

DISTRIBUTION OF MANGROVES

The mangrove cover of the world was estimated to be 15.2 million hectares of which about 90 % is present in the developing countries. Mangroves require warm tropical average temperature of about 20°C in coldest months with seasonal temperature range around 5°C. This restricted distribution is mainly due to the sensitivity of the mangrove species to frost and cold temperatures. The most northerly site of mangrove distribution is the tip of the Red Sea in the Gulf of Aquaba (30° N) and in the south Japan (32° S), while the most southerly sites for mangrove distribution are Australia (38° S) and Chathan Island of New Zealand (44° S).

The geomorphology, environmental and hydrological conditions are responsible for the distribution of mangrove species. Apart from physical conditions such as soil type, rainfall, tidal inundation and fluctuation, salinity gradient, the biotic factors also play important role in mangrove distribution. In salinity gradient, polyhaline and mesohaline zones (salinity 5 – 30 ‰) harbour many mangrove species. The oligohaline zone (salinity 0.05 – 5 ‰) supports limited species such as *Kandelia candel*, *Sonneratia caseolaris* and *Acrostichum aureum* (Fig. 3).

Mangrove species occupy their respective positions in the intertidal areas depending on their requirement for substrate, water replenishment, topography etc. Some of the mangrove species such as *Avicennia* spp. prefer firm exposed substratum towards the landward side, whereas *Sonneratia* sp. grows in soft substrate in the sheltered estuarine mouth. *Bruguiera* and *Rhizophora* spp. are found in sandy, firm bottom and also in the regions of low tide area.

The global distribution of mangroves is divided into two hemispheres: the Atlantic East Pacific and the Indo West Pacific. The Atlantic East Pacific has fewer species than the Indo West Pacific (12 compared to 58 species, respectively) (Fig. 4). Species composition is also very different between the two hemispheres. Out of the 82 mangrove species belonging to 52 genera and 36 families recorded from both the hemispheres, only one, the mangrove fern, is common to both hemispheres. The most extensive mangrove cover is found in Asia, followed by Africa and South America. Four countries, namely Indonesia, Brazil, Nigeria, and Australia account for about 41% percent of all mangroves of the world (Table 1).

Rocky and Sandy	Sandy Clay	Silty Clay	Silt	
Mangroves absent	<i>Sonneratia alba</i> <i>Rhizophora mucronata</i> <i>Avicennia marina</i> <i>Avicennia officinalis</i> <i>Bruguiera gymnorhiza</i> <i>Bruguiera cylindrica</i> <i>Acanthus ilicifolius</i>	<i>Kandelia candel</i> <i>Avicennia officinalis</i> <i>Rhizophora mucronata</i> <i>Aegiceras corniculatum</i> <i>Sonneratia alba</i>	<i>Sonneratia caseolaris</i> <i>Acrostichum aureum</i> <i>Cyperous</i> spp.	
Euhaline	Polyhaline	Mesohaline	Oligohaline	Limnetic
40 to 30 ‰	30 to 18 ‰	18 to 5 ‰	5 to 0.5 ‰	0.5 ‰

Fig. 3 Zonation of mangrove species according to substratum and salinity

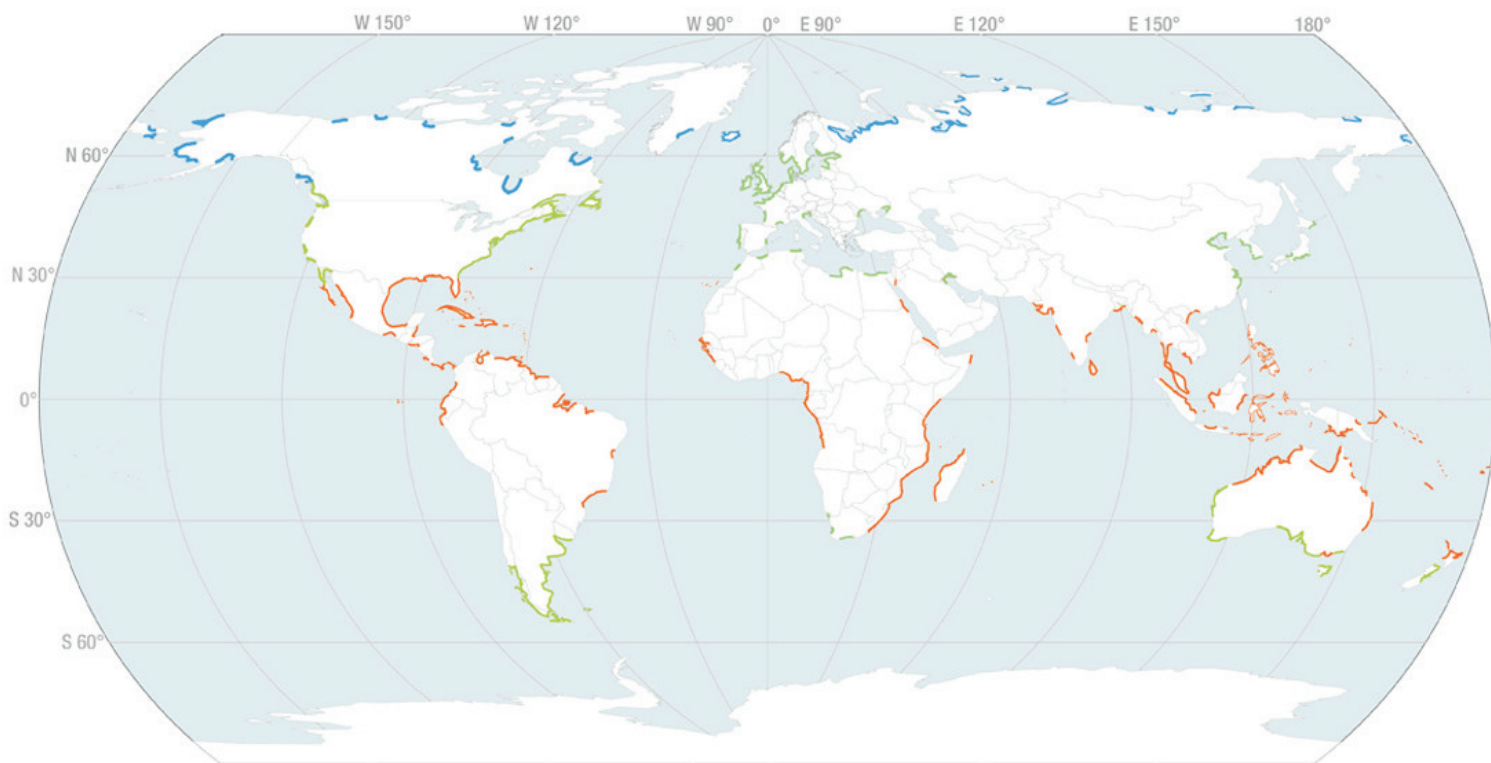


Fig. 4. Distribution of World Mangroves

• Mangroves

In the continental United States, mangroves are mainly distributed along the Atlantic and Gulf coasts of Florida. They also occur in Puerto Rico, the U.S. Virgin Islands, Hawaii, and the Pacific Trust Territories. Mangrove coverage of approximately 1,750 sq. km was reported along the Florida coast, with the highest development along the southwest coast. The Gulf of Mexico and Caribbean regions are characterized by low species richness, with only four dominant species: *Rhizophora mangle*, *Avicennia germinans*, *Laguncularia racemosa* and *Conocarpus erectus*. The mangroves of the Pacific Islands are represented by a very different assemblage of species belonging to the Australasian group. Some of the more characteristic genera include *Bruguiera*, *Rhizophora*, *Avicennia*, *Sonneratia*, and *Cerriops*.

The south and south east countries showed variety of mangrove species, however, their distribution and abundance varied largely due to the environmental factors, developmental pressure and natural forces. Countries situated near the equator, particularly with high humidity and rain fall have favorable condition for mangrove growth. Over all, countries such as Vietnam, India, Darussalam, although have more or less similar number of species, they widely differ in their species composition, distribution and abundance.

MANGROVE DISTRIBUTION IN INDIA

Mangroves in India are spread over an area of 4,639 sq. km. occupying only 0.14 % of Asian mangrove coverage. Around 80 % of mangroves are along the east coast of India and 20 % along the west coast of India (Table 2). This differentiation in the mangrove coverage could be attributed to large estuaries; Ganga and Brahmaputra that pour in to the Bay of Bengal with large deltas and smooth muddy slopes create ideal sites for

Table 1.

Countries with the largest mangrove areas in the world

Sr.No	Country Name	Mangrove Proportion (area in km ²)	(global total)
1.	Indonesia	31,894	20.9 %
2.	Brazil	13,000	8.5 %
3.	Australia	9,910	6.5 %
4.	Mexico	7,701	5.0 %
5.	Nigeria	7,356	4.8 %
6.	Malaysia	7,097	4.7 %
7.	Myanmar	5,029	3.9 %
8.	Bangladesh	4,951	3.2 %
9.	Cuba	4,944	3.2 %
10.	India	4,326	2.8 %
11.	Papua New Guinea	4,265	2.8 %
12.	Colombia	4,079	2.7 %

Source: Spalding et al., 2010

colonization of mangrove species. Whereas west coast has funnel shaped estuaries with no delta formation and has steep and vertical slope. Mangroves are found growing on the banks of estuaries. The mangrove forest cover in India is classified as very dense, moderately dense and open types based on percentage of green cover, i.e. >70 %, 40-70 % and 10 to 40 %, respectively.

East coast of India

Along the east coast, dense mangrove formations are found in Sundarbans in West Bengal with maximum mangrove cover of 46.39 %. Sundarban mangrove forest shows the highest taxa diversity, 69 species, 49 genera, 35 families, including two species, viz. *Scyphiphora hydrophyllacea* and *Atalientia corea* reported for the first time from Sundarbans. In addition, *Acanthus volubilis*, which was regarded as extinct, has been recorded again with its very limited population existing in confined location. This species has not been reported from any other mangrove habitat in India. Importantly, it has been found that both the mangrove palms: *Nypa fruticans* and *Phoenix paludosa* are largely restricted to Sundarban mangrove area and to Andaman & Nicobar groups of Islands; the latter species also occurs in Bhitarkanika mangrove forest.

Other habitats have the following diversity.

Subarnarekha mangrove forest harbours 18 species, 14 genera, 11 families; Bhitarkanika mangrove forest has 57 species, 37 genera, 29 families including one new species *Heritiera kanikensis* and with relatively higher number of true mangroves. Godavari & Krishna delta have 36 species, 26 genera, 21 families; Pichavaram mangrove has 35 species, 26 genera, 20 families, including one new species *Rhizophora annamalayana* Kathir, a hybrid of *R. apiculata* and *R. mucronata*. Andaman & Nicobar group of Islands harbour 61 species distributed in 39 genera and 30 families, including two new species, *R. lamarkii* and *R. stylosa* and has the maximum species of the genus *Rhizophora* (four species)

West coast of India

In all 34 species, 25 genera and 21 families have been reported from west coast of India. Out of these, 21 species have been reported from Gujarat, 28 from Maharashtra, 16 from Goa, 18 from Karnataka, 12 from Kerala and 1 from Lakshadweep group of Islands. Over the years many mangrove areas such as Rann of Kutch, Kandla, Mundra, Gulf of Khambat etc. along the Gujarat coast have been lost due to industrialization, use as fodder for camels/cattle, as fire wood etc. However, recent mangrove plantation programme undertaken by Gujarat Govt. has improved mangrove coverage considerably

Table 2. State/UT wise mangrove cover 2013 (Area in sq. km)

Sr. No.	State/ UT	Very dense	Moderately dense	Open	Total	Change (w.r.t. 2003)
1.	Andhra Pradesh	0	126	226	329	0
2.	Goa	2	20	6	28	0
3.	Gujarat	0	175	928	936	43
4.	Karnataka	0	3	0	3	0
5.	Kerala	0	3	3	8	0
6.	Maharashtra	0	69	117	158	0
7.	Orissa	82	88	43	203	0.9
8.	Tamil Nadu	0	16	23	35	0
9.	West Bengal	993	699	405	2,118	-57
10.	Andaman & Nicobar	276	258	70	637	-13
11.	Daman & Diu	0	0	1	1	0
12.	Pondicherry	0	0.14	1.49	1	007
Total		1,353	1,457	1,823	4,457	-34

Source : Forest Survey of India, Dehradun

along the Gujarat coast. The most dominant mangrove species of Gujarat is *Avicennia marina* which forms almost pure stand at many localities along the Gujarat coast.

