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Diversity of mangroves in Goa, central west cost of India

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Abstract
Indian mangrove vegetation covers about 6,749 km^2 along the 7516.6 km. long coast line. Goa is a small state situated along the central western coast of India. Encompasses an area of 3,702 km^2 (1,429 sq. miles). It lies between the latitudes N 14°53'54" and N 15°40'00" and longitudes E 73°40'33" and E 74°20'13". The highest point is the Sonsog with an altitude of 1,167 meters (3,829 ft). Goa has a coastline of 101 km. The present study documents the diversity of true mangroves and mangroves associates, in Goa selected sites are Zuari, Mandovi, Chapora, Terekhol, Talpona, Galgibag and Salim Ali Bird Sanctuary. For this several field tours of short and long duration during Jan 2015 to Dec 2017 were conducted. These places are far from one another and the mangrove species diversity varies from one place to another, due to factors such as climate, tidal factors and anthropogenic pressures. Sixteen true mangrove floral species were observed along the sea coast in saline swamp and the adjacent regions at the study sites. This paper deals the need of present study to gain knowledge and distribution about the mangrove flora in order to help conservation of mangrove ecosystem.

Keywords: mangroves, diversity

Introduction
The term "mangrove" refers to an assemblage of tropical trees and shrubs that grows in the intertidal zone. Mangroves include approximately 16 families and 40 to 50 species according to Tomlinson (1986). Mangrove is a non-taxonomic term used to describe a diverse group of plants that are all adapted to a wet, saline habitat. Mangrove may typically refer to an individual species. Terms such as mangrove ecosystem, mangrove community, mangrove forest, mangrove swamp and mangal are used interchangeably to describe the entire mangrove community. They fall into two groups according to their habitats in nature true mangrove and mangroves associates. True mangroves refer to species that specifically grow in intertidal zones, while mangrove associates are capable of occurring in either terrestrial or littoral habitats. Mangroves are taxonomically diverse group of salt-tolerant, mainly arboreal, flowering plants that grow primarily in tropical and subtropical regions (Ellison and Stoddart, 1991) [3]. Mangrove formations depend on terrestrial and tidal waters for their nourishment and silt deposits from upland erosion as substrate for support. Mangrove is one of the most productive ecosystems and a natural renewable resource (Kathiresan, 2003) [5].

Zonation of plant communities in intertidal habitats is particularly striking and often results in monospecific bands of vegetation occurring parallel to the shoreline. Although zonation patterns are usually depicted in a manner that suggests a rigid sequence proceeding from the shoreline to upland regions, many patterns resemble a mosaic with vegetation patterns occurring repeatedly where the land mass is interrupted by watercourses or other variations in topography. Mangroves exhibit zonation patterns in a number of different geographic regions (Davis 1940; Smith 1992; Mendelssohn & McKee 2000) [2, 8].

Total mangrove forest area of the world in 2000 was 137,760 km^2 in 118 countries and territories. The total mangrove area accounts for 0.7% of total tropical forests of the world. This areal estimate does not provide information about the quality of the forests. The largest extent of mangroves is found in Asia (42%) followed by Africa (20%), North and Central America (15%), Oceania (12%) and South America (11%). Approximately 75% of mangroves are concentrated in just 15 countries (Giri *et al.*, 2011) [4].

India with a long coastline of about 7516.6 km, including the island territories (Anonymous, 1984) [1], has a mangrove cover of about 6,749 km^2, the fourth largest mangrove area in the world (Naskar & Mandal, 1999) [7]. These mangrove habitats (69°E-89.5°E longitude and 7°N-23°N latitude) comprise three distinct zones: East coast habitats having a coast line of about 2700 km, facing Bay of Bengal, West coast habitats with a coast line of about 3000 km, facing Arabian sea, and Island Territories with about 1816.6 km coastline or estuarine margins" (Duke, 1992) [4]. The Indian mangroves comprise approximately 59 species in 41 genera and 29 families of these, 34 species belonging to 25 genera and 21 families are present along the west coast.

Material Method
Data collection and curation
Regular surveys were made along the beaches, deltaic regions, river channels and the mouth of estuaries to explore the successful results of the true mangroves and their associates. The mangroves and mangrove associated vegetation were plucked during their flowering and fruiting seasons for identification and took photographs with the help of camera. The nomenclature of the specimens followed, by referring

floras and websites like www. iphi. org, www. The plant list. org and consultation of various herbaria. Mangroves are evergreen plants hence tours were arranged frequently. During the field visit, samples of healthy plants were taken for purpose of herbarium specimen. At the same time fresh leaves and stem were taken for chemical analysis. Field data such as habit, habitat, flower color, local names along with Gps location and their uses if anywhere gathered from villagers were also recorded. All the collected specimens were examined critically identified by referring to various Floras such as National and Regional Floras, monographic and revisionary works.

