CHAPTER - I

GENERAL INTRODUCTION
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The family Rhizophoraceae with 16 genera and 120 species of trees and shrubs has a wide range of distribution in tropics and subtropics (Tomlinson, 1986). Four genera of this family viz. Rhizophora L., Bruguiera Lam., Ceriops Arn. and Kandelia W & A., differ from other genera in their habitat and adaptations. According to Bentham and Hooker (1865) this family includes 17 genera and about 50 species. He divided these genera into three tribes namely Rhizophoreae, Legnotideae and Anisophylleae. The tribe Rhizophoreae which includes exclusively mangrove genera differs from other mangroves and tidal forest species by virtue of their viviparous seeds. Tomlinson (1986) depicted this tribe as 'mangrove Rhizophoraceae' because of their adaptability to mangrove ecosystems or mangals. Clough (1982) described mangroves as the only trees of higher plants that have been remarkably successful in colonizing the intertidal zone of the interface between land and sea. MacNae (1968) referred the term 'mangrove' to the individual trees or species and the term mangal for its community.
1. **Role of mangroves**

The importance of mangroves to human population is being increasingly recognized. They are excellent "reservoir" refuge feeding ground and nursery for a wide array of useful and interesting organisms. Mangrove ecosystems or mangals are salt tolerant forest ecosystems which occupy the land between high and low tide levels forming a labyrinthine interface between the land, the river and the sea. They play an important role in the livelihood of people especially in Asia and Pacific. Mangroves help to stabilise coasts, to slow down currents and to check the erosion of land by the sea. The network of characteristic anchoring stilt roots of *Rhizophora*, pneumatophores of *Avicennia* and *Sonneratia*, kneeroots of *Bruguiera*, trap sediment and help in building up of land. Scoffin (1970) reported that the mangroves can reduce tidal currents from 0.4 m per second to zero over a distance of a meter. Carter (1959) showed that removal of mangroves from shore resulted greater erosion. So a consummate study of mangrove ecology, morphology, anatomy, adaptations and modifications is necessary to drive the optimum economic and other benefits.
2. **Historical perspective and frame of existing knowledge**

Mangroves have attracted man's curiosity from the earliest times, but it was in 1970's that man began to understand and appreciate the role of this unique vegetation. The earliest known reference on mangroves goes back to 3580-3536 B.C. in an Egyptian inscription about Mangroves of Red sea. Theophrastus' (305 B.C.) *Historia plantarum* also gives an account of mangrove vegetation. Van Rheede's *Hortus Indus Malbaricus* (1678) gives an illustration of Indian mangroves of Malabar coast. In 1898 Schimper presented a detailed information of the Indo Malayan mangrove vegetation and Prain (1903) studied the mangrove vegetation of the Gangetic Sunderbans. Blatter (1905, 1908, 1909) gave an account of the distribution pattern and biology of mangroves from Bombay Presidency and Gulf of Kutch. The anatomy of aerial roots had been described by Warming (1883), Karsten (1891), Liebau (1914), Bowman (1917), Mullan (1932, 1933 a,b) and Gill and Tomlinson (1971 a). Marco (1935) described the anatomy of woods of Rhizophoraceae species from both mangals and upland forests of Indo-west Pacific region.

The earliest embryological observations were carried out by Karsten (1891), Cook (1907), Carey (1934) and recently by Juncosa (1982b; 1984 a & b). It is reported that the development of anther and pollen has not been investigated (Davis 1966; Johri, 1992). Hypocotyl anatomy of the genus Ceriops was investigated by Wilkinson (1981). Haberlandt (1895) examined the nutritional aspect of embryo.

3. Taxonomic considerations

The taxonomy of the family Rhizophoraceae has been studied extensively by a number of noted botanists: Brown (1814), Bentham and Hooker (1865); Schimper
(1898), Ridley (1922), Salvoza (1936), Ding Hou (1960), Melchior (1964) and Tomlinson (1986). Bessy (1915) and Hutchinson (1926) included Rhizophoraceae in order Myrtales. Subdivisions of Rhizophoraceae according to Hookers (1865) classifications are as follows:

**Tribe 1: Rhizophoreae**, consists of mangrove genera *(Rhizophora, Bruguiera, Ceriops and Kandelia)* which exhibits stipulated opposite leaves, inferior ovary, single style and exalbuminous embryo.