The Maharashtra coast has most diverse mangrove flora along the west coast of India. The Mumbai coast, once comprised of seven islands with luxuriant mangrove coverage was lost due to deforestation and reclamation for development, agriculture, habitation and pollution. Presently, very few mangrove areas such as Thane, Mahim, Vikroli, Mumbra, Vasai etc. are remaining in Mumbai, however, they are under constant threat. The other localities along the Maharashtra coast with luxuriant mangroves are Kundalika estuary (Revdanda), Shigao creek (Ratnagiri), Vaghotan (Vijaydurg), Kolam, Achra etc. which needs protection.

The estuarine systems of the Karnataka coast have fringing mangroves. About 18 species have been reported from this coast. The luxuriant mangrove formations are found growing along the estuaries like Kalinadi, Belamdarnadi, Gangavali and Agnashini. Dense mangrove consisting of very old trees of *R. mucronata*, *S. caseolaris* and *A. officinalis* are found along Sharavati estuary, mostly at Karki, Haldipur, Dhareshvar, Honavar. The dense mangroves vegetation is present at Coondapur, particularly in the confluence zone of the three estuaries namely Chakra, Kollur and Haladi, just before they open into the Arabian Sea.

The Kerala coast, although, left with a small patch of mangroves at present, there had been luxuriant mangroves along the estuaries and backwaters of the Kerala coast. Out of the 12 species reported from this coast, the most dominant were *Avicennia officinalis*, *A. marina*, *Bruguiera cylindrical*, *B. parviflora*, *Rhizophora mucronata*, *R. apiiculata*, *Kandelia candel* etc. Land reclamation for agriculture, construction and aquaculture has resulted in the destruction of mangroves. Efforts to



Fig. 5 Mandovi & Zuari estuary

rehabilitate mangrove are being made by Kerala Govt., many NGO's and coastal fishermen.

Goa coast

Goa is situated in the Central-West Coast of India, borders the Arabian Sea and extends from North to South. The total length of the Goa coast is approximately 105 km and lie within the latitude 15° 48' 00" N - 14° 53' 54" N and longitude 74° 20' 13" E - 73° 40' 33" E. Along the Goa coast there are seven estuaries fringed with mangroves. There exists an intricate network of creeks and backwaters. A luxuriant growth of mangroves and associated swamps can be observed along most of the water bodies within the estuarine reaches.

About 16 mangroves and few associated species have been recorded from the Goa coast. Mondovi - Zuari estuarine complex harbours variety of mangrove species



Fig. 6. Satellite photograph of Chorao Island

(Figure 5). As per earlier estimates, the total area covered by the estuaries in Goa including the major Mandovi Zuari estuarine complex is approximately 12,000 ha of which the mangrove forest occupy 2000 ha. About 900 ha of mangroves are found along the Zuari estuary, 700 ha along the Mandovi estuary and 200 ha along the Cumbarjua canal. However, as on today, the total mangrove area has been estimated to be 22 sq. km.

The composition of mangroves varies at different locations. The size of the propagules of different species plays an important role in establishment of the species in different zones which are formed from high tide level to the low tide level. The longitudinal and vertical strata are very distinct and it forms a compact mass of canopy. The varying colour of canopy from pale green, pale yellowish green to dark green and blackish green from high tide level to low tide level presents distinct species composition along the estuaries. The predominant mangrove species are *R. mucronata*, *S.alba*, *A. officinalis* etc. the other widely distributed species are *R. apiculata*, *S. caseolaris*, *K. candel*, *B. gymnorhiza*, *Aegiceras corniculatum* etc.

CHORAO (CHODAN) ISLAND – DR. SALIM ALI BIRD SANCTUARY

Chorao Island lies in the backwaters of Mondovi estuary, with extensive mangroves towards the western low-lying tip. It is located between 15°25' - 15 °30'N Lat. and 73 °45'E - 73 ° 59' E Long. This natural Island was formed as a result of sedimentation of the Mapusa, Norora

creek and Mandovi estuary (Fig. 6). It is a basically rocky projection of basalt but the land surface has been peripherally extended by heavy siltation up to the present edge of the estuarine water. Earlier the backwater area of this island was protected by the bunds of laterite stones, and was used for paddy cultivation and fish farming. Gradually, the mangroves have grown over about 250 ha area, making the land unsuitable for agriculture recently.

Mangrove flora of this island is represented by 12 genera and 15 species. Fairly good mangrove vegetation has been established occupying about 2.5 sq. km. of the island. The dominant genera of this area are *Avicennia*, *Rhizophora*, *Sonneratia* and *Kandelia*. A small patch of mangrove consists of *Bruguiera cylindrica* was observed along the small creek adjacent to the northern bank of the Mandovi estuary.

Chorao island houses practically the entire mangrove species found along the Goa coast. The avifauna of this mangrove forest is very rich and consists of resident as well as migratory birds. Because of the rich avifauna and presence of practically, all mangrove species found along the Goa coast and rich faunal diversity, the Chorao Island has been declared as protected area as Dr. Salim Ali Bird Sanctuary. The whole sanctuary area consists of mangrove vegetation interspersed with water channel, having tidal variations. There are no major anthropogenic threats except the nearby area of almost 80 ha is under aquaculture, where now mangroves are growing luxuriantly.

DISCONTINUOUS DISTRIBUTION OF MANGROVES

Mangrove distribution along the Indian coast showed variation with regards to the species composition. Forty eight species of mangroves were reported from the east coast and 34 species from the west coast of India. Out of these, 14 species are exclusively found along the east coast of India. The east coast of India along with Andaman and Nicobar group of islands showed more species diversity and unique distribution of mangrove floral elements. *Heritiera fomes*, inhabiting low salinity water area of Sundarbans showed limited distribution along the other parts of the east coast and Andaman Islands. This species is locally known as “Sundari” and the name Sunderban has been derived from this species.

Recent studies have shown that species of *Ceriops tagal*, *Lumnitzera racemosa*, *Sonneratia apetala* and *Kandelia candel* are found only in the certain areas along the west coast of India. *Acanthus ebracteatus* is known to occur only in Andaman and Nicobar group of Islands showed wider distribution in the Australian countries, perhaps, this species has been derived from these countries. A very distinct discontinuous distribution of mangrove species has been observed along the Indian coasts due to various factors.

Maximum number of mangrove species (27 nos.) was reported from Mahanadi delta. Species like *Ceriops tagal* and *S. apetala* are dominant from this delta, while species such as *Avicennia* spp. and *Aegiceras* sp. are dominant along Godavari, Krishna and Cauvery deltas. The dominant species in Gangetic Sundebans are *Excoecaria agallocha*, *Heritiera fomes* and *Xylocarpus moluccensis*. Of these, *X. moluccensis* has been recorded from the Konkan coast. This discontinuous pattern of distribution along the east coast can be attributed to the factors like conversion of the mangrove areas for aquaculture which was going on in big way, and other developmental pressure and domestic usage.

In some areas particularly, along the east coast of India, *Avicennia marina* adapted to poor habitat conditions of deltaic belt attaining height of 9 m and girth of 50 cm. Similar species growing along the Gujarat coast, however, found growing in the arid zone with high salinity and subjected to tremendous grazing pressure by the cattle and camels resulting into a stunted growth. Here biotic factor plays a significant role with regards to the

development of this species along the Gujarat coast.

Kandelia candel showed wider distribution in the South East Asian countries. This indicates that the species have broad temperature tolerance and grow in acidic and low salinity conditions. Recent studies indicated that *K. candel* is slowly disappearing from the region. However, this species found along the Goa coast showed restricted distribution to specific areas in estuarine system. It is most predominant species in the Mandovi estuary in Goa (in Mapusa estuary between Pomburpa to Mapusa, Peddem). *Sonneratia apetala* also has discontinuous distribution. This species is absent along the Goa coast but is present at Alibag and Vasai creek in Maharashtra.

Heritiera fomes and *Nypa fruticans* are dominant mangrove species in the area of the fresh water influence. These species showed wider distribution in South East Asian countries except Pakistan, the Philippines and Hong Kong. Along the Indian coastline, *Nypa* sp. has been reported to be present at the east and west coast of India. However, it has been recently found that this species is extinct from west coast of India due to the biotic and abiotic activities as well as domestic exploitation. *Sonneratia caseolaris* is on the verge of extinction from Indian coast and *Brownlowia tersa* is in the category of near threatened species.

The species like *Rhizophora stylosa*, *Rhizophora lamarkii* and *Bruguiera sexangula* were reported from the east coast and the Andaman and Nicobar groups of islands are totally absent from the west coast of India. Some mangrove species like *Aegialities routindifolia*, *Heritiera kanikensis*, *Myriostachya wightiana* and *Rhizophora anamalayana* are endemic to east coast of India. It has been reported that mangrove species i.e. *Rhizophora anamlayana* Kathir is natural hybrid derived from two species of *R. mucronata* and *R. apiculata* occurring in Pichavaram in Tamil Nadu. This species grow, to the height ranging from 9 to 12 m having broad dark green leaves and robust areal stilt roots. This critically endangered hybrid has been included in Global list of mangrove species.

Xylocarpus moluccensis, *X. granatum* and *X. mekongensis* have been reported from Andaman and Nicobar group of Islands, Sunderbans, Mahanadi delta, Andhra Pradesh and Pichavaram. However, a species of *Xylocarpus* namely *X. moluccensis* has been recently recorded from Achra, Konkan coast in Maharashtra. Presently, *Xylocarpus* species are becoming rare due to

over exploitation by locals for medicinal purpose.

A study was carried out recently to categorize all mangrove species found along the Indian coast based on IUCN criteria. In all 60 mangrove species (including mangrove associates), 23 marine benthic algae from the

mangroves were assessed. It is a known fact that Indian mangrove ecosystem is threatened and there is more than 50 % reduction in mangrove cover during the last 50 years.



PHENOLOGY OF MANGROVES

*R*UE MANGROVE SPECIES

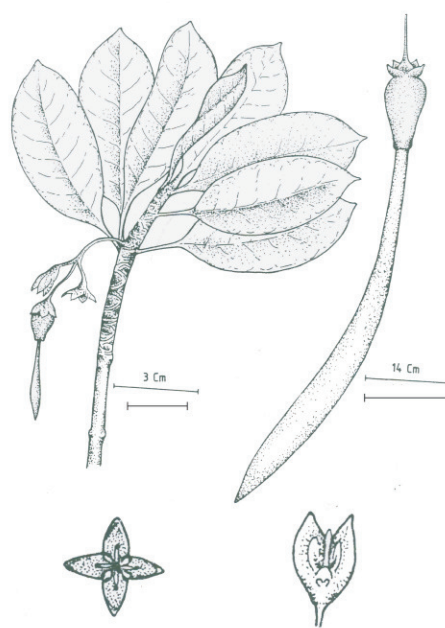
1. *Rhizophora mucronata* Lamk.

