \pm 11 \mu m$ in thickness. The WST is centrally located in between the palisade layers and it is more abundant, it fills at least 85% of the volume of the leaf. Thickness of the water storing tissue is $2394.6 \pm 22 \, \mu m$. The percentage of WST to the total thickness of the lamina is $85.9 \pm 0 \, \mu m$. The cells of the WST are polygonal in transverse section. They are larger than the epidermal cells. No bundle sheath formation was observed.

**Phytochemicals**

The phytochemicals observed in the leaves of *Suaeda maritima* are alkaloids, flavonoids, steroids, tannins, glycosides, terpenoids and phenols but saponin is absent.
14. *Suaeda monoica* (Forsk) ex J.E.Gmel

Shrub 1.2–6 m high, much branched, glabrous or slightly and inconspicuously pubescent on young parts only. Leaves fleshy, linear to linear-oblong, obtuse to acute at apex, narrowed near the sessile or very shortly petioled base, inferior and middle leaves mostly 1-4cm long and 0.1-0.3cm wide, superior leaves (bracts) progressively shorter. Flowers green, clustered in upper axils, the clusters aggregated to form interrupted or sometimes dense spikes bracteate as throughout or below only; plants with male and female flowers or only flowers with 5 stamens and a rudimentary ovary expanded at apex into a peltate disk; stigmas 3–4. Seeds vertical, testa black, almost smooth.

**Leaf architecture**

Leaves simple, alternate, exstipulate, isobilateral, succulent and sessile. Leaf blade is leptophyll type, linear-oblong in shape, symmetrical. Base angle of the lamina is acute and it is truncate in shape. Apex angle of the lamina is acute and it is straight in shape. Lamina margin entire and the leaf surface is glabrous. Leaves are 1-4 cm long and 0.1-0.3 cm wide in size. Lamina length and width ratio is 13:1.

**Leaf anatomy**

**Epidermis**

The epidermal cells on the lower surface are generally larger than those of upper side. The cells in the lower epidermis are 2381.1 ± 7.2µm in size, whereas the cells on the upper epidermis are 1708.1± 6.5µm. In the lower epidermis the number of epidermal cells in the per sq mm are 216 ± 24 whereas the number of epidermal cells in the upper epidermis are 344 ± 20. All epidermal cells are polygonal in outline with straight anticlinal wall.
Stomata

Stomata are found all over leaf in an irregular manner. Stomata are of the paracytic type with 2 subsidiary cells. Stomatal ledges are completely absent. There is no size variation in the stomata found on both upper and lower epidermis and they are $50.1 \pm 1.4 \times 24.1 \pm 1.4 \mu m$ in size. Stomatal index is $23.7 \pm 3.9$ and the stomatal frequency is $60 \pm 5$ per sq mm.

TS of lamina

The lamina is $1210 \pm 22 \mu m$ in thickness. The epidermis is coated with thin cuticle. The mesophyll is not differentiated into palisade and spongy parenchyma. Only the palisade parenchyma is present. The palisade tissue is in two layers on both sides of the epidermis and it is $304 \pm 10.7 \mu m$ in thickness. The outer layer of palisade cells consists of relatively small chloroplasts and the inner layer of palisade cells composed of many large chloroplasts which are arranged in centripetal manner. The WST is centrally located in between the epidermal layers and it is $805.3 \pm 5.5 \mu m$ in thickness. The percentage of WST to the total thickness of the lamina is $66.1 \pm 0.6 \mu m$. The cells of WST also contain few scattered chloroplasts which are smaller than those of the inner layers of the chlorenchyma. No bundle sheath formation was observed.

Phytochemicals

The phytochemicals observed in the leaves of *Suaeda monoica* are alkaloids, flavonoids, steroids, tannins, glycosides, saponins, and phenols but terpenoids are absent.
Acanthus ilicifolius Linn.

1a. T.S. of Leaf

1b. T.S. of petiole

1c. T.S. of petiole (showing vascular bundle)
Plate 1. Acanthus ilicifolius Linn.

1d. Leaf venation

1e. Leaf: LE

1f. Leaf: UE

1g. Leaf: LE
Aegiceras corniculatum (L.) Blanco

2a. T.S. of Leaf

2b. T.S. of petiole

2c. Leaf venation
Aegiceras corniculatum (L.) Blanco

2d. Leaf : UE

2e. Leaf : LE

2f. Leaf : LE
Avicennia marina (Forssk.) Vierh.

