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Community Structure and Diversity of Mangroves at Kannur District of Kerala, Southwest Coast of India

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ABSTRACT
Mangrove forests are among the world's most productive ecosystems situated at the interface between land and sea/backwaters in tropical and subtropical latitudes. Mangrove vegetation in three geographical regions of Kannur on the southwest coast of India was assessed for its community structure and diversity indices. Thirteen true mangrove species belonging to 9 genera and 7 families formed the mangrove vegetation of the region. Highest density was recorded for *Acanthus ilicifolius* (7953 stems/ha), followed by *Rhizophora mucronata* (3750 stems/ha). *A. ilicifolius* is the most common species with maximum important value index (IVI) of 49.19. Shannon-Weiner Index of diversity ranged from 2.249 to 2.527. Kunhimangalam region have more species richness with a Simpson dominance index of 0.920 and Shannon - Weiner index of 2.527. The sites selected were distinct from each other as the species diversity varied due to the climatic, biotic, anthropogenic stresses at each location. The need to gain further knowledge about the mangrove flora of the region to help the conservation of mangrove ecosystems is highlighted.

Key words: Importance Value Index, frequency, Floristic study, Diversity, Ecosystem, Conservation

INTRODUCTION

Mangrove species are the salt tolerant halophytic plants, provide a wide range of ecological and economic products, and support estuarine and marine ecosystems. They are among the world's most productive ecosystems situated at the interface between land and sea/backwaters in tropical and subtropical latitudes. According to their habitats, mangroves are categorized into two groups namely eumangroves (true mangroves) and mangrove associates. True mangroves are the species that are specifically grown in inter-tidal zones, while mangrove associates can grow in either littoral or terrestrial habitats. The mangrove species belong to several unrelated families, but they possess similar physiological characteristics and structural adaptation with similar habitat preference.

In India, the total area of mangroves was estimated to be 6740 km^2 (Anonymous 1987), which was about 7% of the world's mangrove area. This is presently reduced to 4992km^2, occupying 3% of the global mangroves (Anonymous 2021). In the last two decades, mangrove areas have witnessed annual loss between 0.16 and 0.39% globally due to various anthropogenic activities (Anonymous 2007, Hamilton and Casey 2016).

Kerala, the southwestern tip of peninsular India, with a shoreline of 590km is blessed with about 70 km^2 mangroves till 1957. The mangrove areas in Kerala have been dwindling widely in the past few decades from ~70 km^2 in 1985 (Ramachandran et al. 1985) to ~16.71 km^2 in 1991 (Basha 1991), ~10.95km^2 in 1994 (Kurien et al. 1994), ~25.02 km^2 in 2014 (Vidyasagaran and Madhusoodanan 2014) and ~ 9.36 km^2 in 2021 (Anonymous 2021). Out of the 16.71 km^2 total area of mangroves in Kerala, 14.70 km^2 are with private holders (Basha 1991). Vidyasagaran and Madhusoodanan (2014) report the extent of mangroves of Kerala was 25.02 km^2 of which 11.89 km^2 belongs to the state and 13.13 km^2 under private ownership.

Kannur is the northern most district of Kerala state and exhibits luxuriant mangrove forests which cover almost 66% of the total mangrove forests of the state (Anonymous 2021). Even though there were reports (Vidyasagaran et al. 2011, Sreeja and Khaleel 2010) on the diversity of mangroves from different regions of Kannur district, the diversity and ecology of Pazhayangadi, Chemballikund and Kunhimangalam is not fully explored. There were approximately 7.55 km^2 of mangrove forests in Kannur (Pillai and Harilal 2018). However, it has now reduced to 6.39 km^2 (Anonymous 2021). Nowadays, mangrove

ecosystem in this region is heavily influenced by sand mining, land filling, waste dumping, extensive collection of mangrove resources and also infrastructure development which cause pose threats to mangrove biodiversity and its natural regeneration. The lack of ecological information significantly hampers the assessment of existing species, their present status and threats which might facilitate their long term conservation. Hence, an attempt was made to study the distribution and phytosociological parameters of mangrove vegetation in the Pazhayangadi, Chemballikund and Kunhimangalam regions of the Kannur District, Kerala.

