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·ATOMY OF LEAVES OF SOME MANGROVES AND THEIR ASSOCIATES OF SUNDARBANS, WEST BENGAL[1]

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Abstract

The anatomy of leaves of twenty two species of mangroves and seven species of mangrove associates from Sundarbans of West Bengal is described. The leaves of most true mangroves are dorsiventral except one monocot (*Phoenix paludosa*) and two dicot species (*Kandelia candel* and *Sonneratia apetala*) which show isolateral type. Three species of mangrove associates have dorsiventral leaves and four species show isolateral leaves. Cuticle is comparatively thicker in true mangroves than in mangrove associates. Colourless, non-assimilatory water storage tissue is hypodermal in dorsiventral leaves but is deep-seated in the mesophyll region of isolateral leaves. Terminal tracheids at vein endings are commonly found in many species; branched sclereids occur in two species. Mucilage cells, tannin cells and laticifers occur in hypodermal zone in some species. Crystalliferous cells are common in many species. Vascular bundle sheath extension occurs in two monocots and one dicot mangroves. An identification key to genera based on leaf anatomy is provided.

Key Words : Leaf anatomy, mangroves, mangrove associates, Sundarbans.

Mangroves are specialized woody halophytic plants which grow in the littoral zones of the tropical world. These forest systems are dominated by salt tolerant halophytic seed plants which range in size from shrubs to tall trees. Sundarbans is the delta of the river Ganga and Brahmaputra of India and Bangladesh, respectively, and is the largest single block of mangrove vegetation in the world; it occupies about 14,600 sq km area. The Indian part consists of 4266.6 sq km and the rest belongs of Bangladesh (Banerjee 1964, Naskar & Guha Bakshi 1982).

The anatomical study of leaves in mangroves though has received much attention but most of the work is confined to certain aspects of leaf anatomy in not too large number of mangroves from different parts of the world (Areschoug 1902, Artz 1936, Chapman 1976, Das & Ghose 1993, Fahn & Shimony 1977, Mullan 1931a, 1931b, Rao 1971, Rao & Sharma 1968, Seshavatharam & Srivalli 1989, Shah & Sunder Raj 1965, Tomlinson 1986, Wehe 1964).

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The present article is an extension of a previous work (Das & Ghose 1993) where detailed studies on morphology of stomata and leaf hairs of these halophytes were made. Therefore, the present study is aimed at other anatomical peculiarities of leaves of 22 species of true mangroves and seven species of mangrove associates from the dominating flora of Sundarbans of West Bengal.

Materials and Methods

Samples of lamina of 22 typical mangroves and seven mangrove associates belonging to 17 families were collected from a position approximately half-way between the base and apex of a sector from one side of lamina (see Table 1). Transverse sections of 10 - 16 μm thickness were cut on a rotary microtome and stained with safranin and fast green (Johansen 1940, Sass 1958); hand sections were stained with Toluidine blue O.

Observations

Most true mangroves possess simple, entire leaves. Among the dicotyledons, pinnately compound leaves (paripinnate) occur in *Xylocarpus*, while in monocotyledons *Phoenix* and *Nypa* show pinnately compound leaves . On the basis of shape of leaf segments, palms can be divided into two categories :

(i) Induplicate palm (segments "V" shaped in section) - *Phoenix paludosa.*
(ii) Reduplicate palm (segments reverse "V" shaped in section) - *Nypa fruticans.*

Among the mangrove associates, only *Derris trifoliata* has pinnately compound leaves while others have simple leaves.

LAMINA — The lamina of most of the true mangroves studied is usually dorsiventral, but in *Kandelia candel*, *Phoenix paludosa* and *Sonneratia apetala* it is isolateral (Figs 1I, 2E,F). In mangrove associates isolateral lamina is observed in *Heliotropium curassavicum*, *Porteresia coarctata*, *Sesuvium portulacastrum* and *Suaeda maritima* (Fig. 2C, D,G,H), and dorsiventral lamina in the rest of the species.

The cuticle (Table 1) is considerably thick in *Bruguiera gymnorrhiza* (0.014 mm), *Aegiceras* (0.01 mm), *Avicennia officinalis* (0.009 mm), *Ceriops decandra* (0.009 mm), *Kandelia candel* (0.009 mm) and *Sonneratia* (0.009 mm) but is rather thin (0.003 mm) in *Heritiera littoralis*, *Nypa* and *Phoenix*. The cuticle is thinner in mangrove associates than the true mangroves e.g. *Clerodendrum* (0.002 mm), *Derris* (0.002 mm), *Suaeda* (0.003 mm) and *Porteresia* (0.004 mm). The cuticular surface is usually smooth in the investigated taxa, but uneven in *Aegialitis* and *Sonneratia*, and interrupted due to the presence of stellate hairs in *Heritiera*, uniseriate capitate hairs on the abaxial epidermis of *Avicennia* (Figs 1A,3A) and club shaped unicellular hairs in *Porteresia* (Fig. 2H).