Result and Discussion

Seven estuaries has been observed in present work. These estuaries originate in the Sahyadri ranges of Western Ghat. The estuaries flow westward and join the Arabian Sea. Mangroves occur along the seven estuaries and Cumbarjua canal.

Seven estuaries of Goa namely

Table 1: GPS location of estuaries

Site No.	Estuary Name	Latitude	Longitude
1.	Terekhol	$15^0$42'30" N -$15^0$45'N	E $73^0$40' E - $73^0$48' E
2.	Chapora	N $15^0$40' N - $15^0$35'N	E $73^0$45' E - $73^0$50'E
3.	Mandovi	N $15^0$36' N - $15^0$24'N	E $74^0$00' E - $74^0$12'E
4.	Zuari	N $14^0$54' N - $15^0$48'N	E $73^0$41' E - $74^0$20'E
5.	Sal	N $15^0$10' N - 15^0.43'N	E $73^0$00' E - $73^0$36'E
6.	Talpona	N $15^0$0' N - $15^0$34' N	E $74^0$4' N - $41^0$51' E
7.	Galgibag	N $14^0$58' N - 14.67'	E $74^0$04' E -$74^0$63' E

True Mangroves

The results after the intensive survey, made from the selected sites, showed the following sixteen true mangrove species belonging to seven families.

Table 2: A classified list of Mangroves Distribution

Sr.No.	Name Of Species	Family	Life Form	Site-1	Site-2	Site-3	Site-4	Site-5	Site-6	Site-7
1.	*Rhizophora mucronata* Poir.	Rhizophoraceae	T	G	P	G	G	G	M	G
2.	*Rhizophora apicularta* Blume	Rhizophoraceae	T	-	-	M	-	-	-	G
3.	*Ceriops tagal* (Perr.) C. B. Rob.	Rhizophoraceae	S	G	-	-	-	-	-	-
4.	*Avicennia officinalis* L	Acanthaceae	T	M	G	G	G	G	G	G
5.	*Avicennia marina var. acutissima* Stapf and Moldenke	Acanthaceae	T	P	P	M	G	-	M	M
6.	*Avicennia alba* Blume	Acanthaceae	T	-	-	P	-	G	-	-
7.	*Sonneratia alba* J. Smith	Sonneratiaceae	T	G	G	G	G	P	G	G
8.	*Sonneratia caseolaris* (L.) Engler	Sonneratiaceae	T	P	G	G	P	-	-	-
9.	*Bruguiera gymnorrhiza* (L.)	Rhizophoraceae	T	-	-	P	M	-	M	P
10.	*Bruguiera cylindrica* (L.) Blume	Rhizophoraceae	T	-	-	P	P	-	-	-
11.	*Kandelia candel* (L.) Druce.	Rhizophoraceae	T	P	G	G	P	-	-	-
12.	*Exoecaria agallocha* Linn.	Euphorbiaceae	T	M	G	P	M	P	G	M
13.	*Aegiceras corniculatum* (L.) Blanco.	Myrsinaceae	S	P	-	P	P	M	G	-
14.	*Acanthus ilicifolius* Linn.	Acanthaceae	S	M	G	G	G	M	G	G
15.	*Derris heterophylla* Willd.	Fabaceae	T	P	M	M	-	M	M	P
16.	*Acrostichum aureum* (L.)	Petridaceae	S	G	M	G	-	M	M	P

Life forms : T= tree, S= shrub.
Mangroves cover : G = Good, M = Moderate, P = Poor, (-) = Absent.

Result

Site 1: Terekhol Estuary

The Terekhol estuary is between Goa and Maharashtra. The length of this is about 26 km. The dominant mangrove species in this area are *Rhizophora mucronata* Poir., *Sonneratia alba* J. Smith, *Acrostichum aureum* (L.)
and *Avicennia officinalis* L Whereas *Exoecaria agallocha* Linn. and *Acanthus ilicifolius* Linn. are observed in moderate condition. Most important characteristics of this site is that there is a large concentration of *Ceriops tagal* (Perr.) C. B. Rob. which are not present elsewhere in Goa. Very poor representation of *Avicennia marina var. acutissima* Stapf and Moldenke, *Sonneratia caseolaris* (L.) Engler, *Kandelia candel* (L.) Druce., *Aegiceras corniculatum* (L.) Blanco. and *Derris heterophylla* Willd. were observed.

