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# Study of Floral Morphology of Some Indian Mangroves in Relation to Pollination

[1]Arunima Ghosh, [1]Suparna Gupta, [1]Subrata Maity and [2]Sauren Das
[1]Department of Seed Science and Technology, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia-741 252, India
[2]Agricultural and Ecological Research Unit, Indian Statistical Institute, 203 B.T. Road, Calcutta-700108, India

**Abstract:** Floral morphology of four dominating mangrove species belonging to the two genera, Rhizophoraceae (*Bruguiera sexangula*, *Ceriops tagal* and *Rhizophora mucronata*) and Avicenniaceae (*Avicennia marina*) from Sundarbans, a world's largest mangrove swamps have been studied with special reference to their pollination mechanism. In the members of the family Rhizophoraceae, the floral parts are uniformly protected within a comparatively thick and fleshy calyx lobes, a number of filiform appendages present at the apex of the petals and the number of stamens are usually twice as many as the number of petals. The flowers are small, 4-stamens, shortly filamented and minute hairs present on the style; unilocular superior ovary in *Avicennia marina*. In all the investigated taxa the outcrops mechanism of pollination occur. Pollination agent varied from bird to insect. A basic knowledge of reproductive biology of a plant in important towards cope up a meaningful conservation strategy.

**Key words:** Floral morphology, mangroves, pollination, sundarbans

## INTRODUCTION

A group of biotic components constitute the marine environment of the tropical and subtropical world. Apart from the faunal and microbial diversity, true mangrove plant community (Tree or shrub) that are highly adapted to intertidal salinity stress plays a major role in this ecosystem. Mangrove vegetation define the landscape and act as a balancing factor of this ecological zone (Hamilton and Snedakar, 1984; Tomlinson, 1986). But this economic and ecological utility plant community is now under severe threat, mainly due to excessive demographic pressure. It is estimated that there are 181,399 sq km of mangrove vegetation which is only about 50% of the past vegetation coverage (Spadling *et al*., 1997). Over exploitation of this natural recourses causes depletion of mangrove forest is more than 1% in tropical world (Hatcher *et al*., 1989).

Hence, conservation of these unique vegetation should a primary task for any ecologists with proper management technique. A basic biological and morphological knowledge of the plant taxa, especially their reproductive biology is a must for adopting a meaningful conservation strategy (Lewis, 2000). Moreover, identification of the functional and adaptive significance of variation in flower morphology is fundamental towards the understanding of the process of seed production and floral evolution (Galen and Cuba, 2001; Aigner, 2004). Nishihiro *et al*. (2000) commented that the position of the stigma within the flower is a key aspect of flower morphology that influences the efficiency of pollen transfer. Cesaro *et al*. (2004) pointed that the intraspecific variation in stigma position is found to be associated with the interference of self-pollination.

Floral biology of mangrove species have been studied time to time (Aluri, 1990; Reddi and Aluri, 1997; Sun *et al*., 1998; Jayatissa *et al*., 2002; Coupland *et al*., 2006). Those works were based on

**Corresponding Author:** Sauren Das, Agricultural and Ecological Research Unit, Indian Statistical Institute, 203 B.T. Road, Calcutta-700108, India

floristic, biology, ecology, phytogeography, utilization and conservation of mangroves individually or in combination of them. As a consequence of vivipary and other seedling peculiarities, interest in the reproductive biology of mangroves has been centered on seed biology, Tomlinson (1986) described the basic botany of mangroves. Snedaker and Snedaker (1984) reviewed earlier mangrove research and made recommendations for further research. The present works deals with the floral biology in relation to pollination as it appears more obviously related to their fruit setting and seed characteristics.

## MATERIALS AND METHODS

Among the flora, Rhizophoraceae is known as true mangrove and it's the most dominant group, Avicenniaceae is the second largest group. For collection of material, three places were selected. (1) Patharpratima, (2) Bakkhali, (3) Naamkhan of the district 24-Parganas (South), the area belongings to the Sundarbans mangrove swamps (Fig. 1). Flowering twigs were randomly collected from the well identified plants of the two families viz. Rhizophoraceae (*Rhizophora mucronata*, *Bruguiera sexangula* and *Ceriops tagal*) and Avicenniaceae (*Avicennia marina*).