The epidermis is always cutinized, either wholly (e.g. *Aegiceras*, *Ceriops* and *Rhizophora*) or only the outer tangential walls (e.g. *Avicennia*, *Bruguiera* and *Sonneratia*). The outer wall of the epidermal cells is usually thicker than the rest of the walls (e.g. *Acanthus*). Comparatively thin-walled epidermal cells occur in *Acanthus*, *Allamanda*,

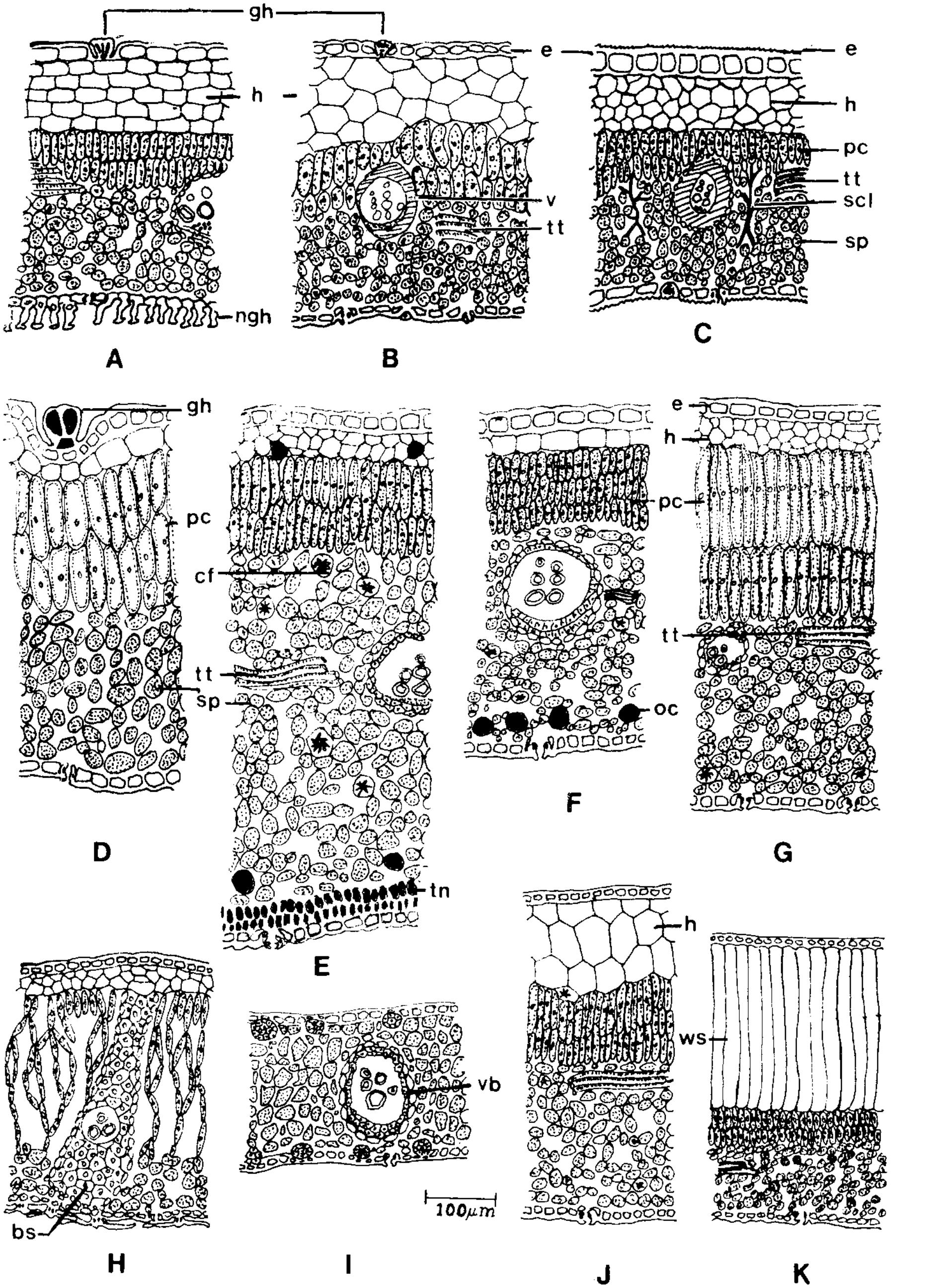

Fig. 1A-K — Camera lucida drawings of transections of leaves (bs, bundle sheath; *c*, cuticle; *cf*, crystalliferous cells, *e*, epidermal cells; *gh*, glandular hairs; *h*, hypodermis; *ngh*, non-glandular hairs; *oc*, oil cells; *pc*, palisade cells; *s*, stomata; *scl*, sclereids; *sp*, spongy parenchyma; *tn*, tannin cells; *tt*, terminal tracheids; *vb*, vascular bundle; *ws*, water storage tissue). **A.** *Avicennia alba*. **B.** *Aegiceras corniculatum*. **C.** *Aegialitis rotundifolia*. **D.** *Acanthus ilicifolius*. **E.** *Ceriops decandra*. **F.** *Bruguiera gymnorrhiza*. **G.** *Excoecaria agallocha*. **H.** *Heritiera fomes*. **I.** *Phoenix paludosa*. **J.** *Xylocarpus granatum*. **K.** *X. mekongensis*.

TABLE 1 — SOME LEAF ANATOMICAL FEATURES OF THE INVESTIGATED TAXA

SL. NO.	NAME OF THE INVESTIGATED TAXA	NAME OF THE FAMILY	LEAF SYMMETRY	LEAF THICKNESS[2]	CUTICLE THICKNESS[2]	EPIDERMAL THICKNESS[2]	COLOURLESS ZONE[1] THICKNESS[2]
	Mangrove : Dicot						
1.	*Acanthus ilicifolius* L.	Acanthaceae	Dorsiventral	0.61	0.004	0.026	0.065
2.	*Aegialitis rotundifolia* Roxb.	Plumbaginaceae	Dorsiventral	0.30	0.007	0.017	0.043
3.	*Aegiceras corniculatum* (L.) Blanco	Myrsinaceae	Dorsiventral	0.37	0.01	0.072	0.082
4.	*Avicennia alba* Blume.	Avicenniaceae	Dorsiventral	0.44	0.006	0.01	0.12
5.	*A. marina* (frosk.) Vierh.	Avicenniaceae	Dorsiventral	0.48	0.004	0.011	0.085
6.	*A. officinalis* L.	Avicenniaceae	Dorsiventral	0.41	0.009	0.019	0.10
7.	*Bruguiera cylindrica* (L.) Bl.	Rhizophoraceae	Dorsiventral	0.39	0.006	0.015	0.12