Habit:- Evergreen medium to tall tree reaching up to 12 m high, deliquescent branched; branches spreading horizontally and erect, marked with fallen leaf scar; trunk not conspicuous and supported by profuse stilt roots, 3 to 7 m. high; aerial roots hang out from the main tree or branches.

Leaves:- Leaves dark green, broadly ovate, leaf tip mucronate, always rolled up, 7 to 18 cm long, 4 to 9 cm broad, margin entire, phyllotaxis opposite and decussate.

Flowers:- Inflorescence axillary cyme, more than 2 flowered (4-8), mature flowers within the leafy cluster; peduncle long up to 3 cm, slightly bent; flowers medium up to 1.7 cm long, pedicellate; petals hairy in the margin; calyx lobbed triangular narrowing upwards; stamens mostly 8; stigma sessile; style 0.5-1 mm long.

Flowering season:- August to December.



Rhizophora mucronata

Fruits:- Coriaceous, one celled, one seeded, ovoid, persistent, reflexed calyx, lobes surrounding its base, hypocotyl pendulous, seed germination modified epigeal-viviparous, seedling up to 70 cm long or more.

Fruiting season:- Mid-October to April.

Distribution:- Gujarat, Maharashtra, Goa, Karnataka

Economic Importance:- Wood is used as timber and fuel or Charcoal. Tannin content is up to 20%. The bark powder is

astringent. It is used for the treatment of diabetes, hemorrhage, hematuria and angina.



Leaf



Flower

2. *Rhizophora apiculata* Blume

Habit:- Medium tree, 3 to 7 m high, deliquescent, much spreading, horizontally and erect with prominent fallen leaf-scar; trunk not conspicuous and supported by profuse delicate stilt roots; bark brownish to whitish gray, longitudinally fissured; stilt roots up to 3-5 m high, looping from lower branches and trunk bases, giving mechanical support to the tree in the loose tidal substratum.

Leaves:- Leaves 10 to 18 cm long and 2.5 to 7.5 cm broad, opposite decussate, lanceolate, broad, leaf tip acute, not rolled up, cunate at base, ex-stipulate; petiolate 12 cm long.

Flowers:- Inflorescence cyme, ebracteate, sessile, glabrous, complete, hermaphrodite, regular, erect, 0.8 - 1.2 cm long; calyx inconspicuously persistent in the fruit; sepals 4 polysepalous, superior, sepals ovate, acute; corolla white, petals 4, polypetalous, petals lanceolate, entire, acute, glabrous, white, herbaceous, deciduous, alternate to sepals; stamens 12.

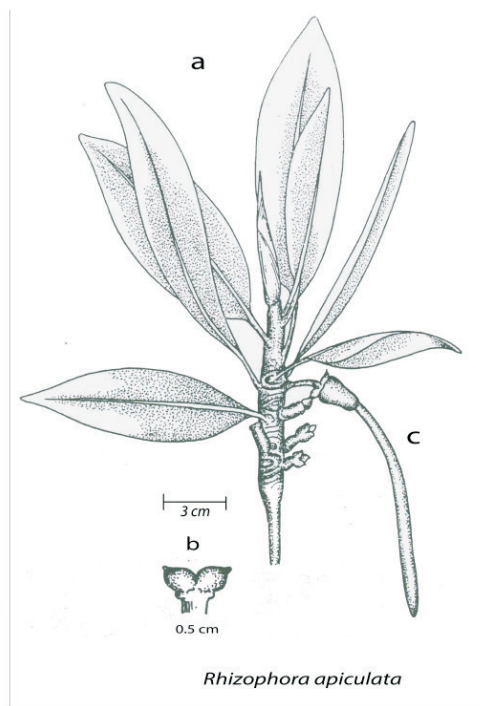
Flowering season:- June to October.

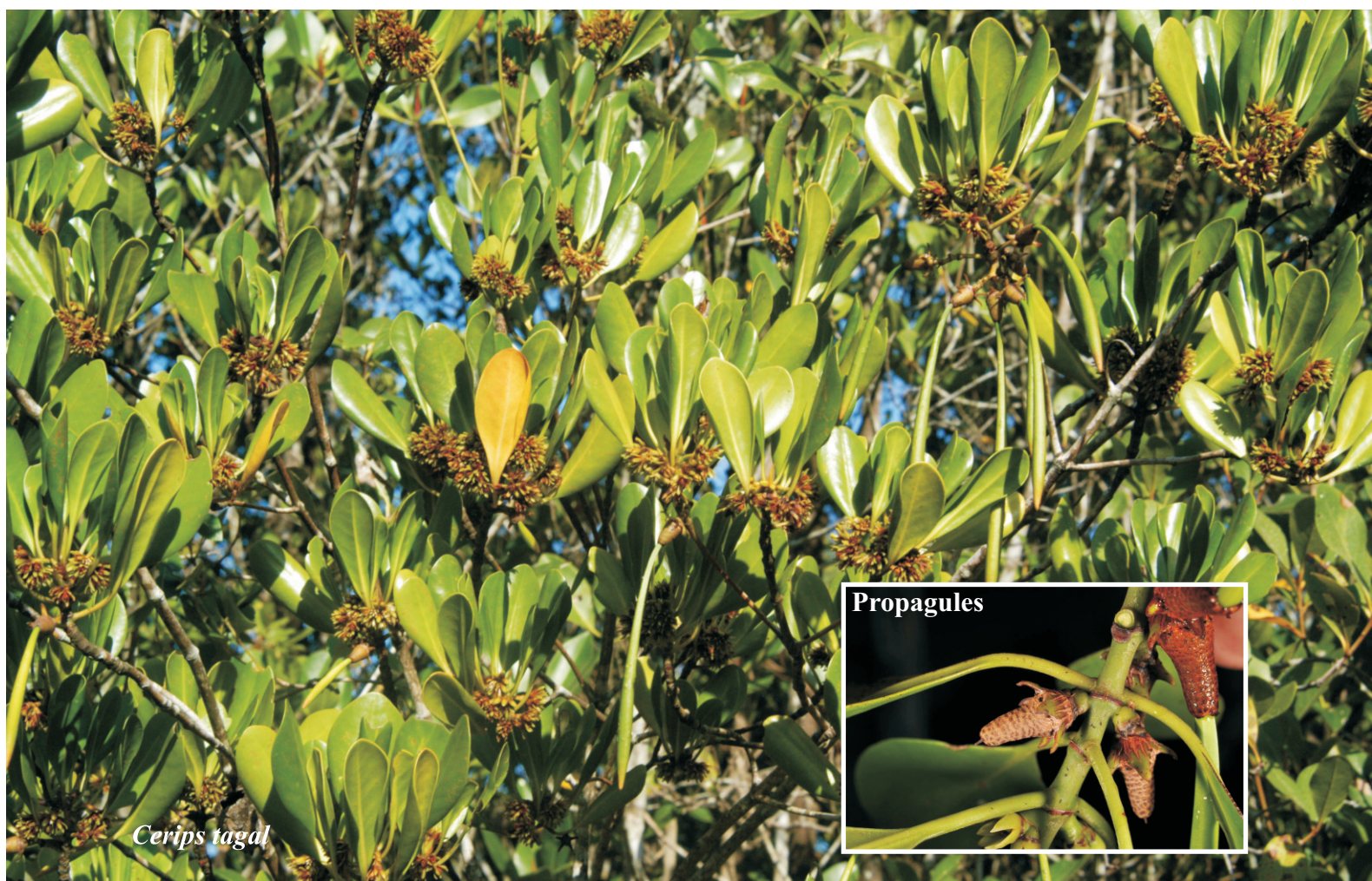
Fruits:- fruit capsule 3 to 5 cm long, oval, tapering towards apex, brownish in dry condition; seed one, covered by thick indehiscent pericarp; germination viviparous, 10 to 50 cm long and curved.

Fruiting season:- September to March.

Distribution:- Maharashtra, Goa, Karnataka

Economic importance:- Produce high quality timber and fuel wood. Tannin content is up to 33%.





Ceriops tagal

Propagules

3. *Ceriops tagal* (Perr.) C.B. Robinson

Habit:- Evergreen small or moderate shrub or tree, height 2 to 4 m, grows up to 6 m high, canopy conical; aerial roots form short buttresses or root-knees or flange like plank roots at the base of the trunk.

Leaves:- Simple, 8-10 cm long and 4-5 cm broad, coriaceous, obovate-oblong, leathery apex rounded, cuneate at base; petiole 1.5 to 2 cm long, glabrous.

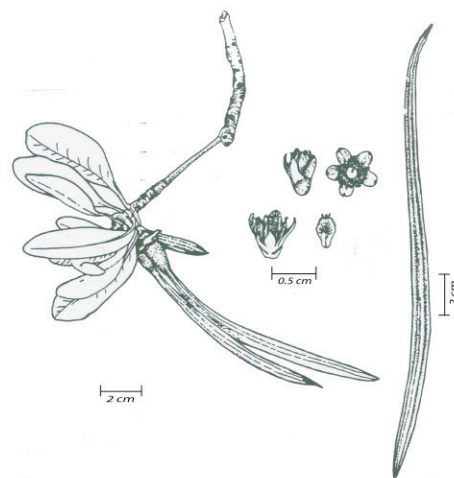
Flowers:- Inflorescence axillary cyme or glomerules; peduncle short; sepals 5 lobed; petals white with clavate appendages, shorter than the calyx; stamens 10 to 12 alternately long and short; anthers shorter than the filament; ovary 3 celled.

Flowering season:- January to December.

Fruits:- Slightly conical, 1.5 - 2.0 cm long, pointed apically; germination epigeal, viviparous, hypocotyleterete or slightly ridged, up to 25 cm long warty throughout; germination starts soon after the maturation of the fruits; hypocotyl remain on the mother plant till the end of monsoon.

Fruiting season:- April to December.

Economic importance:- Produce high calorific valued fuel-wood, timber, pole for domestic cottage, piles and pillars. The wood is very hard and durable. Tannin content is up to 29%.



Ceriops tagal



Inflorescence

4. ***Bruguiera gymnorhiza* (L.) Lamk.**

Habit:- Medium height, 8 to 12 m tall tree; bark rough, fissured, corky lenticellate; much densely spreading branches, branches and stems marked with leaf-scars; stipules short or shallow; buttressed like knee roots, thickened trunk base.

Leaves:- Opposite decussate, stipulate, slightly acuminate, 9 to 12 cm long and 3.5 to 4.5 cm broad, cauline, exstipulate; petioles reddish green in colour, elliptic oblong, acute apex or bluntly pointed.

Flowers:- Inflorescence solitary cyme; flower scarlet, large, 2.5 cm in diameter, coriaceous; calyx deep orange red/yellow, ribbed, campanulate, large (3 - 4 cm), calyx tip acute, 11 - 13 numbers; petals 1.2 - 1.6 cm long, oblong, lobed, tips acute; stamens 16 to 28 nos.; filaments filiform; anthers linear, mucronate; ovary 2 to 4 celled.