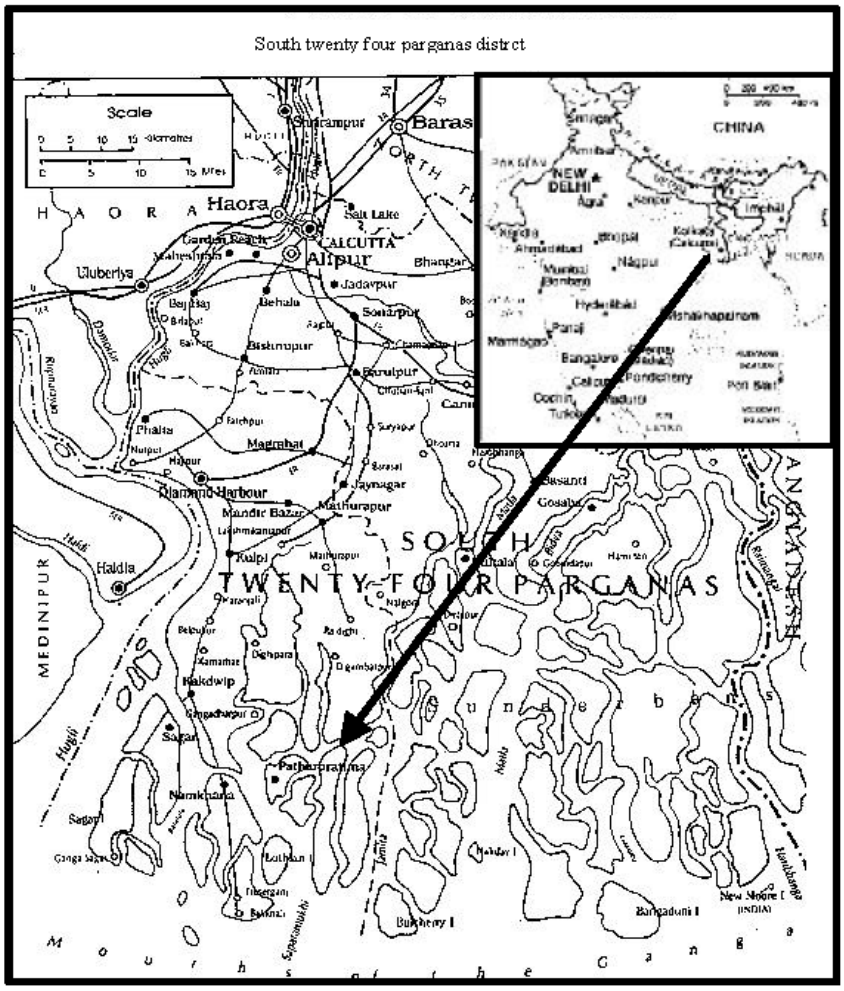


Fig. 1: The location map of the plant samples collection

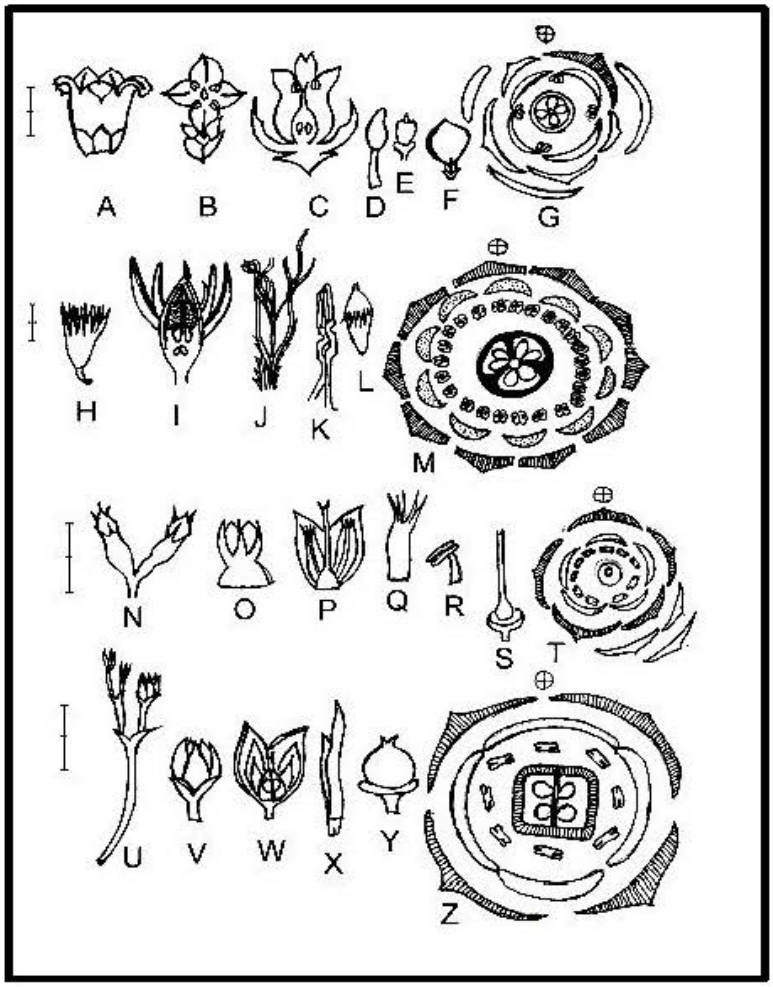


Fig. 2: A-Z. Dissected floral parts of the investigated taxa. A-G: *Avicennia* sp. A: flower, B: Anterior view of the flower, C: L.S. of the flower, D: Androecium showing anther and filament, E: Gynoecium showing ovary style and stigma, F: Fruit, G: Floral diagram of the given specimen. H-M: *Bruguiera sexangula*. H: Flower, I: L.S. of the flower, J: Petals showing attachment of the anther, K: Androecium showing anther and filament, L: Fruit, M: Floral diagram of the given specimen. N-T: *Ceriops tagel*. N: Twig, O: Flower, P: Petals showing attachment of the anther, Q: Petal, R: Androecium showing anther and filament, S: Gynoecium showing ovary, style and stigma, T: Floral diagram of the given specimen. U-Z: *Rhizophora mucronata*. U: Twig, V: Flower, W: L.S of flower, X: Androecium showing anther and filament, Y: Fruit, Z: Floral diagram of the given specimen

Flowers were dissected in order to describe the basic form of flowers and floral parts and illustrated with camera lucida drawings (Fig. 2). Dissected floral parts at different stages of maturity were measured with a graduated side for easy understanding the differential period of maturity of androecium and gynoecium of a same flower in order to ascertain the possible mechanism of pollination.