MATERIALS AND METHODS

Study area

Kannur is the northern most district of Kerala state, lies between the latitude 11º40' and 12º48' N and longitude 74º52' and 76º7' E. The region receives an annual average rainfall of 2,555 mm and average temperature ranges between 24 and 30°C. The present study was conducted in three regions of Kannur district namely Pazhayangadi (12.0189º N, 75.2588º E), Kunhimangalam (12.1103º N, 75.219º E), and Chemballikundu (12.0500º N, 75.2424º E) (Fig.1).

Ecological data analysis

Field studies were carried out from April 2019 to March 2020. Ten quadrats of 10×10 m size were laid at each site. On the basis of data enumerated, density, frequency, basal area and importance value index (IVI) of mangrove species were calculated following standard phytosociological methods (Shannon, 1948, Simpson, 1949, Curtis and Mclntosh 1951, Curtis 1959). Girth of trees exceeding 10 cm diameter at breast height (dbh at 1.37m above the ground) was measured.

RESULTS AND DISCUSSION

Kunhimangalam possesses the highest area of 0.286 km^2 of the total extent of mangroves in Kerala. It has also been highlighted that out of 10 districts studied, Kannur district occupied highest mangrove cover with 7.465 km^2 which is coming around 38.22 % of the total extent within the state (Pillai and Harilal 2018).

Species composition

Floristic study of the three sites in Kannur revealed the occurrence of 13 species belonging to 9 genera and 7 families (Table 1). Among the families, Rhizophoraceae was the most frequent having five