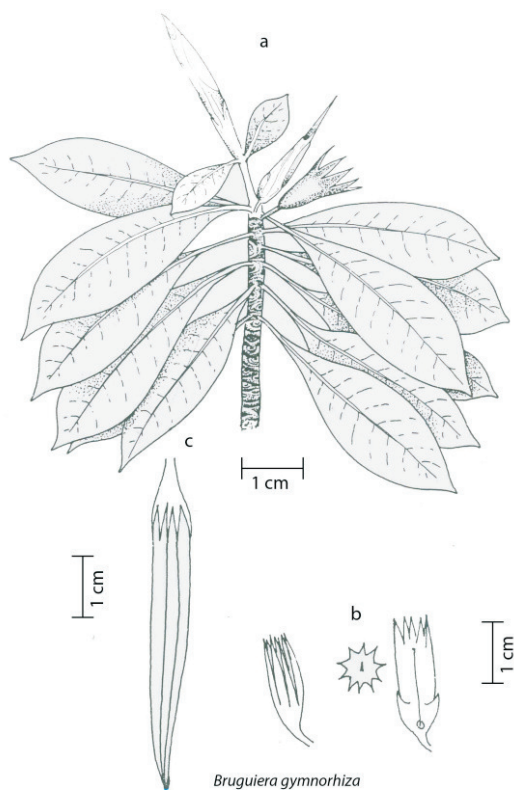
Flowering season:- January to December.

Fruits :- fruit capsule pendulous with persistent calyx; seed one; hypocotyle fusiform, 15 - 17 cm long, cigar-shaped, narrow at apex, blunt apically, slightly angular, blackish dark green, vertical narrow ridges, showy with distinct persistent reddish calyx.

Fruiting season:- April to September.

Distribution:- Maharashtra, Goa, Karnataka.

Economic Importance:- High calorific valued fuel wood and timber. Tannin content is up to 36%.



5. *Bruguiera cylindrica* (L.) Blume

Habit:- Medium tree, 3 to 5 m tall can grow up to 16 m. perennial, evergreen, deliquescent, woody, erect; branching slightly pyramidal shape; bark smooth gray; shallow buttressed from the trunk base, root-knees occasionally blunt end; pneumatophores present.

Leaves:- Simple, opposite decussate, cauline, exstipulate, petiolate, glabrous, terete, yellowish, solid, pulvinous, 10 to 15 cm long and 4 to 5 cm broad, elliptic, bluntly shining above, dull beneath.

Flowers:- Inflorescence axillary cyme, 4 -7 flowers on each peduncle, 2 to 3 cm long, glabrous, terete, yellowish; flowers yellow-green bracteate, pedicellate; pedicel up to 0.8 cm long, bisexual, regular, complete, pendulous; calyx tube ribbed; sepals 8, polysepalous; corolla 8 polypetalous, petals 1.5 mm long, folded into two parts, at the terminal part 3 long cilia, petal margin slightly hairy, thin, herbaceous, glabrous, each petal containing two stamens of unequal filament length.

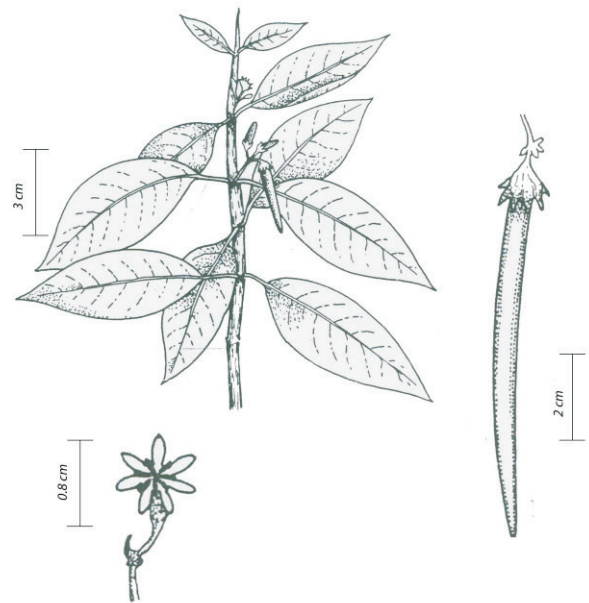
Flowering season:- January to December.

Fruits:- Radicle subcylindric, pendulous, up to 2 cm long and 0.4 to 0.6 cm diam.; sepal lobes short, persistent with long calyx tube, end slightly pointed; germination epigeal, viviparous, hypocotyle 15 cm long.

Fruiting season:- April to September.

Distribution:- Maharashtra, Goa, Karnataka.

Economic Importance:- Produce hard timber and fuel wood. Tannin content is up to 25%.



Bruguiera cylindrica



Bruguiera cylindrica

Flower



6. *Kandelia candel* (L.) Druce

Habit:- Small to medium tree, height 2.5 to 5 m can grow up to 7 m high; bark smooth, grayish or reddish brown; without any aerial root, but occasionally aerial roots developed in some cases; lower trunk triangular.

Leaves:- Opposite, oblong-elliptic apex obtuse, 6.5 to 10 cm long and 2.5 to 4 cm broad, dark green above and pale beneath; petiole 0.8 to 1.5 cm long; stipules 1.7 to 3.8 cm long.

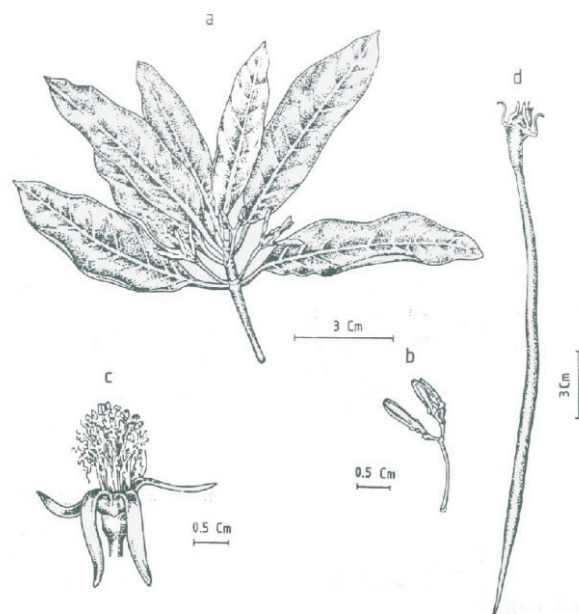
Flowers:- Inflorescence axillary cyme, peduncles longer than petiole. 4 to 9 flowered; petals 5 to 6 bifid white, lobes divided into numerous capillary segments; calyx 2 to 3 cm long, lobes linear acute; stamen lacerate; ovary one celled.

Flowering season:- January to December.

Fruits:- 1.5 to 2.5 cm long, obclavate, viviparous; hypocotyle of the seedling slender and tapered at each end, cylindrical acuminate, up to 40 cm long at maturity.

Fruiting season:- April to January.

Economic Importance:- Timber is very hard and durable and good quality fuel-woods. Tannin content is up to 15%. Endangered species need protection.



Kandelia candel



Propagules



Flower



Kandelia candel

7. *Sonneratia caseolaris* (L.) Engler

Habit:- Small evergreen tree, up to 10 m high; deliquescent branching, woody, erect, branches horizontal, twig slender; pale brown bark, smooth or furrows at maturity, much spreading horizontal roots; pneumatophors 20 to 100 cm tall, tapering towards the end, with spongy outer surface and secondary growth, prefers low salinity.

Leaves:- Simple, opposite decussate, cauline, short pedicellate; petiole 0.5 -1 cm long, flat, glabrous, pale-green or reddish, pulvinous; lamina 8 to 12 cm long and 4 to 5 cm broad, ovate-elliptic, entire, unicostate, reticulate venation; apex becomes acute at young stage but occasionally degenerate at maturity.

Flowers:- Inflorescence solitary cyme, flowers ebracteate, pedicellate; pedicel 4 to 6 cm long showing differentiation of nodes and inter-nodes; flower complete, bisexual, regular; calyx tube green with 6 lobes, linear, entire; petals 6, polypetalous, purple to violet red, alternated with calyx teeth; stamens numerous, free, showy, fertile, filament 4 cm long, soft, pendulous, white above and reddish below; carpels 6, syncarpous, superior; ovary cup shaped, green. globose, flattened, round, locules 20, each with numerous ovules; placentation exile, style 1, terminal, generally twice the length of stamens.

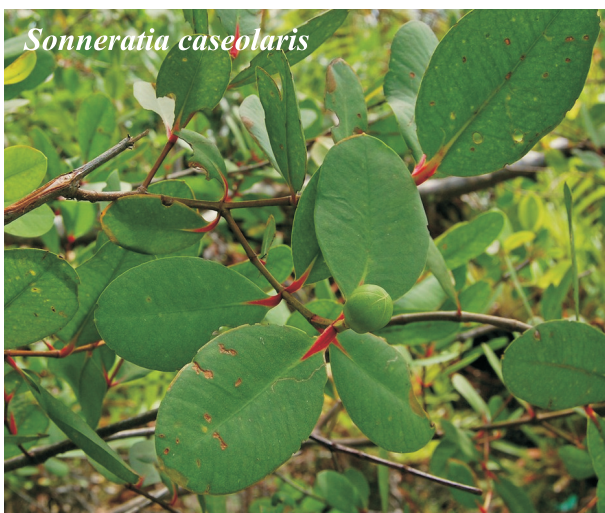
Flowering season:- February to July.

Fruits:- A berry, green, stalked, flattened, globose, persistent substending; calyx, 5 to 8 cm in diam.; seeds numerous, angular, small curved, germination epigeal.

Fruiting season:- July to January.

Distribution:- Goa, Karnataka.

Economic importance :- Fuel, honey; fruit edible



8. *Sonneratia alba* J. Sm.

Habit:-Pioneer species. Tree or shrub, 10 to 15 m tall, much branched; corky; bark with fine, longitudinal fissured, cream to brown in colour; pneumatophores short, thick, negatively geotropic; aerial root present.

Leaves:- Glabrous simple, opposite, coriaceous, elliptic, oblong or suborbicular, obtuse at apex, 5 - 10 cm long, 4 - 4 cm broad, narrowed to a short petiole at base; petiole 3 -6 mm long.

Flower:- Inflorescence 1 to few flowered cyme, terminal or branchlet; flowers 3 to 5 cm across, white; Calyx tube cup shaped, 6 - 8 lobed; petals white, small; ovary depressed-globose; style up to 4 cm long; stigma capitate; Stamens numerous, 5 to 8 cm long, white in colour; flowers ephemeral, opening in late evening, and lasting one night, plenty of nectar in the calyx tube.

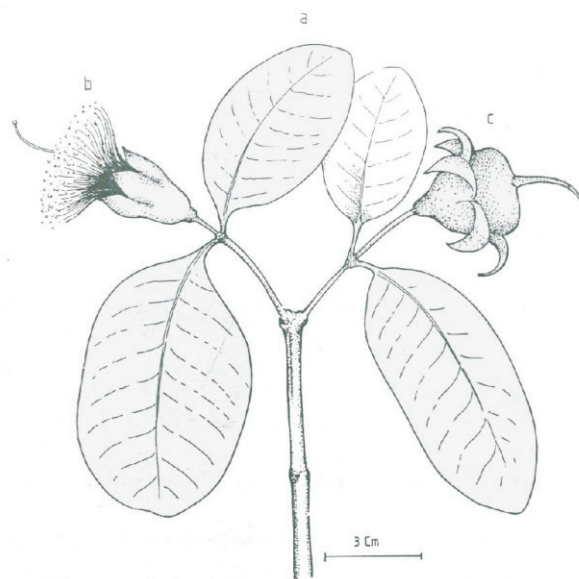
Flowering season: - February to July.