## RESULTS

**Description of the Investigated Taxa: Rhizophoraceae**

The family Rhizophoraceae includes the largest taxonomic assemblage exclusively of mangroves, with 4 genera and about 18 species. All species have the same basic floral structure, but field observations a wide variety of pollination mechanisms. Variation in such features as size and orientation of flowers, numbers of flowers per inflorescence, number of stamens, time of stamen dehiscence of method of pollen discharge can be shown to have direct relevance to pollination biology. Pollen vectors predominantly wind incase of *Rhizophora.* An explosive method of pollen release occurs in *Bruguiera* and *Ceriops tagal,* but is modified to suit a range of flower visitors such as birds in the large flowered *Bruguiera* sps. e.g., *B. Parviflora* and moths in *Ceriops tagal. Ceriops decandra* lacks the explosive mechanism of pollen release. There is similar district trend for self-incompatibility in *Rhizophora* and *Ceriops.* This pattern is less clear in *Bruguira.* Bees regularly visit and pollinate species of *Rhizophora.* Some wasps and flies are highly dependent on mangroves for nesting and are particularly important pollinators of *Ceriops decandra. Rhizophora* species produce prolific amounts of pollen and are mainly wind-pollinated, though the stigma has no special modifications in top to capture the wind-borne pollen (Tomlinson, 1986). So, the flowers of mangrove Rhizophoraceae are adapted to three different pollination mechanism i.e., *Rhizophora*-wind pollinated, *Ceriops decandra*-insect pollinated and explosive pollen release evolved independently in *Ceriops tagal* and in *Bruguiera.*