Site 2: Chapora Estuary

Mangroves are not observed Near the mouth region, they are not present due to strong currents in the area. Mangroves started appearing near Morgim and up to a stretch of around 3 km. up to Siolim. The length of this estuary is about 3 km. in length. The dominant mangrove species in this area are *Avicennia officinalis* L, *Sonneratia alba* J. Smith, *Sonneratia caseolaris* (L.) Engler, *Kandelia candel* (L.) Druce., *Exoecaria agallocha* Linn. *and Acanthus ilicifolius* Linn..Whereas *Derris heterophylla* Willd. *and Acrostichum*

aureum (L.) are observed in moderate condition. Very poor representation of *Rhizophora mucronata* Poir. *and Avicennia marina var. acutissima* Stapf and Moldenke is observed. All along the Chapora estuary, mangrove vegetation occurred in the form of small and scattered patches. Except few good patches, mangroves along the Chapora estuary can be classified as degraded mangroves.

Site 3: Mandovi Estuary

The Mandovi estuary is about 68 km. in length. It has several tributaries with total length of about 109 km. Mouth region of this estuary is from Miramar to Mandovi bridge at Panjim. Because of strong wave action and pure sandy substratum which is not suitable for growth of mangroves. The dominant mangrove species in this area are *Rhizophora mucronata* Poir., *Avicennia officinalis* L, *Sonneratia alba* J. Smith, *Sonneratia caseolaris* (L.) Engler, *Kandelia candel* (L.) Druce. and *Acanthus ilicifolius* Linn. Whereas *Rhizophora apicularta* Blume, *Avicennia marina var. acutissima* Stapf and Moldenke *and Derris heterophylla* Willd. are observed in moderate condition. Very poor representation of *Avicennia alba* Blume, *Bruguiera gymnorrhiza* (L.), *Bruguiera cylindrica* (L.) Blume, *Exoecaria agallocha* Linn. *and Aegiceras corniculatum* (L.) Blanco. is observed.

Site 4: Zuari estuary

The Zuari estuary is 63 km. in length. Maximum mangroves vegetation occurs in this area. Mouth region was rocky and wave action was strong in this area. Because of these reasons, mangroves were not found in the first 4-5 km. The dominant mangrove species in this area are *Rhizophora mucronata* Poir., *Avicennia officinalis* L, *Avicennia marina var. acutissima* Stapf and Moldenke, *Sonneratia alba* J. Smith and *Acanthus ilicifolius* Linn. Whereas *Bruguiera gymnorrhiza* (L.) and *Exoecaria agallocha* Linn. are observed in moderate condition. Very poor representation of *Sonneratia caseolaris* (L.) Engler, *Bruguiera cylindrica* (L.) Blume and *Kandelia candel* (L.) Druce. is observed.

Site 5: Sal Estuary

The Sal is a small estuary having length of about 10 km. All along the estuary mangroves were present in the form of scattered patches. The dominant mangrove species in this area are *Rhizophora mucronata* Poir., *Avicennia officinalis* L and *Avicennia alba* Blume. Whereas *Aegiceras corniculatum* (L.) Blanco, *Acanthus ilicifolius* Linn., *Derris heterophylla* Willd and *Acrostichum aureum* (L.) are observed in moderate condition. Very poor representation of *Exoecaria agallocha* Linn. is observed.

Site 6: Talpona Estuary

The Talpona is a small estuary approximately 9 km. The mangrove vegetation is very scanty and scattered. The dominant mangrove species in this area are *Avicennia officinalis* L, *Sonneratia alba* J. Smith, *Exoecaria agallocha* Linn., *Aegiceras corniculatum* (L.) Blanco *and Acanthus ilicifolius* Linn.. Whereas *Rhizophora mucronata* Poir., *Avicennia marina var. acutissima* Stapf and Moldenke, *Bruguiera gymnorrhiza* (L.), *Derris heterophylla* Willd. and *Acrostichum aureum* (L.) are observed in moderate condition.

Site 7: Galgibag Estuary

The Galgibag estuary is about 16 km. in length with dense mangrove vegetation. Near Galgibag, which is close to the estuary mouth, mangrove vegetation was very dense. The dominant mangrove species in this area are *Rhizophora mucronata* Poir., *Rhizophora apicularta* Blume, *Avicennia officinalis* L, *Sonneratia alba* J. Smith *and Acanthus ilicifolius* Linn.. Whereas *Avicennia marina var. acutissima* Stapf and Moldenke, and *Exoecaria agallocha* Linn. are observed in moderate condition. and Very poor representation of *Bruguiera gymnorrhiza* (L.), *Derris heterophylla* Willd. and *Acrostichum aureum* (L.) were observed.

The species *Avicennia officinalis* L, *Rhizophora mucronata* Poir.are the dominant mangroves found in almost all the sites. The next dominating species are *Kandelia candel* (L.) Druce., *Bruguiera gymnorrhiza* (L.), *Sonneratia alba* J. Smith, *Aegiceras corniculatum* (L.) Blanco found distributed in all the selected sites. The other species are *Exoecaria agallocha* Linn. and *Acanthus ilicifolius* Linn. found distributed in all the selected sites. Similar observations were made by M. J. Kothari and K. M. Rao-January 2002.

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