Fruits:- 3.5 - 4.5 cm in diameter, green, smooth; calyx cup shaped, enclosing the base of the fruit; 150 - 200 seeds in the fruit, seeds small, curved, angular, embedded in pulp; cotyledon convolute.

Fruiting season: - August to February.

Distribution:- Maharashtra, Goa, Karnataka.

Economic importance:- Fuel, timber and Honey.



Sonneratia alba



9. *Avicennia marina* var. *marina* (Forssk.) Vierh.

Habit:- Small bushy trees, evergreen, height 9 to 12 m; bark smooth, yellowish-gray, lenticellate in younger parts; tap root absent, aerial roots rare; pneumatophores 3 to 10 cm long, narrowly pointed.

Leaves:- 3 to 6 cm long and 2 to 2.5 cm broad, leaves opposite, elliptic-oblong beneath, acute at apex, rounded, or tapering towards base; petioles 3 to 5 mm long, glabrous, shining above and grayish brown below.

Flowers:- Inflorescence capitate, 2 to 4 mm across, sessile, pale-yellow in terminal condensed cyme; calyx deeply lobed, hairy tomentose; corolla lobes ovate-acute; ovary globose, densely pubescent; style short; stigma minutely bilobed.

Flowering season:- May to December.

Fruits:- Russet brown, almond shape, beaked at the tip; capsule 12 to 15 mm long, ovoid, apiculate, greyish-tomentose, compressed, smaller than *A. officinalis*.

Fruiting season:- January to march.

Distribution:- Dominant along the southern coast of Gujarat and north coast of Maharashtra. Occurring along the south coast of Maharashtra, Goa and Karnataka.

Economic importance:- Fuel, fodder for camels and cattle.



Avicennia marina



10. *Avicennia officinalis* L.

Habit:- True mangrove species, medium tree, 15 to 30 m tall can grow up to 50 m high with smooth bark; branches both spreading and erect; pencil like pneumatophores; occasionally stilt roots present; aerial roots with thick corky parenchyma cells and numerous lenticels present on the cortex.

Leaves:- Entire, 8 to 10 cm long, 2.5 to 5 cm broad, coriaceous, elliptic, oblong or obovate oblong, very obtuse or rounded glabrous, smooth and shining above, whitish beneath; bract 3 to 5 mm long, ovate, bractioles smaller.

Flowers:- Terminal or axillary cyme, zygomorphic, sessile in compact heads. 6 to 8 mm in diam.; corolla orange yellow, glabrous within; calyx 3 to 3.5 mm long minutely pubescent; corolla 5 to 6 mm, 4 lobed, ovate acute; stamen exserted; ovary and style together reaching 0.6 cm long; ovary tapering; stigma shortly bifid.

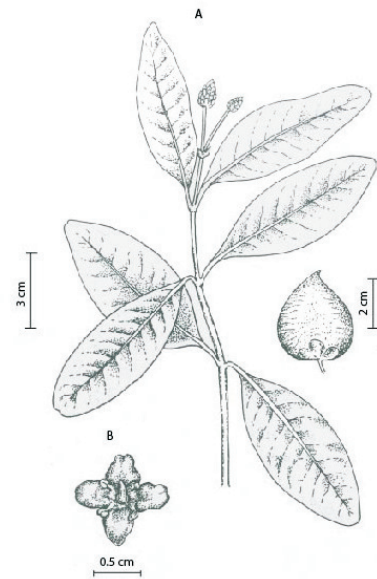
Flowering season:- June to September.

Fruits:- fruit 2 to 3 cm long; capsule contain 4 seeds; seeds flattened with thin testa, seed germination epigeal or modified epigeal, crypto-viviparous or incipient viviparous.

Fruiting season:- September to march.

Distribution:- Present along the entire west coast.

Economic Importance:- Produce fire wood, timber, honey and tannin; leaves used as fodder, litter enrich the soil and water with high organic manure.



Avicennia officinalis



Avicennia officinalis



11. *Lumnitzera racemosa* Wild.

Habit:- Evergreen tree, height 1.5 to 4.5 m.; Outer bark dark brown, inner bark reddish brown, deliquescent and diffused, erect and much branched; pneumatophores occasionally developed as looping lateral roots.

Leaves:- 2.5 to 7 cm long and 1.5 to 5 cm broad, simple cyclic or alternate, exstipulate, petiolate, apex rounded to emarginate, flattened, green, glabrous, pulvinous; laminasubulate, entire or slightly wavy, obtuse or slightly notched in apex bearing a small gland/ hydathod, reticulate venation, vein inconspicuously present.

Flowers:- Inflorescence spike, 2 to 3 cm long, terminal or axillary; flowers pedicellate, pedicel short, bracteate, ovate, entire, acute, green, coriaceous; sepals 5, gamosepalous, forming a tube like structure from the base to half portion of calyx; petals 5, polypetalous, oblong lanceolate, entire, acute; stamens 10, free, arranged in two whorls, 5 stamens develop at the base of petal and other 5 stamens at the base of the sepal teeth; anther bilobed; superior carpels 1, ovary inferior, 3 ovules, hanging from upper end of the ovarian chamber; style one terminal, stigma simple.

Flowering season:- January to May.

Fruits:- Fruit is a drupe with one seed covered by sclerotic layer, woody, 1 to 2 cm long, flat, yellowish green in colour, glossy surface, vase-shaped with hard corky, buoyant, dispersed by current; seed germination hypogeal or modified epigeal.

Fruiting season:- June to December.

Distribution:- Common along the Maharashtra coast.

Economic importance:- Stem juice is said to be useful for herpes and itches. Tannin content is up to 19%.



12. *Xylocarpus moluccensis* (Lamk.) Roem

Habit:- Large evergreen tree up to 15 m tall, trunk ca 60 cm in diam. at base, dark red with thick flakes; wood red in colour; pneumatophores woody, buttresses absent or very short; horizontal root developing blunt, peg like; pneumatophores up to 20 cm long and 3 - 4 cm in diameter.

Leaves :- Leaves compound, leaflets 2 - 4 paired, 7-12 x 3-6 cm, ovate, apex, acute, base oblique.

Flowers:- Inflorescence panicle, lateral cyme, up to 8 cm long; flowers 2—3 cm across, white with red glands inside; calyx 4 lobed, short; petals 4, free, spreading, contorted; stamens 8; ovary 4- celled, style thick; stigma short cup-shaped.

Flowering season:- from June—September

Fruits:- small, about size of an orange, capsular globose, upto 12 cm in diameter, brown; seeds tetrahedral.

Fruiting season:- from June—September
Economic importance :- Wood used for making furniture and to extract tannin.



13. *Excoecaria agallocha* Linn.

Habit:- Medium dioecious tree, 8 to 10 m high, can grow up to 18 m, deliquescent, woody, perennial, partially deciduous, much branched, very dense with dark leaves and spreading branches; bark gray, fissured with poisonous milky latex, lenticellate; roots generally without any aerial growth.

Leaves:- Simple, alternate, spirally arranged, somewhat cluster to the end of the erect shoot, exstipulate, petiolate; petiole, round, green, reddish occasionally on maturity; lamina ovate, elliptic, inconspicuously notched with a minute gland in the notch of young leaves, the glands usually circular often associated with additional outgrowth like the marginal glands.

Flowers:- Male inflorescence catkin, pendulous or erect; flower bracteate, sessile, monochlamydous, dioecious, zygomorphic; stamens 3, free, fertile, superior, filament 1.2 cm in length, glabrous, round; anther bilobed, basifixed, extrorse, exerted, dehiscent longitudinally. Female inflorescence mixed cyme; flower bracteate, bracts glandular, sessile, with a pair of bracteoles; carpels 3, syncarpous, superior; ovary ovoid, 3 chambered, basal placentation, one ovule in each chamber.

Flowering season:- February to August.

Fruits:- 3 lobed, schizocarp (fruit like combined 3 balls) about 0.6 cm in diam., dehiscent into 3 cocci to release the solitary seeds, black in colour, the pricarp green, somewhat leathery but not fleshy.

Fruiting season:- June to January.

Distribution:- Common along the west coast of India.

Economic Importance:- Milky latex is very poisonous and medicinal; wood is soft and largely used for packing boxes; paper pulp, match-box and splints of matches. Leaves are used to treat epilepsy, ulcer etc.



14. *Aegiceras corniculatum* (L.) Blanco

Habit:- Small ever green bushy shrub grows up to 2 to 5 m high; aerial roots absent; stem much branched, glabrous, with brownish - gray bark, sap wood white.

Leaves:- 7 to 8 cm long and 3 to 4 cm broad, alternate, entire, obtuse, sometimes obovate, retuse, base cunate; petiole 5 to 6 mm long, pale green and pedicel 1 to 1.2 cm long; salt excreting glands on the abaxial surface, imbricate.

Flowers:- Inflorescence umbellate, terminal or axillary flowers, 1.5 to 2 cm long, white, fragrant, subsessile, opposite or rarely axillary umbels; pedicel 0.63 to 1.2 cm, exserted; corolla horny; anthers exserted, versatile.

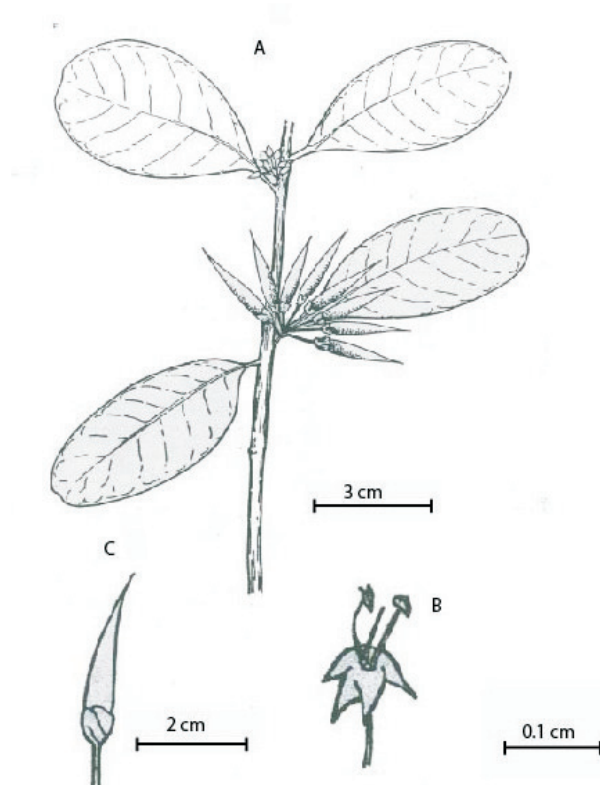
Flowering season:- March to December.

Fruits :- 2.5 to 3.5 cm long, 4 to 5 mm broad, tapering to an acute, sharply pointed, coriaceous, green yellowish brown with persistent imbricate calyx, curved apex; hypocotile 3 to 4 cm long.

Fruiting season:- July to February.

Distribution:- Common along the Maharashtra coast, rare along Goa and Karnataka coast.

Economic importance:- Used as fuel, stem and bark are used to treat fish poison and mosquito larvae, a source of antifungal compound and honey.