8.	*B. gymnorrhiza* (L.) Lamak.	Rhizophoraceae	Dorsiventral	0.54	0.14	0.018	0.027
9.	*B. parviflora* W. & A.	Rhizophoraceae	Dorsiventral	0.55	0.006	0.014	0.037
10.	*Ceriops decandra* (Griff.) Ding Hou.	Rhizophoraceae	Dorsiventral	0.70	0.009	0.017	0.097
11.	*C. tagal* (Pierr.) Robins	Rhizophoraceae	Dorsiventral	0.61	0.004	0.14	0.084
12.	*Excoecaria agallocha* L.	Euphorbiaceae	Dorsiventral	0.50	0.006	0.014	0.045
13.	*Heritiera fomes* Buch. Ham.	Sterculiaceae	Dorsiventral	0.37	0.005	0.019	0.037
14.	*H. littoralis* Dry.	Sterculiaceae	Dorsiventral	0.41	0.003	0.016	0.036
15.	*Kandelia candel* (L.) Druce.	Rhizophoraceae	Isolateral	1.60	0.009	0.016	1.35

16.	*Rhizophora apiculata* Bl.	Rhizophoraceae	Dorsiventral	0.48	0.004	0.013	0.068
17.	*R. mucronata* Lam.	Rhizophoraceae	Dorsiventral	0.54	0.006	0.015	0.074
18.	*Sonneratia apetala* Buch. Ham.	Sonneratiaceae	Isolateral	0.90	0.009	0.015	0.54
19.	*Xylocarpus granatum* König.	Meliaceae	Dorsiventral	0.49	0.006	0.15	0.10
20.	*X. mekongensis* Pieree.	Meliaceae	Dorsiventral	0.94	0.004	0.016	0.59
Mangrove : Monocot							
21.	*Nypa fruticans* (Thunb). Wurmb.	Arecaceae	Dorsiventral	0.28	0.003	0.006	0.14
22.	*Phoenix paludosa* Roxb.	Arecaceae	Isolateral	0.22	0.003	0.006	0.12
Mangrove associates : Dicot							
23.	*Allamanda cathertica* L.	Apocynaceae	Dorsiventral	0.68	0.004	0.027	0.055
24.	*Clerodendrum inerme* (L.) Gaertn.	Verbenaceae	Dorsiventral	0.32	0.002	0.022	0.04
25.	*Derris trifoliata* Lour.	Leguminosae	Dorsiventral	0.15	0.002	0.010	0.018
26.	*Heliotropium curassavicum* L.	Boraginaceae	Isolateral	0.68	0.004	0.03	0.33
27.	*Sesuvium portulacastrum* L.	Aizoaceae	Isolateral	1.6	0.005	0.019	0.84
28.	*Suaeda maritima* Dumort.	Chenopodiaceae	Isolateral	1.47	0.003	0.066	0.15
Mangrove associates : Monocot							
29.	*Porteresia coarctata* (Roxb.) Takeoka	Poaceae	Isolateral	0.28	0.004	0.015	0.057

1 : considering the colourless non-assimilatory zone including hypodermis where present; 2-thickness measured in mm.