3a. T.S. of Leaf

3b. T.S. of petiole

3c. Leaf : UE

3d. Leaf venation
Plate 4

Avicennia officinalis Linn.

4a. T.S. of Leaf

4b. T.S. of petiole

4c. Leaf venation

4d. Leaf: UE

4e. Leaf: UE
Bruguiera cylindrica (Linn.) Blume

5a. T.S. of Leaf

5b. T.S. of petiole

5c. Leaf venation (showing midrib and the secondary vein)

5d. Leaf venation (showing secondary vein and tertiary veins)
Bruguiera cylindrica (Linn.) Blume

5e. Leaf : UE

5f. Leaf : LE

5f. Leaf : LE

5f. Leaf : LE
Ceriops decandra (Griff.)

6a. T.S. of Leaf

6b. T.S. of petiole

6c. Leaf venation
Plate 6

Ceriops decandra (Griff.) W. Theob.

6d. Leaf : UE

6e. Leaf : LE

6f. Leaf : LE

6g. Leaf : LE
Excoecaria agallocha Linn.

7a. T.S. of Leaf

7b. T.S. of petiole

7c. Leaf venation
Excoecaria agallocha Linn.

7d. Leaf : UE
7e. Epidermis above vein
7f. Leaf : LE
7g. Leaf : LE
7h. Stoma - Enlarged
Holosarica indica (Willd.) Paul G. Wilson

8a. T.S. of stem
8b. Epidermis of the stem
8c. Epidermis of the stem
8d. Stoma - Enlarged
Lumnitzera racemosa Willd.

9a. T.S. of Leaf

9b. T.S. of petiole

9c. Epidermis above vein
Lumnitzera racemosa Willd.

9d. Leaf : LE

9e. Leaf : LE

9f. Leaf : LE

9g. Leaf : LE
Plate 10

Rhizophora apiculata Blume.

10a. T.S. of Leaf

10b. T.S. of petiole

10c. Leaf venation

10d. Leaf: UE
Plate 10

Rhizophora apiculata Blume.

10e. Epidermis above vein

10f. Leaf: LE

10g. Leaf: LE

10h. Leaf: LE
Rhizophora mucronata Poir.

Plate 11

11a. T.S. of Leaf

11b. T.S. of petiole

11c. Leaf venation

11d. Leaf: LE
Rhizophora mucronata Poir.

11e. Leaf: UE

11f. Leaf: UE

11g. Leaf: LE

11h. Leaf: LE
Sesuvium portulacastrum Linn.

Plate. 12

12a. T.S. of Leaf
12b. T.S. of petiole
12c. Leaf: UE
12d. Leaf: LE
12e. Leaf: LE
Plate 13

*Suaeda maritima* (Linn.) Dum

13a. T.S. of Leaf

13b. Leaf: LE

3c. Leaf: LE

3d. Leaf: LE
Plate 14

Suaeda monoica Forsk. ex J.E. Gmel.

14a. T.S. of Leaf

14b. Leaf: LE

14c. Leaf: LE
Sea Holy, Holy mangrove

Aegiceras corniculatum (L.) Blanco

River mangrove
Avicennia marina (Forsk.) Vierh.

Grey or white mangrove

Avicennia officinalis Linn.

Greyish brown mangrove
**FIG - 5**

*Bruguiera cylindrica* (Linn.) Blume

Yellow or Flat-leaf spurred mangrove

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**FIG - 6**

*Ceriops decandra* (Griff.)

White Burma mangrove
**FIG - 7** Excoecaria agallocha Linn.

Blinding tree, River poison tree, Milky mangrove

**FIG - 8** Holosarica indica(Willd.)Paul G.Wilson

Traditional medicinal halophyte
FIG - 9  
Lumnitzera racemosa Willd.

FIG - 10  
Rhizophora apiculata Blume.
**FIG -11** Rhizophora mucronata Poir.

Red or Asiatic or Loop-root mangrove

**FIG -12** Sesuvium portulacastrum Linn.

Shoreline or Sea purslane
Common Seablite, Annual seablite, Herbaceous seepweed, Common Indian Saltwort

Monoecious seablite