**Avicinniaceae**

The family Avicenniaceae is the second largest family after Rhisophoraceae in mangroves. It comprises of only one genus Avicennia. Flowering and pollination of the tree, Avicenmia were examined from Sunderban under West Bengal area. From the above table it was studied that individual flowers are protandrous and open for 2-4 week. *A. officinalis* is occationally self-fertile but mostly cross-fertilize. In *A. marina* protandry makes self pollination of an individual flower unlikely. About 16000 pollen grains and four ovules are produced per flowers. Self pollination of an individual flowers is unlikely because of protoandry, but the sequence and synchrony of flowering, together with pollinator behaviour, flavours geitonogamy. Phonologically each reproductive stage is unimodal and the whole process from bud initiation to abscission of mature fruit is completed within a years.

**Floral Morphology: Taxonomic Description**

| | | |
|---|---|---|
| Specimen | : | *Rhizophora mucronata* |
| Vernacular name | : | Gorjon |
| Inflorescence | : | Axillary cyme, 2-3 chotomously branched; upto 5.3 cm long, 4 flowers in each peduncle, opposite, ebracteate, 6-8 inflorescence in each branch. |
| Flower | : | Ebracteate, upto 2.0 cm long with long stalk, regular hermaphrodite, glabrous, erect. |
| Calyx | : | It persistent in fruit, sepals 4, polysepalous, ovate, acute. |
| Corolla | : | Petals white, polypetalous, hairy in margin. |
| Stamens | : | Eight in number, free, four stamens opposite to sepals, superior, filaments short, 1.0 cm long, round, white basifixed, anther bilobed, introrse. |
| Carpel | : | Two, syncarpous, ovary globose, inferior, 0.3 cm long, two chambered, 2 ovules in each chamber. |
| Capsule | : | 5-7 cm long, 7.5 cm periphery with 4 persistent sepal teeth. |
| Seed | : | One, covered by thick indehiscent pericarp, after maturation the seed bifurcated transversely within fruit, seed 1.8 cm long × 2.2 cm diameter, germinate when the fruit hang in mother plant. |

**Flowering and Fruiting Time: July to January**

**Distribution**

Common on the tidal forests of the sundarbans, along with the other mangroves species. In India distributed throughout the muddy shores and the tidal creeks: also distributed in Bangladesh, Sri Lanka, Tropics of the Old World and Australia.

**Floral Morphology: Taxonomic Description**

| | | |
|---|---|---|
| Specimen | : | *Bruguiera sexangula* |
| Vernacular name | : | Cancra bokul |
| Inflorescence | : | Solitary, single flower in each peduncle, flowers ebracteate, pedicillate, pedicel 1.0 cm long. |
| Flower | : | Bisexual, regular, spiral, pendulous, 2.0 cm long. |
| Calyx | : | Sepals 10-12, polysepalous, pointed sepal lobes above but cup shaped base, yellowish, glabrous, ridged, 1.5 cm long, persistent in fruit and viviparous germinated hypocotyle. |
| Corolla | : | 10-12 petals, polypetalous, yellowish |
| Androcium | : | Stamens 20-24, free, 2 stamens pairs within one petal, filament upto 0.25 cm long; basifixed, anther bilobed. |
| Gynoecium | : | Carpels-3, syncarpous, ovary 0.5 cm long, superior, cup shaped, 2-4 celled, 2 ovules in each chamber. |
| Fruit and seed | : | Capsule, pendulous with persistent calyx; seed one, seed germinates when the fruit hang in mother plant, mature viviparous germinated hypocotyle attain the length upto 12.0 cm long and 2.5 cm diameter. Hypocotyls fall on the underneath soil and immediately anchor on soft soil and from gregarious seedling plants. |

**Flowering and Fruiting Time: January to May**

**Distribution**

Occasionally found on the tidal zones of the mangrove littoral forests, sides of the small rivers and creeks. In India it is distributed in the sundarbans, Orissa, Carole coast, Andaman and Nicobar Islands also in Bangladesh's Lanka etc.