Derris, *Heliotropium*, *Heritiera*, *Sesuvium*, *Suaeda* and *Xylocarpus*. The walls of epidermal cells (in surface view) are usually straight but sinuous in *Porteresia*. The shape of cells is mostly polygonal except in *Nypa*, *Phoenix* and *Porteresia*, where it is more or less rectangular. In transverse section the cells are cubical, except in *Suaeda*, where they are semi-circular (Fig. 2G). The size of epidermal cells varies considerably among different genera, usually larger cells occur among the species of mangrove associates (e.g. *Heliotropium*, *Sesuvium* and *Suaeda*) but they are smaller in true mangroves (e.g. *Avicennia*, *Ceriops*, *Heritiera*, *Phoenix*, *Rhizophora* and *Xylocarpus*). The adaxial epidermal cells are often larger than those of the abaxial cells e.g. *Avicennia*, *Bruguiera* (Figs 1A, F, 3A,D-G) and *Heritiera* (Fig. 1H).

The hypodermis is composed of one or more layers of colourless cells below the adaxial epidermis. The colourless cells often function as water storage tissue. According to the symmetry of lamina, number of cell layers and position of colourless water storage tissue, four types of hypodermis have been distinguished :

(i) Lamina isolateral, hypodermis absent or rarely single-layered, colourless tissue deep-seated : *Heliotropium* (Fig. 2C), *Kandelia* (Figs 2E,3J), *Phoenix* (Fig. 1I), *Porteresia* (Fig. 2H), *Sesuvium* (Fig. 2D), *Sonneratia* (Figs 2F, 3K), *Suaeda* (Fig. 2G).

(ii) Lamina dorsiventral, hypodermis one-layered below adaxial epidermis, cells are polygonal, cubical or narrow and sometimes extensively vertically elongated : *Acanthus* (Fig. 1D), *Bruguiera* (Figs 1F,3D-G), *Clerodendrum*, *Nypa* (Fig. 2B), *Xylocarpus mekongensis* (Figs 1K,3L).

(iii) Lamina dorsiventral, hypodermis two-layered, cells are polygonal and often larger than the epidermal cells : *Ceriops* (Figs 1E,3C), *Derris* (Fig. 2I) *Heritiera* (Fig. 1H).

(iv) Lamina dorsiventral, hypodermis comprises more than two layers; the cells are cubical or polygonal in transverse section, larger than epidermal cells : *Avicennia* (Figs 1A,3A), *Aegiceras* (Figs 1B,3H), *Aegialitis* (Fig. 1C), *Excoecaria* (Figs 1G,3I), *Rhizophora* (Fig. 2A), *Xylocarpus granatum* (Fig. 1J).

The mangrove mesophyll is composed of thin-walled chlorenchyma. These cells can be differentiated into one or more layers of adaxial, anticlinally extended palisade cells, and oval or round shaped compact or loose abaxial isodiametric cells, e.g. *Acanthus* (Fig. 1D), *Aegiceras* (Fig. 1B), *Allamanda*, *Avicennia* (Fig. 1A), *Bruguiera* (Fig. 1F), *Ceriops* (Fig. 1E), *Clerodendrum*, *Excoecaria* (Fig. 1G), *Nypa* (Fig. 2B), *Rhizophora* (Fig. 2A) and *Xylocarpus* (Fig. 1J,K). One, two or even three layers of columnar palisade cells occur beneath each surface, and the middle cells become polygonal and colourless as in *Kandelia* (Fig. 2E), *Sesuvium* (Fig. 2D), *Sonneratia* (Fig. 2F) and *Suaeda* (Fig. 2G). In *Heliotropium* (Fig. 2C), instead of columnar palisade, the cells beneath each epidermis become oval and somewhat spongy, and the middle cells are polygonal and colourless. The adaxial palisade tissue in *Heritiera* is very loosely arranged and contains large number of air spaces (Fig. 1H). In *Porteresia*, the colourless polygonal cells usually surround the vascular and fibrous bundles. Mesophyll tissue often contains dark brown coloured tannin cells in the lower (*Ceriops*), and both upper and lower hypodermal regions (*Kandelia*, Fig. 3J). Large mucilage cells occur in the adaxial hypodermal region in *Bruguiera* (Fig. 1F) and *Rhizophora* (Fig. 2A), and beneath each epidermis in *Sonneratia* (Figs 2F,3K). The laticifers are common in the