Aegiceras corniculatum



15. *Acrostichum aureum* Linnaeus

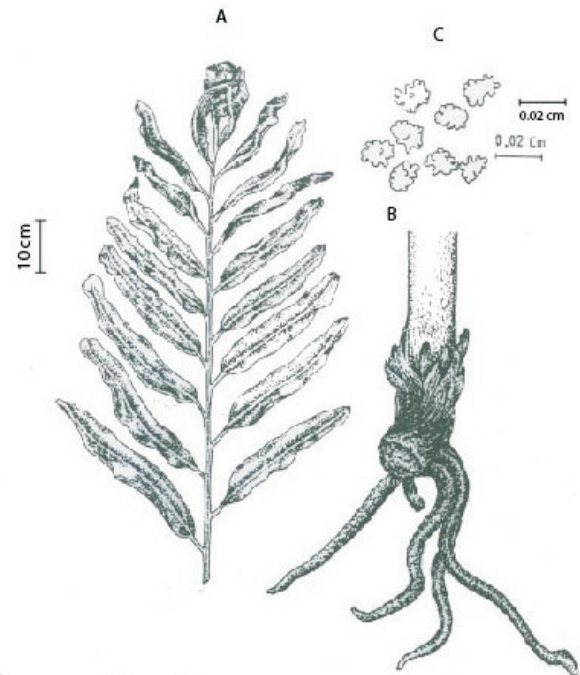
Habit:- Erect fern, attaining up to 1.5 m high, having small bushy appearance, fibrous typical fern like roots but without any aerial roots; rhizome globose, horizontal.

Leaves:- Pinnate leaves with a terminal leaflet, pinnae stalked, sessile, acute to acuminate, circinate venation, young rachis covered by gregarious hair like structures known as ramenta, frond simple, semipinnatifid, upto 1 m long, and 4.0 cm wide, isobilateral, distinct mid-vein and reticulate vein, entire, blunt end, green and yellow on maturity with sorus,

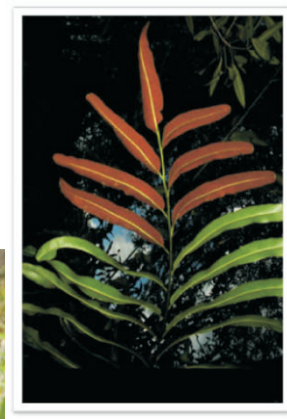
Fruits:- Mature leaves or fronds become sporophyllous, diffuse sporangia at abaxial surface, mixed sporangia on both side of the mid-vein with paraphyses, paraphyses with terminal cell unextended, symmetric, outlined irregular and lobed, brown sporangia stalked, upper globose, spores large and tetrahedral, minutely tuberculate.

Distribution:- Upstream region of estuaries in Maharashtra, Goa, Karnataka and Kerala.

Economic importance:- Tender fronds/leaves are edible as vegetable, known as Akur.



Acrostichum aureum



Acrostichum aureum



16. *Acanthus ilicifolius* Linn.

Habit:- A perennial erect shrub or tall herb, up to 1.5 m high, scarcely woody, bushy, with very dense growth; shallow tap roots, but occasionally stilt roots are conspicuous.

Leaves:- Leaves simple, opposite, oblong or ovate, sinuate margin with spine tipped lobes, exstipulate; petiole short, flattened, glabrous; lamina oblong, elliptic-oblong, spiny margin and wavy, apex acute, basal angled, dorsoventrally green.

Flowers:- Inflorescence raceme, spike, up to 16 cm long, peduncled; flowers 3.5 to 4 cm long, violet, bracteate, curved, ovoid, entire, flower bisexual, typically zygomorphic, complete, erect, sessile, hypogynous; sepals 5, polysepalous, twisted, margin folded, acute, coriaceous, greenish, persistent; petals 1, large, showy, violet, ovate, entire, obtuse, coriaceous; stamens 4, free filament, erect; carpels 2, syncarpous; ovary dumbel-shaped, glabrous, terete, ovary superior, two chambered, two ovules in each chamber, exile placentation; style 1, terminal, persistent, terete, glabrous; stigma two bifid.

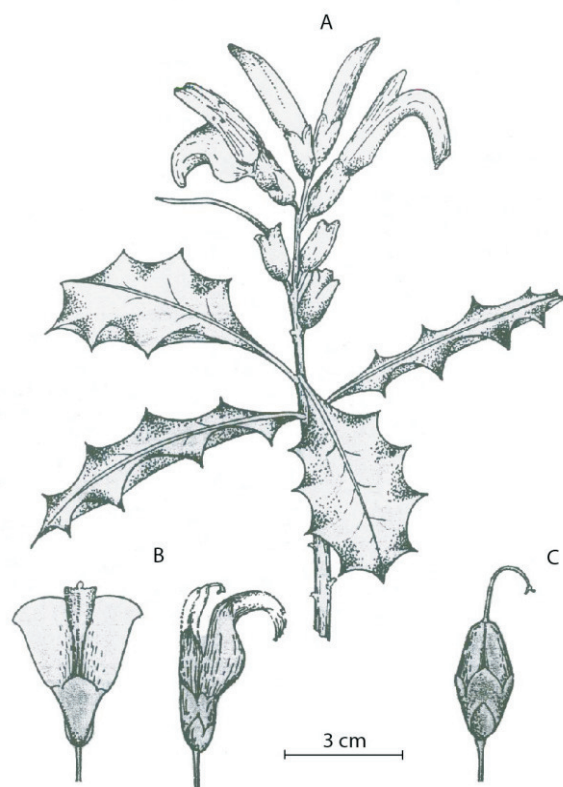
Flowering season:- April to December.

Fruits:- Fruit green, 2.5 to 2.0 cm long, kidney shaped, 4 seed drupe; seed 0.5 to 1.0 cm long, germination of seed hypgeal.

Fruiting season:- July to February.

Distribution:- Common along the west coast of India.

Economic importance:- Useful in asthma, decoction used in dyspepsia. Leaves used as fomentation in rheumatism, neuralgia and also used in snake bite.



Acanthus ilicifolius Linn.



ASSOCIATES OF MANGROVES

1. *Derris heterophylla* Lour.

Habit:- Climber, much branched shrub or twining plant, ever green, perennial; tap roots deep sunken and without any aerial outgrowth.

Leaves:- Compound, 3 to 5 leaflets, leaf axis upto 15 cm long, pulvinous, terete, green alternate, imparipinnate, leaflets elliptic oblong, entire, acuminate, cuneate dark green, coriaceous, dorsiventral, unicostate reticulate venation.

Flowers:- A raceme on peduncle; flower pedicellate, zygomorphic, bisexual, complete; sepals 5, gamosepalous, 5 short lobes above, beneath cup-shaped tube; petals 5, polypetalous, vexillary, one standard, ovate, apical grooved, white pinkish, basal short notched with two edges, curved, two wings, two keels; stamens 10 (9 + 1), diadelphous; anthers remains free, anther bilobed, basifixed; ovary superior, conical, flattened, single chambered, marginal placentation, ovules 7 to 8; style 1, terminal, stigma absent.

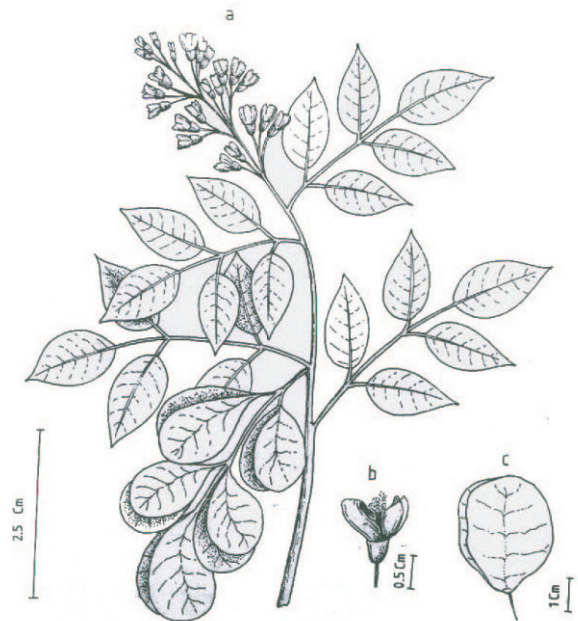
Flowering season:- June to December.

Fruits:- Pods variable in shape, obliquely rounded or orbicular; seed solitary, sub-orbicular, reddish brown, prominently veined with distinct narrow wing to the upper suture.

Fruiting season:- October to February.

Distribution:- Commonly found along the west coast of India.

Economic importance:- Entire plant is used as stimulant, antispasmodic. Bark is used as an alternative in rheumatism and mild poison for fishing.



Derris heterophylla



2. *Clerodendrum inerme* (L.) Goertn.

Habit:- Much branched shrub occurring abundantly near the coastal region, 1 to 3 m tall.

Leaves:- Leaves are fragrant, opposite, entire, elliptic or obovate, obtuse, glabrous, base acute; petiole 0.6 to 1.9 cm long.

Flowers:- Inflorescence axillary pedunculate cyme, peduncle long, slender; calyx copular, teeth 5; corolla tubular, white, tube long hairy inside, 5 lobbed, limb bilabiate, lobes unequal oblong; stamens 4, filaments exerted, red, di-dynamous; anthers oblong; ovary imperfectly 4 celled, long style, stigma bifid.

Flowering season:- April to December

Fruits:- A large drupe, 4 lobbed pyrene surrounded by enlarged calyx.

Fruiting season:- October to February.

Distribution:- All along the west coast.

Economic importance:- Plant is used as hedge for fencing. Leaves used as remedy to bring down fever and febrifuge, roots boiled in oil can be used in rheumatism. Plant is used in preparation of tincture and it has wound healing properties.

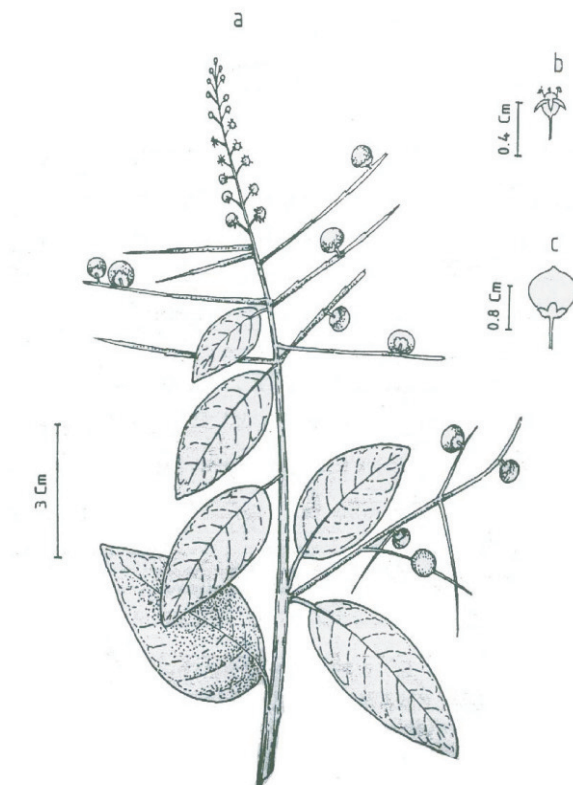


3. *Salvadora persica* L.

Habit:- Ever green small shrub, 1 to 3 m tall.