**Tribe 2: Legnotideae**, consists of inland genera *(Carallia, Gynotroches and Pellacalyx)* which exhibit stipulated opposite leaves, inferior or half inferior ovary, small embryo with fleshy albumen.

**Tribe 3: Anisophylleae**, consists of inland genera *(Anisophyllea and Combretocarpus)* which exhibit stipulated alternate leaves, inferior ovary, 3-4 styles exalbuminous macropodous embryo.

Schimper (1898) rejected Bentham and Hooker's proposals on the ground that adaptation characters are
insufficient to designate a natural group. As a result of this disagreement, Schimper proposed an entirely different classification. Subdivisions of Rhizophoraceae according to Schimper (1898) are as follows:

Subfamily 1: Rhizophoroideae, which exhibit perigynous or epigynous flowers, simple styles, opposite stipulate leaves.

Tribe 1 : Gynotrocheae

Subtribe 1: Gynotrochinae (consists of Crossostylis, Gynotroches, Ceriops, Kandelia and Rhizophora).

Subtribe 2: Carallinae (consists of Carallia, Pellacalyx and Bruguiera).

Tribe 2 : Mecarisieae (consists of Blepharistemma, Cassipourea, Dactylopetalum, Mecarisia and Weihea).

Subfamily 2: Anisophylloideae, which exhibit epigynous flowers, 3-4 styles, estipulate alternate leaves: consists only two genera Anisophyllea and Combretocarpus (Plate 7&8).
Ridley (1922) in his investigation found that the genera *Carallia*, *Gynotroches* and *Pellacalyx* (Plate 7) are closely related and raised the tribe *Legnotideae* of Bentham and Hooker (1865) into an independent family. Melchior (1964) divided the family Rhizophoraceae into four co-ordinated tribes: *Mecarisieae*, *Gynotrocheae*, *Anisophylleae*, and *Rhizophoreae*. Whereas Van Vliet (1976) supported the inclusion of Anisophyllaceae in Rhizophoraceae, based on the comparative anatomy on the two groups. Dahlgren (1980) in his new classification excluded the tribe *Anisophylleae* from the family Rhizophoraceae and given it the status of a family: *Anisophyllaceae*, in order: Cornales; Super order: Corniflorae; and placed the family Rhizophoraceae in his order: Rhizophorales; Super order: Myrtiflorae.

Recently Tobe and Raven (1987) emphasized the isolation of *Anisophylleae* from the order Myrtales and suggested a separate order Rhizophorales for Rhizophoraceae. Cronquist (1981) objected this view and placed Anisophyllaceae in Rosales (Rosidae) and Rhizophoraceae in order Rhizophorales. Behnke (1984) however, opposed the view of Van Vliet and suggested the separation of Anisophyllaceae from Rhizophoraceae based on the features of sieve tube plastids.
Tomlinson (1986) listed 6 eastern and 3 western species of *Rhizophora* L.

**Eastern species**

1) *R. mucronata* Lamk (Fig. 9)


   *R. macrorrhiza* Griff.

   *R. longissimia* Blanco.

   *R. latifolia* Miq.

   *R. mucronata* var. *typica* Hochreuter, Schimper.

2) *R. stylosa* Griff. (Plate 9).


3) *R. apiculata* Blume (Fig. 9)


   *R. conjugata* (non L.) Arn., Henslow, Hooker, Schimper.

4) *R. samoensis* (Hochr.) Salvoza

   Syn. *R. mangle* Guppy (non L.)

   *R. mangle* var. *samoensis* Hoch.
5) *R. X lamarckii* (Montr.) Salvoza, Ding Hou.

   Syn. *R. conjugata* var. *lamarckii* (Montr.)

   Guillaumin

   *R. pachypoda* Baillon.