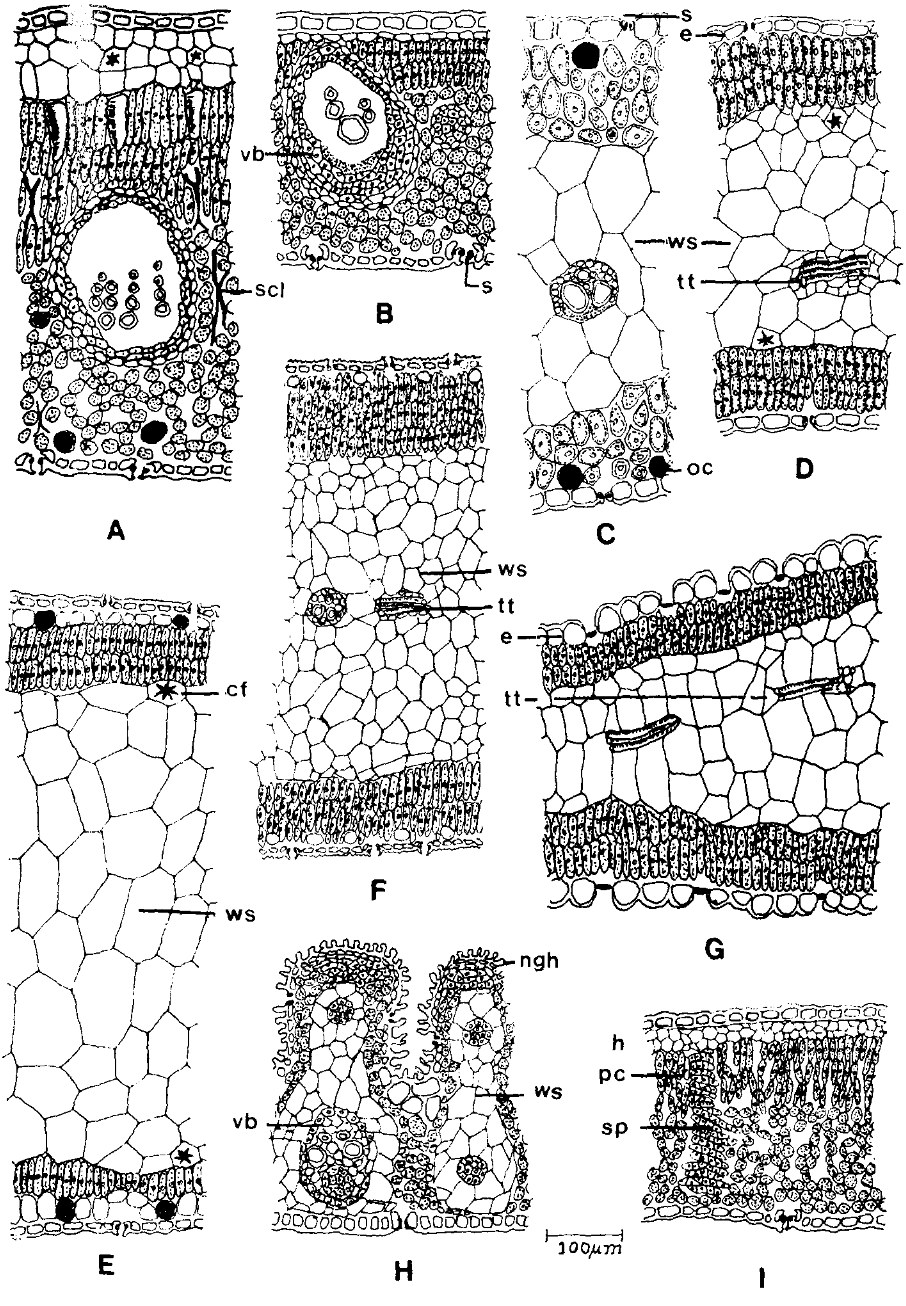

Fig. 2A-I — Camera lucida drawings of transections of leaves (*c*, cuticle; *cf*, crystalliferous cells, *e*, epidermal cells; *h*, hypodermis; *ngh*, non-glandular hairs; *oc*, oil cells; *pc*, palisade cells; *s*, stomata; *scl*, sclereids; *sp*, spongy parenchyma; *tn*, tannin cells; *tt*, terminal tracheids; *vb*, vascular bundle; *ws*, water storage tissue). **A.** *Rhizophora mucronata*. **B.** *Nypa fruticans*. **C.** *Heliotropium curassavicum*. **D.** *Sesuvium portulacastrum*. **E.** *Kandelia candel*. **F.** *Sonneratia apetala*. **G.** *Suaeda maritima*. **H.** *Porteresia coarctata*. **I.** *Derris trifoliata*.

hypodermal region of *Excoecaria*. Crystalliferous cells are common in many species e.g. *Bruguiera*, *Ceriops* (Fig. 1E), *Excoecaria* (Fig. 1G), *Kandelia* (Fig. 2E), *Rhizophora* (Fig. 2A), *Sesuvium* (Fig. 2D) and *Xylocarpus* (Fig. 1J,K).