Leaves:- 6 to 8 cm long, 3 to 3.5 cm broad; petiole 1 to 1.2 mm long, entire, acute, lanceolate, opposite and decussate; penicle 5 to 12 cm long, often compound,

Flowers:- Flowers white, scattered; calyx 1.5 mm, lobes ovate; corolla 2.5 mm, 5 partite; filaments short; anther ovate



Fruits:- Drupe 3.2 mm in diameter.

Distribution :- All along the west coast

Economic importance : The plant is mentioned in holy Quran and Sonnah, and the roots and shoot sticks have been used for centuries as oral hygiene tools in many parts of the world. Root bark is tonic, stimulant and emmenagogue and used to relieve splenalgia. The stem bark is good for gastropathy. Leaves are antiscorbutic, diuretic, anthelmintic, astringent, expectorant and tonic.

They are useful in asthma, bronchitis, cough, strangury, painful tumors, constipation, verminosis and aemorrhoids. Shoots and leaves are bitter and used in all types of poisons, cough and bronchitis. Fruits are sweet, acrid, bitter, thermogenic, aphrodisiac, emollient, stomachic, purgative and digestive. They are useful in constipation, flatulence and seminal weakness. Tender twigs are used as toothbrush. The extract of the root is said to relieve the pain due to spleen troubles.

4. *Dolichandrone spathacea* (L.f.) K. Schum

Habit:- Moderate sized deciduous trees commonly called as mangrove trumpet tree, 18 m high; bark greyish-brown; bole smooth; often branching near base.

Leaves:- Compound, imparipinnate opposite, estipulate; rachis 23-30 cm long, stout, glabrous; leaflets 5-9, opposite; petiole up to 6 mm, stout, glabrous; lamina 7.5-15.2 x 2.5-7.5, rhomboid or ovate, elliptic, ovate-lanceolate; base oblique; apex acuminate; margin entire, glabrous and shiny.

Flowers:- Bisexual, white, 3-4 together on terminal short erect corymbs; calyx spathaceous, cleft to the base on one side, spathe acuminate at tip; corolla 10-18 cm long, tube long, slender below, widening half way to a funnel; lobes 5, 10 cm, spreading, crisped; stamens 4, didynamous, included; disc annular; ovary sessile; ovules many; style long; stigma 2 lobed.

Flowering season:- April—August

Fruits:- A capsule, to 45 x 2.5 cm, purplish-brown; smooth to obscurely ribbed; seeds corky winged, flat, rectangular, 1.6 cm across.

Fruiting season:- April—August

Distribution:- Found along the west coast of India (Maharashtra, Karnataka and Kerala and east coast of India (West Bengal, Odisha, Andhra Pradesh, Tamil Nadu



and Andaman and Nicobar group of islands).

Economic importance:- Flower edible, Young shoot can be used as vegetable. Wood is used for making charcoal; wood being soft can be used for making match sticks and toys.



Fig. 7 Map of Goa

ESTUARY WISE MANGROVE DISTRIBUTION

Goa is located in the western part of the Indian subcontinent and is bounded by the state of Maharashtra to the north, Arabian Sea to the west and state of Karnataka to the south-east. The total area of Goa is 1,429 sq. km and is intercepted by seven estuaries of which Mandovi-Zuari are the longest. The Mandovi estuary (77 km) is also known as Mahadayi or Mahdei and it originates from a cluster of 30 springs at Bhimgad in Western Ghats in Belgaum District of Karnataka. The Zuari estuary also referred to as Aghanashani is the largest in Goa (92 Km)

and originates at Hemad-Barshem in the Western Ghats. These estuaries are connected by Cumbharjua canal (15 km). The other estuaries of Goa Terekhol (22 km), Chapora (29 km) are in the northern part of Goa, while, Sal (16 km), Talpona (11 km), and Galgibag (4 km) are in the southern part of Goa. Their lengths and widths vary with tidal and other seasonal flooding. All these estuaries have fringing mangroves and the mangrove species composition varies depending on the topography and environmental conditions. (Fig. 7)



Rhizophora mucronata

1. MANDOVIESTUARY

I Mapusa side

- (a) Betim Fisheries Jetty & near Mandovi Bridge = *Sonneratia alba*–(D); *Rhizophora mucronata* – (A); *Avicennia marina* & *A. officinalis* (C) others –(P).
- (b) Penha De Franca (Britona) = *Avecenia marina* & *R. mucronata* – (A); *A. officinalis*–(C); *Acanthus illicifolius*, *Deris heterophylla* & others – (M).
- (c) Salvador do Mundo & Pomburpa = *A. officinalis* – (A) *A. marina* (C) *R. mucronata*, *Kandelia candel* & others –(M).
- (d) Moira & Aldona = *A. officinalis* (A); *K. candel* (M); *Acrosticum aurum*, *A. illicifolius* & others (P).
- (e) Mapusa & Peddem = *A. officinalis* (A); *K. candel* (C); *A. aurum* & *A. illicifolius* (P).

II Mandovi (Diwar Narova side)

- (a) Vanshi = *Avicennia officinalis* (A); *K. candel* (C); *R. mucronata*, *R. apiculata*, *Porterasia coaretata* (M); *Bruguiera cylindrica*, *A. illicifolius* & others –(P).
- (b) Narova & vicinity = *A. officinalis* (C); *R. mucronata*, *R. apiculata* (M); *K. candel*,

Porterasia coaretata, *A. illicifolius* & others–(P).

III Mandovi (Old Goa Side)

- (a) Piedade & Old Goa = *A. officinalis*–(C); *S. alba*, *R. mucronata*, *R. apiculata* (M) and *P. coaretata* & others (P).
- (b) Panaji, Patto & Ribandar = *R. mucronata*, *R. apiculata*– (C); *A. officinalis* & *A. marina*–(M); others –(P).
- (c) Old Goa & Dhauji = *A. officinalis* (C); *R. mucronata* & *R. apiculata* (M); *S. alba*, *A. illicifolius* & others –(P).
- (d) Khandola, Amona, Tonca (Marcel) = *Sonneratia caseolaris* – (C); *A. officinalis* & *R. mucronata* (M); *A. aureum*, *A. illicifolius*, *Aegiceras corniculatum* & others (P).

IV Chorao area (Sanctuary)

- (a) *A. officinalis* & *A. marina* (A); *R. mucronata* & *R. apiculata* (C); *A. illicifolius*, *A. corniculatum*, *K. candel* & *Bruguiera cylindrica* (M); *S. alba*, *Excoecaria agallocha*, *D. heterophylla* & others –(P) *Xylocarpus moluccensis* (R) is newly introduced species in Dr Salim Ali Bird Sanctuary.

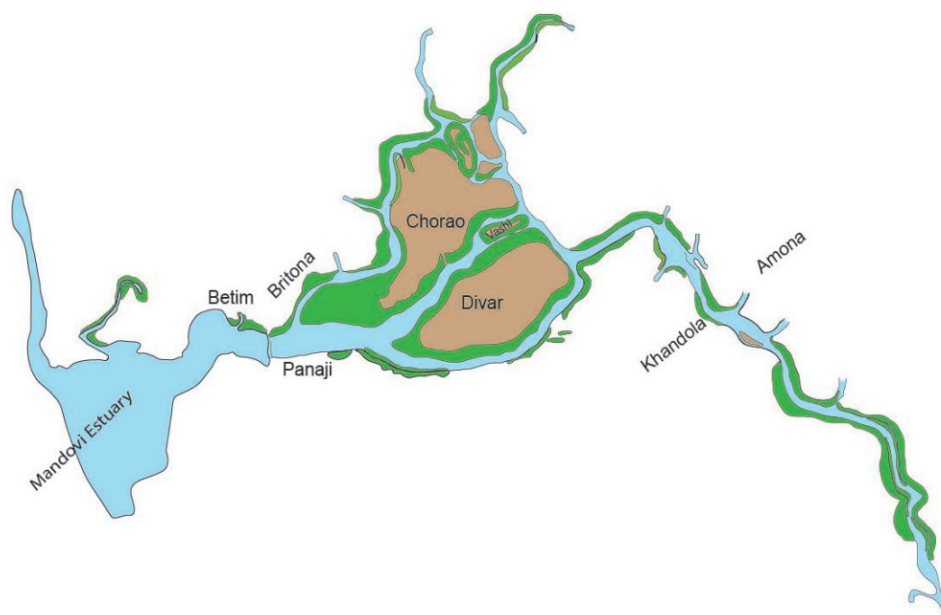


Fig. 8 Distribution of mangroves along the Mandovi estuary

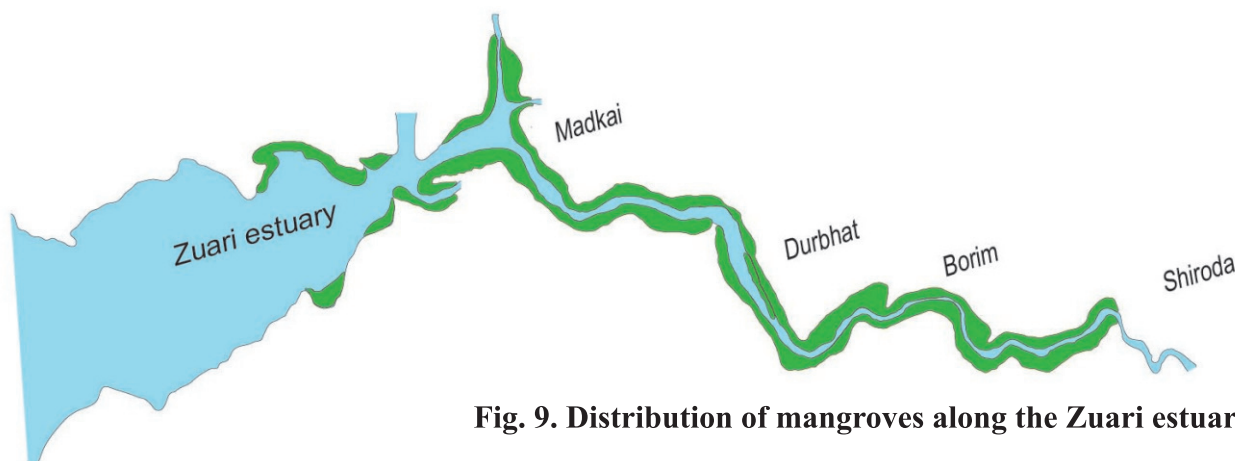


Fig. 9. Distribution of mangroves along the Zuari estuary

2. ZUARI ESTUARY

I. Cortalim side

- (a) Cortalim = *A. officinalis* & *A. marina* (D); *R. mucronata* – (A); *S. alba*, *A. corniculatum* & *E. agallocha* – (M); *A. illicifolius* & others – (P).
- (b) Loutolim & Raia = *A. officinalis* & *A. marina* – (A); *S. alba* (C); *R. mucronata* & *R. apiculata* (M); *E. agallocha*, *A. illicifolius* & others (P).
- (c) Borim, Sanvordem = *A. officinalis* & *A. marina* (A); *R. mucronata*, *R. apiculata*, *S. caseolaris* (C); *A. illicifolius*, *A. aurum* & others (P).

II. Agacaim side

- (a) Agacaim & Madkai = *A. officinalis* (A); *R. mucronata* & *R. apiculata* (C); *S. alba*, *B. gymnorrhiza* (M), *A. illicifolius* & others – (P).
- (b) Durbhat & Borim = *A. officinalis* & *A. marina* (A); *R. mucronata*, *R. apiculata* & *B. gymnorrhiza* (C); *S. alba*, *A. illicifolius*, *Clerodendron inerme* & others (M).