6) *R. X selala* (Salvoza) Tomlinson


Western species

7) *R. mangle* L. (Plate 9)

   Syn. *R. mangle* var. *racemosa* Hiern

   *R. smoensis* Salvoza

8) *R. X harrisonii* Leechman

   Syn. *R. brevistyla* Salvoza

   *B. racemosa* (non Meyer) Bentham, A. chev., Exell., Hooker, Hutchinson & Dalzid, Oliver, Salvoza.

   *R. mangle* Hooker.

   *R. mangle* var. *racemosa* Mart.

9) *R. racemosa* Meyer.

   Syn. *R. mangle* var. *racemosa* Engler

   *R. harrisonii* Salvoza
The genus *Bruguiera* Lamarck is segregated into two groups: large solitary flowered and small many flowered (Tomlinson, 1986) Blume recognised these two groups as two different genera viz. *Bruguiera* and *Kanilia* (cf. Tomlinson, 1986). Whereas Ding Hou (1960) considered these two genera as a single one because of many morphological similarities of flowers irrespective of their number and size and he recognized 6 species:

1) **B. gymnorrhiza** (L.) Lamk. (Fig. 10)
   
   
   *Rhizophora palun* DC.
   
   *Rhizophora rheedii* Stend.
   
   *Bruguiera rheedii* Bl., Arn., Wight.

2) **B. sexangula** (lour.) Poir
   
   Syn. *Bruguiera eriopetala* Wight and Arnold
   
   *Bruguiera malabarica* F. Vill.
   
   *Rhizophora sexangula* Lour.
   
   *Rhizophora polyandra* Blanco
   
   *Rhizophora-eriopetala* stend.

3) **B. exaristata** Ding Hou

4) **B. parviflora** Wight and Arnold ex Griffith. (Plate 9)
   
   
   *Rhizophora cylindrica* Roxb.

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5) *B. cylindrica* (L.) Bl. (Fig. 10).

Syn. *Rhizophora cylindrica* L.

*Rhizophora caryophylloides* Burn., Jack

*Rhizophora ceratophylloides* Gm., Raeusch.

*Bruguiera caryophylloides* Arn.

*Bruguiera malabarica* Arn.

*Kanilia caryophylloides* Bl.

6) *B. hainesii* C.G. Rogers.


The genus *Ceriops* Arnold consists of two species.

1) *C. tagal* (Perr.) C.B. Robinson (Fig. 11)

Syn. *Ceriops candolleana* Arn.

*Ceriops timoriensis* Domin

*Rhizophora tagal* perr.

*Ceriops tagal* var. *tagal* Mac Nae

*Ceriops tagal* var. *australis* Mac Nae

2) *C. decandra* (Griff.) Ding Hou

Syn. *Ceriops roxburghiana* Arn. (Plate 9)

*Bruguiera decandra* Griff.

*Ceriops zippeliana* Bl.

*Rhizophora decandra* Roxb. W & A.
The genus *Kandelia* Wight and Arnold occupies a narrow niche in the mangrove communities with a single species.

*K. candel* (L.) Druce (Fig. 11).

Syn. *Kandelia rheedii* Wight and Arnold.

*Rhizophora candel* Linn., DC.

Though the knowledge of taxonomy, morphology and ecology of Rhizophoraceae is quite substantial, it is observed that a thorough knowledge of anther development, microsporogenesis, megasporogenesis and embryogenesis is lacking. As reported by Davis (1966) and Johri (1992) so far no study was carried out in anther development and microsporogenesis of this family. Further no attempt was reported on the comparative morphological observations of the family Rhizophoraceae from the west coast of India. A comparative morphological study of the family along the west coast of India was, therefore, felt essential and hence this challenging task was undertaken. The main objectives of the present study were to give a comparative account of the general morphology, microsporogenesis, pollen morphology, megasporogenesis, embryogenesis and seedling morphology.
of *R. mucronata*, *R. apiculata*, *B. cylindrica*, *B. gymnorrhiza*, *C. tagal* and *K. candel* from the west coast of India about which there are vast gaps in our knowledge. West coast has been selected as the study area because of the availability of six species of mangrove Rhizophoraceae representing all the four genera.