**Floral Morphology: Taxonomic Description**

| | | |
|---|---|---|
| Specimen | : | *Ceriops tagal* |
| Vernacular name | : | Goran |
| Inflorescence | : | 2.0 cm long, within leafy cluster, cyme, opposite decussate, ebracteate, peduncle develop from leaf base, peduncle erect but lent downwards, 1.0 cm ,galbrous, green flattened, 2-4 peduncles terminate into 4-6 shout branches, each branch have 2-3 flowers. |
| Flowers | : | Short, pedicellate, 0.1 cm long, glabrous, green, bisexual, complete, regular, rosaceous, pentamerous, minute, 12-12 flowers on single peduncle. |
| Calyx | : | 5-sepals, polysepalous, superior, elliptic-lanceslate, entire, thick, green, acute, 0.45 cm long × 0.25 cm, broad at base, persistent, tapering end, woody, equal length, upper surface same level. |
| Corolla | : | 5-petal, polypetalous, valuate, petals white, thin herbaceous, inconspicuous venlets; petals 0.3 cm long. |
| Androcium | : | 10-stamens, free superior, filament 0.25 cm long, terete, soft, white, anther bilobed, 0.1 cm long, sagittate, introrse, inserted, filaments unequal length. |

| | | |
|---|---|---|
| Gynoecium | : | 3-carpels, syncarpous, ovary inferior, elliptic globose, 2 chambered, axile placentation, 2 ovules on each chamber, but 1 survives and 3 degenerate, 0.3 cm diameter, style terminal 0.3 cm long, tereli, short, greenish white, glabrous, stigma-3, shortly tri-fid. |
| Fruit | : | Capsule 2.5 cm long with 5 persistent calyx, brown with rough surface, sharp pointed apex. |
| Seed germination: | | Epigeal, viviparous, hypocotyle upto 25.0 cm long, pendulous and sharp end and ridged. |

**Flowering and Fruiting Time: January to May**

But viviparous germinated hypocotyls present on the mother plant throughout the year.

**Distribution**

Occasionally found on riverslopes, the sides of the creeks and tidal forests of the sundarbans: associated with the other mangrove species. Distributed throughout the tidal swamps and along the coasts; also distributed in the Tropical World.

**Floral Morphology: Taxonomic Description**

| | | |
|---|---|---|
| Specimen | : | *Avicennia marina* |
| Vernacular name | : | Kala bain |
| Inflorescence | : | Cyme globuse, compound spike, peduncle long upto 10.0 cm, infrequently branched, glabrous, round, condensed terminal cyme. |
| Flowers | : | Flower head capitate, flower 4-lobed, actinomorphic, condensed in terminal or axillary cyme, sessile, 0.5-0.9 cm long, 0.5 cm across in open condition, pale yellow or orange yellow, complete bisexual, regular, cyclic, hypogynous. |
| Calyx | : | 5-sepals, polysepalous. |
| Corolla | : | 4-petals, gamopetalous. |
| Androcium | : | 4-stamens, epipetalous, filament 0.2 cm long. |
| Gynoecium | : | Ovary superior, 0.3 cm long, dumbbell shaped. |
| Fruit | : | Spherical to ovoid, with short apical, beak, flattened 2.5 cm. |
| Seed germination: | | Crypto-viviparous, seedling germination. |
| Seed | : | Simple, dark green, completely occupy the fruit cavity. |

**Flowering and Fruiting Time: June to September**

**Distribution**

Grow on the tidal forests and river banks of the Sundarbans ridge forests. Distributed throughout the mangrove swamps of India: Very common in the Bangladesh Sundarbans and all other tropical mangrove forests of the world.