- (c) Panchwadi, Shiroda = *A. marina* & *A. officinalis* (C); *S. caseolaris* (A); *K. candel* (P); *R. mucronata*, *A. illicifolius*, *A. aurum* & others (M).

Note – *Sonneratia caseolaris* is very prominent and dense in Panchawadi, Shiroda areas which is due to the low salinity.

3 CHAPORA (COLVALE) ESTUARY

- I **Agarwada, Siolim** = *A. officinalis* & *S. alba* (A); *A. illicifolius* (C); *R. mucronata* (M); *P. coarctata* & others (P).

- II **Colvale Macazana** = *A. officinalis* & *S. alba* (A); *Ceriops tagal* (M); *K. candel*, *R. mucronata* & *R. apiculata* (C); *A. illicifolius*, *P. coarctata* & others (P).

- III **Virnoda, Camurlim** = *R. mucronata*, *R. apiculata* & *A. officinalis* (M); *B. gymnorrhiza* & *A. corniculatum* (C); *S. alba* & *S. caseolaris* (P); *A. illicifolius* & others (R).

Note - This estuary is rich in *Bruguiera gymnorrhiza* and *Aegiceras corniculatum* at Virnoda ;

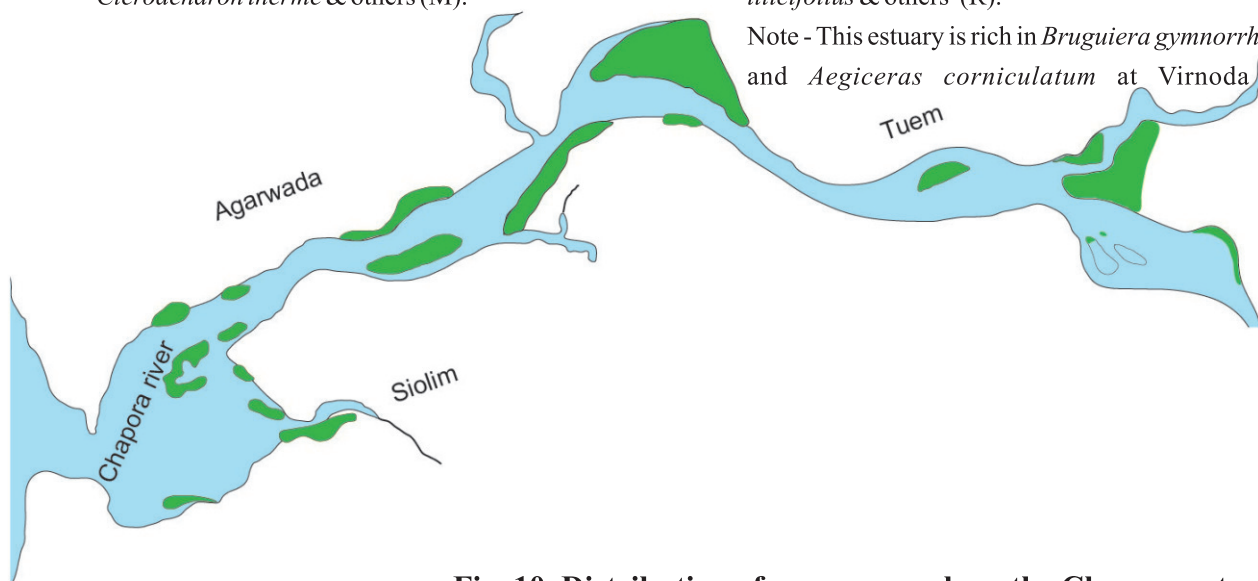


Fig. 10. Distribution of mangroves along the Chapora estuary

4. TEREKHOL ESTUARY

I. **Keri, Palyem, Kiran Pani** = *A. officinalis* & *S. alba* (C); *C. tagal* (R); *R. mucronata* (M); *A. ilicifolius*, *D. heterophylla* & others (P).

II **Deusa** = *A. officinalis* (A); *S. alba*, *R. mucronata* (C); *C. tagal* (M), *A. ilicifolius* & others (P).

Note -This is the only estuary where *Ceriops tagal* grow luxuriantly and now it has also spread in other adjacent estuaries.

5. SAL ESTUARY

I **Cavalossim** = *A. officinalis* (A); *S. alba* (C); *R. mucronata* (M); *A. ilicifolius*, & others (P).

II **Towards Margao** = *A. officinalis* (D); *S. alba*-(C);

R. *mucronata*, *A. aurum*, *A. ilicifolius* & others (M).

Note - This is the smallest estuary with well protected banks. Mangroves are subjected to siltation and pollution

6 TALPONA ESTUARY

I **Talpona, Khalwada** = *A. officinalis* & *A. marina* (A); *R. mucronata* (C); *B. gymnorrhiza* (M); *A. ilicifolius*, *D. heterophylla*, *A. corniculatum* & others (P).

Note - Mangroves are in few patches but dense.

7 GALGIBAG ESTUARY

I **Mashem, Loliem** = *A. officinalis* & *A. marina* -



Fig. 11. Distribution of mangroves along the Terekhol estuary

(A); *R. mucronata* & *R. apiculata* (C); *A. corniculatum* (M); *A. ilicifolius* & others (P).

II **Poinguinim & Galgibag** = *A. officinalis* & *A. marina* - (A); *R. mucronata* & *R. apiculata* (C); *B. gymnorrhiza* & *Bruguiera cylindrica* (M); *A. ilicifolius* & others (P).

Note - Mangroves are dense at the mouth of the river.

8. CUMBHARJUA CANAL ESTUARY

The prominent species are *A. officinalis* & *A. marina* (A); *R. mucronata* & *R. apiculata* (C); *S. alba* (M); *B. gymnorrhiza*, *A. ilicifolius*, *D. heterophylla* & others (P).

Note -The canal joins two major estuaries of Goa namely, Mandovi and Zuari and harbours luxuriant fringing mangrove that hosts estuarine crocodile, *Crocodilus palustris*. This fresh water crocodile species adapted to the estuarine conditions. These mangroves protect the bunds and prevent the entry of blackish water into the khazan lands.

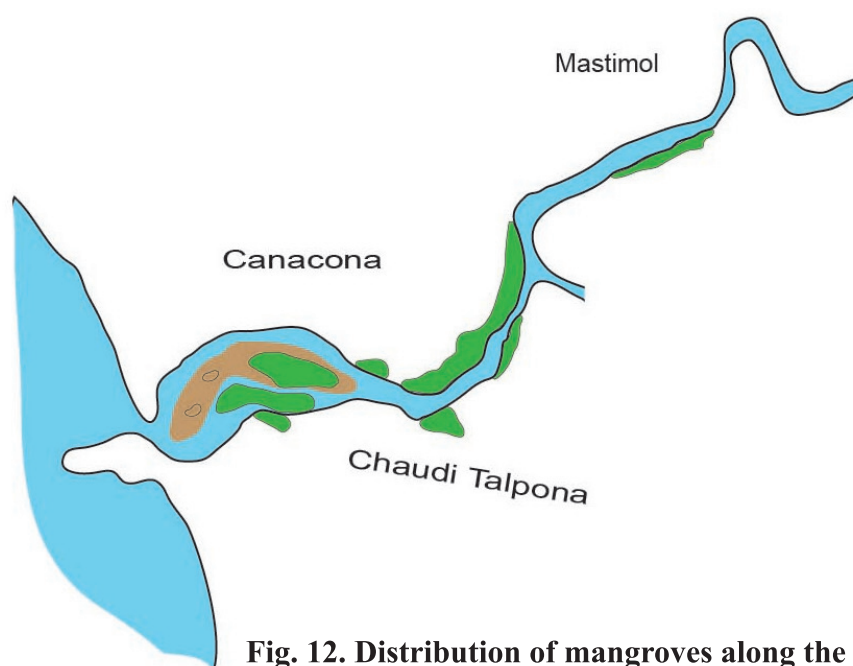
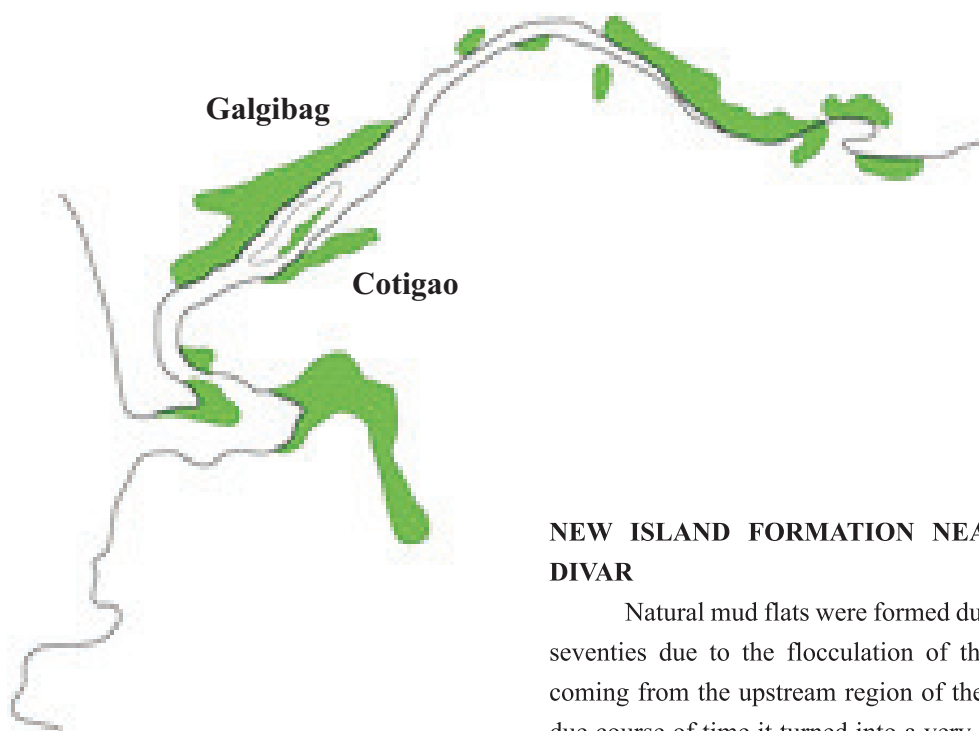


Fig. 12. Distribution of mangroves along the Talpana estuary

Fig. 13. Distribution of mangroves along the Galgibag estuary



(Dominant (D) > 80 %; Abundant (A) 80 – 70 %;
Common (C) 70 - 50%; Moderate (M) 50 – 30 %;
Patchy (P) 30 – 10%; Rare (R) <10%).

NEW ISLAND FORMATION NEAR CHORAO-DIVAR

Natural mud flats were formed during later part of seventies due to the flocculation of the sedimentation coming from the upstream region of the mining belt. In due course of time it turned into a very dense mangrove island. Initially, the pioneer species, grass was established and in due course of time some mangrove seedlings got trapped and started growing. Presently, this island has number of mangrove species with well grown mangroves up to 4 to 6 m tall. Number of birds visits this area for nesting, roosting, feeding and taking shelter.

During 2013-14, Mangrove Society of India, planted about 2000 mangrove seedlings in the exposed muddy area of this island. This plantation programme was the part of the “Awareness campaign amongst the student community regarding mangrove conservation” project funded by the Dept. of Science, Technology and Environment, Govt. of Goa.



Fig. 14. Distribution of mangroves along the Cumbharjua canal



Fig. 15. New island formed in Mandovi estuary