Branched fibre-sclereids occur in a few species and lie scattered in the mesophyll cells of *Aegialitis* (Fig. 1C) and *Rhizophora* (Fig. 2A). Fibre bundles are frequent at the hypodermal region in *Phoenix* (Fig. 1J). Enlarged terminal tracheids are common in the mesophyll tissue of many of the species investigated e.g. *Avicennia, Aegiceras, Ceriops, Bruguiera, Excoecaria, Sesuvium, Suaeda and Derris* (Figs 1A, B, E-G, 2D,G,I).

The vascular bundles are usually sheathed by one or two layers of sclerenchyma in most of the taxa investigated but they are extended upto both the hypodermal regions in *Heritiera* (Fig. 1H). The sheath is absent in *Allamanda, Heliotropium, Sesuvium* and *Suaeda*, and well developed in *Aegialitis* (Fig. 1C) and *Nypa* (Fig. 2B).

The longitudinal veins are usually equidistant from each surface and independent of surface layers in most of the plants studied. Veins in abaxial mesophyll occur in *Heritiera fomes*, *Porteresia* and *Xylocarpus mekongensis*. The xylem of veins is situated on the adaxial side of the vascular bundles. The largest vascular bundle includes one or sometimes two wide metaxylem vessels and a few protoxylem elements. The phloem is situated on the abaxial side of vascular bundles. The largest vascular bundle includes one or sometimes two wide metaxylem vessels and a few protoxylem elements. The phloem is situated on the abaxial side of vascular bundle, and is separated from the xylem elements by one or additional layers of thin-walled paranchyma cells (e.g. *Acanthus*, *Bruguiera*, Fig. 3B, F, G).

On the basis of anatomical features of lamina an identification key to the genera of mangroves and their associates has been prepared.

1A. Leaves dorsiventral	...1
1B. Leaves isolateral	...15
2A. Leaves with glandular or non-glandular hairs	...3
2B. Leaves without glandular or non-glandular hairs	...8
3A. Non-glandular hairs present at the abaxial leaf surface	...4
3B. Non-glandular hairs absent at the abaxial leaf surface	...5
4A. Uniseriate 3-celled hairs present	...*Avicennia*
4B. Star-shaped stellate hairs present	...*Heritiera*
5A. Glandular hairs present on both surfaces of the leaf	...6
5B. Glandular hairs present only at the abaxial leaf surface	...*Aegialitis*
6A. Terminal tracheids present in the mesophyll	...7
6B. Terminal tracheids absent	...*Acanthus*
7A. Multilayer hypodermal tissue	...*Aegiceras*
7B. Single-layer hypodermal tissue	...*Clerodendrum*
8A. Hypodermis with well-developed colourless cells	...11
8B. Hypodermis single-layered	...9
9A. Stomata with elaborate ledges	...10
9B. Stomata without ledges	...*Allamanda*
10A. Vascular bundle encircled by sclerotic sheath	...*Nypa*
10B. Sclerotic tissue at the abaxial side of the vascular bundle	...*Bruguiera*

11A.	ached sclereids present in the mesophyll	...*Rhizophora*
11B.	ached sclereids absent	...12
12A.	minal tracheids extended from upper odermis to lower epidermis	...*Derris*
12B.	minal tracheids scattered in the mesophyll region	...13
13A.	series of tanniniferous cells present in the er hypodermal region	...*Ceriops*
13B.	nniniferous cells absent	...14
14A.	iciferous cells present in the mesophyll	...*Excoecaria*
14B.	iciferous cells absent	...*Xylocarpus*
15A.	aves with club-shaped hairs on adaxial surface	...*Porteresia*
15B.	aves without any hairs	...16
16A.	ticle layer smooth	...17
16B.	ticle layer uneven	...*Sonneratia*
17A.	t.s. epidermal cells barrel shaped	...18
17B.	.s. epidermal cells semi-circular	...*Suaeda*
18A.	ore bundles present at the hypodermal ion of both the surfaces	...*Phoenix*
18B.	ore bundles absent	...19
19A.	omata with distinct outer ledges	...*Kandelia*
19B.	omata without ledges	...20
20A.	il cells present on both upper and wer hypodermal region	...*Heliotropium*
20B.	il cells absent	...*Sesuvium*