## DISCUSSION

Table 1 represents a glimpse of floral characteristics of some of the dominating taxa from two different Families such as Rhizophoraceae (*Rhizophora mucronata, Bruguiera sexangula* and *Ceriops tagal*) and Avicenniaceae (Avicennia marina) from Sundarbans vegetation. In all the cases the flowers are actinomorphic. In the members of the family Rhizophoraceae, the floral parts are uniformly protected within a comparatively thick and fleshy calyx lobes, a number of filiform appendages present at the apex of the petals and the number of stamens are usually twice as many as the number of petals,

Table 1: Comparative account of the floral parts of the investigated taxa

| Species | Complete flower length | Sepal | Petal | Androecium | |
|---|---|---|---|---|---|
| | | | | Anther | Filament |
| *Rhizophora mucronata* | 1.590±0.04 | 1.520±0.03 | 1.340±0.03 | 0.155±0.02 | 0.925±0.03 |
| *Bruguiera sexangula* | 3.810±0.04 | 2.120±0.02 | 1.415±0.02 | 0.345±0.04 | 0.905±0.03 |
| *Ceriops tagal* | 0.825±0.02 | 0.590±0.02 | 0.360±0.03 | 0.048±0.07 | 0.337±0.02 |
| *Avicennia marina* | 0.460±0.02 | 0.295±0.02 | 0.465±0.02 | 0.145±0.01 | 0.320±0.02 |

| Species | Gynoecium | | | Relative length of anther and stigmatic head | Outbreeding mechanism |
|---|---|---|---|---|---|
| | Style | Stigma | Ovary | | |
| *Rhizophora mucronata* | 0.365±0.02 | 0.095±0.01 | 0.435±0.02 | 1.205±0.02 | Possibly weak, protandry, favour outcrossing |
| *Bruguiera sexangula* | 0.140±0.01 | 2.255±0.03 | 0.380±0.04 | 0.451±0.02 | Pollination may favour outcrossing |
| *Ceriops tagal* | 0.047±0.04 | 0.150±0.01 | 0.173±0.03 | 1.144±0.17 | Pollination may favour outcrossing |
| *Avicennia marina* | 0.080±0.01 | 0.075±0.01 | 0.205±0.02 | 1.323±0.08 | Protandrous, Pollination outcrossing |

but in *Kandelia candel* (a member of the family Rhizophoraceae) the stamens are numerous (Das, 1994). In *Avicennia marina*, the flowers are small, 4-stames, shortly filamented and minute hairs present on the style; unilocular superior ovary.

The floral characters are obviously related to their pollination mechanisms and fruit/seed characteristics. Tomlinson *et al*. (1979) observed the floral biology of the family Rhizophoraceae and commented that a wide range of pollination mechanisms exist in the members of the family. The present work is in conformity of that, the larger flowered members showed bird pollination and the small flowered showed insect pollination. The floral characters revealed that in both the family members outbreeding mechanism occur. Based on the bagging experiments Sun *et al*. (1998) commented that automatic self-pollination is negligible and as the anthesis occurred in several flowers consecutively at the same time of a same or different inflorescences of a single plant, the potential for geitonogamous selfing is high. Cesaro *et al*. (2004) pointed out the possible reasons of inhibiting self-pollination is the intraspecific size variation of the reproductive parts of the flower. Setoguchi *et al*. (1996) worked on *Crossostylis* sp., an inland species of Rhizophoraceae and found marked differences in floral morphology from that of other mangrove species of the same family. Coupland *et al*. (2006) assessed natural rates of floral abortion in four common mangrove species from northern Australia and observed low rates of fruit setting in *Ceriops* and *Rhizophora* sp. is due to lack of autogamy. Pollinators were expected to be more important for the outcrossing species than for the selfing species and this was confirmed by the results of the exclusion experiments (Pandit and Choudhury, 2001). The present investigation reveals that the all studied taxa shows outcrops type of pollination. In all the studied taxa, the persistence of calyx lobes till the fruit setting seems to be a protective element for successful fruit setting. The percentage of fruit setting in those species are yet to be worked out.

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