Discussion

The present study reveals some common anatomical features among many mangroves and also in some of their associates; these features are (i) colourless water storage tissue at different levels of mesophyll and at hypodermal layers, (ii) short tracheids at the vein endings, (iii) absence of sclerotic vascular bundle sheaths (with the exception in *Heritiera* which has prominent sheaths extending up to both the hypodermis) and (iv) sclereids of various shapes. These features may be interpreted as an adaptation to climate and habitat. The presence of water storage tissue and terminal tracheids causes leaf succulence with high water content. Wehe (1964) on the basis of experimental evidences, reported that the leaf succulence of mangroves increased with the increase in salinity of the substrate. Biebl & Kinzel (1965) observed that in mangrove leaves fleshy texture and high water content develop with an increase in leaf thickness with age. According to Zimmermann (1983) both sclereids and tracheids are involved in capillary water storage. Tomlinson (1986) suggested that in addition to water storage, sclereids might also provide mechanical support to leaves with diminished turgor or discourage herbivores. The coriaceous nature of many mangrove leaves is probably due to presence of these sclereids.

The cuticle is considerably thick in many mangroves and the outer epidermis is always cutinized (present study). Artz (1936) reported that non-stomatal water loss is restricted by

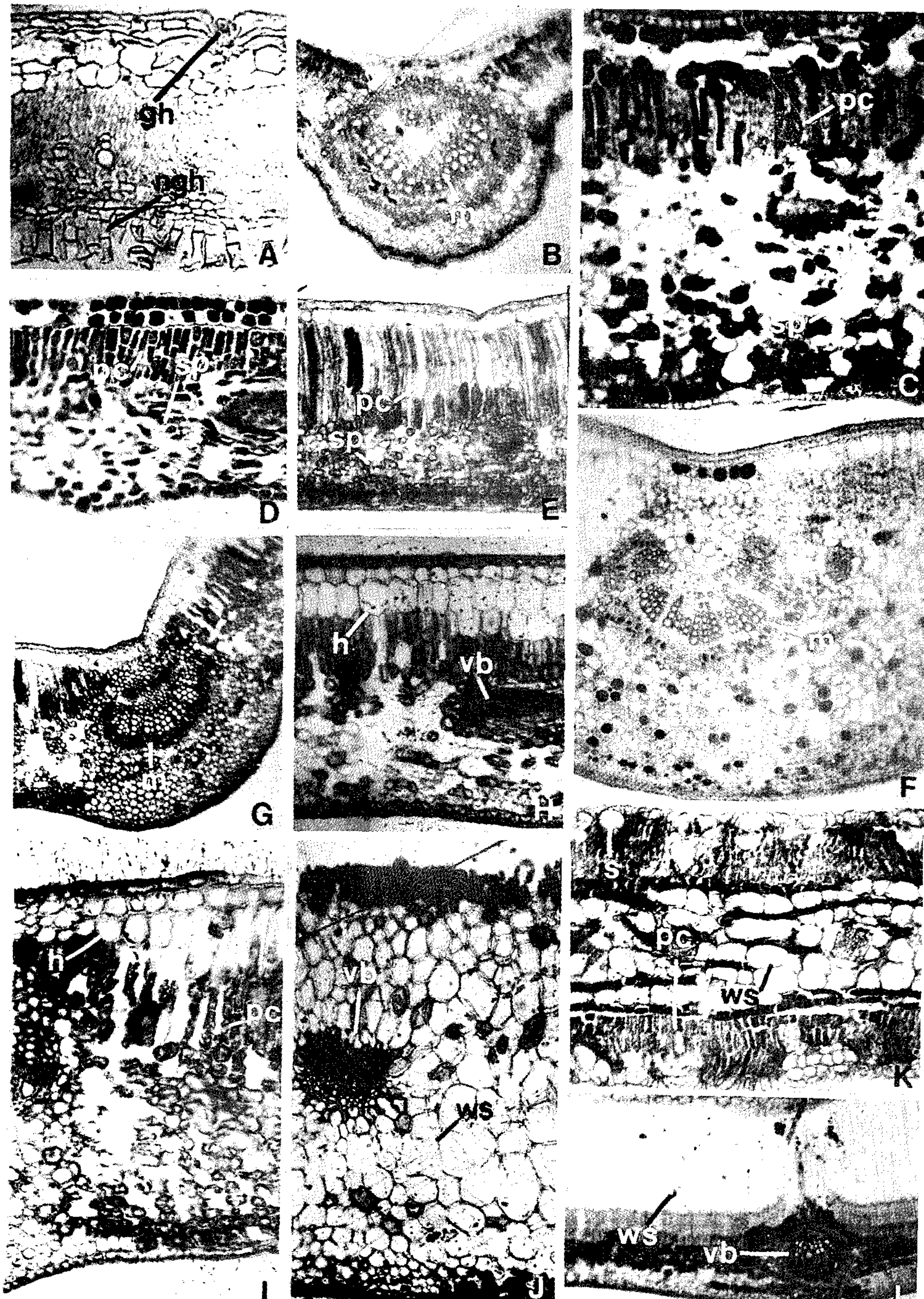

Fig. 3A-L

the presence of strongly cutinized thickened outer epidermal cells. The cuticle is generally smooth in most of the taxa studied except in *Aegialitis* and *Sonneratia*, where it is uneven. Tomlinson (1986) also reported sculptured cuticle in *Aegialitis*. Waisel (1972) assumed that the cuticle of mangrove leaves is an adaptive feature.

Chapman (1976), on the basis of transverse section of leaves categorized *Excoecaria* as isolateral, but we found it clearly dorsiventral because mesophyll is clearly demarcated into abaxial spongy parenchyma and adaxial palisade tissue and also by the presence of stomata only on abaxial epidermis.

On the other hand, Tomlinson (1986) described *Kandelia* leaves as dorsiventral but the present study shows that they have isolateral characteristics like presence of stomata on both abaxial and adaxial surfaces, palisade chlorenchyma beneath each epidermis and colourless water storage tissue occupying the middle region of the mesophyll.

It is interesting to note that *Heritiera* possesses some anatomical features which do not help adaptation to the habitat, for example, presence of the highest number of stomata per unit area (Das & Ghose 1993), thin cuticle interrupted by stellate hairs, almost absence of water storage tissue, loosely arranged mesophyll tissue, extensive bundle sheath extension upto both the hypodermal region and poor presence of chlorenchyma cells. All these features indicate that *Heritiera* is unsuitable to the highly saline habitat of the Sundarbans. Somewhat similar situation is also noticed in *Nypa* and *Phoenix*. They have thin cuticle, less developed colourless water storage tissue and sclerotic bundle sheaths.

Many mangroves and their associates contain some isolated specialized cells such as sclereids (discussed earlier, common in *Aegialitis* and *Rhizophora*), oil cells (in *Bruguiera* and *Heliotropium*), crystalliferous cells (in *Bruguiera, Kandelia, Rhizophora* and *Xylocarpus*), mucous cells (in *Bruguiera, Rhizophora* and *Sonneratia*), tannin cells (in *Ceriops*, *Kandelia* and *Rhizophora*) and laticiferous cells (in *Excoecaria*). Mullan (1931a, 1931b) observed that each palisade cell of *Bruguiera* and *Avicennia officinalis* has large oil globules. Shah & Sunder Raj (1965) reported brachysclereids as well as astrosclereids in the stipule of *Rhizophora mucronata*. Rao & Sharma (1968) reported lack of leaf sclereids in *Ceriops* but observed secretory cells in the palisade layer. Rao (1971) also observed two or more kinds of sclereids in *Aegiceras*. The exact chemical composition of the elements of these cells is rarely known in any detail and their functional activities are mostly conjectural (Tomlinson 1986). Thus, the chemical study of these ideoblasts of halophytes needs considerable attention.

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Fig. 3A-L — Photomicrographs of transections of leaves (*gh*, glandular hairs; *h*, hypodermis; *ngh*, non-glandular hairs; *pc*, palisade cells; *s*, stomata; *sp*, spongy parenchyma; *vb*, vascular bundle; *ws*, water storage tissue). **A.** *Avicennia alba*, showing adaxial glandular and abaxial non-glandular hairs, and multilayered adaxial hypodermis. x 90. **B.** *Acanthus ilicifolius*, note vascular bundle of mid vein semi-circularly arranged. x 30. **C.** *Ceriops decandra*, showing dorsiventral structure with dark coloured tanniniferous cells. x 80. **D.** *Bruguiera gymnorrhiza*, showing single-layered hypodermis. x 55. **E,F.** *B. cylindrica*, E showing single-layered hypodermis. x 55. **F.** Transection of midrib. x 90. **G.** *B. gymnorrhiza*, transection of midrib. x 40. **H.** *Aegiceras corniculatum*, note three-layered hypodermis and terminal tracheids. x 100. **I.** *Excoecaria agallocha*, showing three-layered hypodermis. x 110. **J.** *Kandelia candel*, showing colourless water storage tissue in the mesophyll region. x 40. **K.** *Sonneratia apetala*, showing isolateral structure with water storage tissue in the mesophyll zone. x 45. **L.** *Xylocarpus mekongensis*, note the hypodermal water storage tissue extended upto two-third area of the lamina. x 30.

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