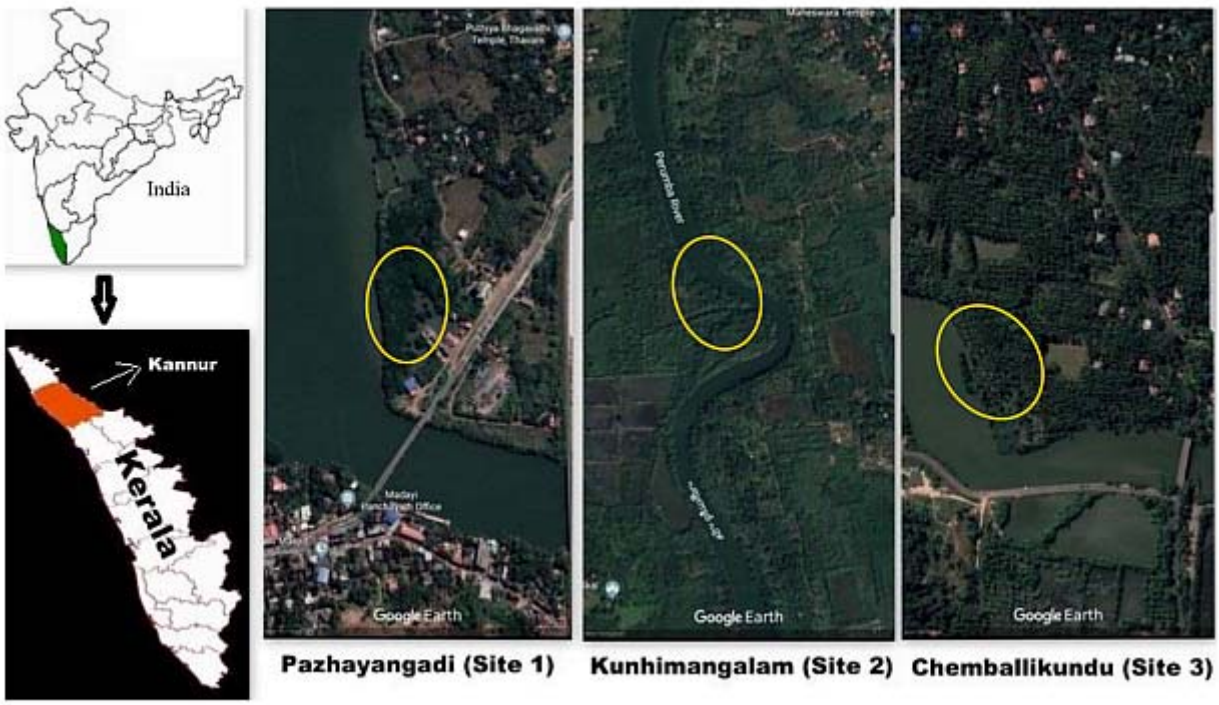

Figure 1. Sampling sites at Kannur

Table 1. Distribution of mangrove species in the three sampling sites at Kannur

True mangrove species	Family	Pazhayangadi	Kunhimangalam	Chemballikundu
Rhizophora mucronata Poir.	Rhizophoraceae	+	+	+
Avicennia officinalis L.	Avicenniaceae	+	+	+
Avicenniamarina (Forssk.)Vierh.	Avicenniaceae	+	+	+
Kandelia candel (L.)Druce	Rhizophoraceae	+	+	+
Sonneratia alba J.E.Smith	Sonneratiaceae	+	+	+
Sonneratia caseolaris (L.)Engl.	Sonneratiaceae	+	+	+
Bruguiera cylindrical (L.) Blume	Rhizophoraceae	+	+	+
Aegiceras corniculatum (L.) Balnco	Myrsinaceae	+	+	+
Excoecaria agallocha L.	Euphorbiaceae	+	+	+
Acanthus ilicifolius L.	Acanthaceae	+	+	+
Bruguiera sexangula (Lour.) Poir.	Rhizophoraceae	-	+	-
Lumnitzera racemosa Willd.	Combretaceae	-	+	-
Rhizophora apiculata Blume	Rhizophoraceae	-	-	+

species, followed by Avicenniaceae and Sonneratiaceae with two species each, Myrsinaceae, Euphorbiaceae, Acanthaceae, and Combretaceae with one species each. Among the sites, Kunhimangalam recorded the highest number of species (12 species) followed by Chemballikund (11 species) and the least was recorded in Pazhayangadi (10 species).

Rhizophora mucronata, Avicennia marina, A. officinalis, Kandelia candel, Sonneratia alba, S. caseolaris, Bruguiera cylindrica, Aegiceras corniculatum, Excoecaria agallocha and *Acanthus ilicifolius* are found in all the studied sites, which shows that these species are common in Kannur District. *Bruguiera sexangula* and *Lumnitzera racemosa* are found only in the estuaries of Perumba river at Kunhimangalam. *Rhizophora apiculata* is found only in Chemballikundu (Annexure 1). Kannur has a maximum of 12 true mangrove species, which include *A. corniculatum*, *A. marina*, *A. officinalis*, *B. cylindrica*, *B. sexangula*, *E. agallocha*, *K. candel*, *L. racemosa*, *R. apiculata*, *R. mucronata, S. alba* and *S. caseolaris* (Pillai and Harilal 2018).

Usually, an increase in the number of the plant species is an index of ecosystem health in wetlands. But in the case of mangroves, their species distribution is restricted by competition, salinity, and other physical factors (Hogarth 2007). Mangrove forests, in contrast, appear to have species and communities with more pioneer-stage than mature-stage characteristics, including light-demanding seedlings, competition for light, dispersal by tides etc. (Alongi 2020). The species composition and the agent causing maximum destruction are related to the difference in localities (Rao 1986).

In Kerala, 15 true mangrove species have been recorded, falling under 9 genera and 7 families (Pillai and Harilal 2018, Sukumaran and Hari 2018) along with 49 mangrove associates (Anupama and Sivadasan 2004). Vidyasagaran et al. (2011) reported 12 species of mangrove in the entire Kannur district. Eleven true mangrove species and six associates were found in Thekkumbad island of Kannur (Sreeja and Khaleel 2010). Vaiga and Joseph (2016) reported 7 species of true mangroves, 4 species of semi-mangroves and 7 species of mangrove associates at Vellikkeel as well as 10 true, 3 semi, 7 mangrove associates at Ezhome of Kannur district.

Phytosociological parameters

Phytosociological assessment is to understand floristic vegetation characteristics and to estimate the species richness and diversity which exists in the study area. The dynamics of each species as well as the relations among each other in a community can be analyzed with a sufficient number of samples as database (Knight 1975). This study is important for understanding the functioning of community, and shows the structure and composition of the component species.

A. ilicifolius has the highest stem density (7953 stems/ha) among the 13 true mangrove species,

followed by *R. mucronata* (3750 stems/ha) followed by *A. officinalis* (3659 stems/ha), and *S. caseolaris* (354 stems/ha) (Table 2). Relative density of the species ranged from 1.26 to 28.31% (Table 2). *A. officinalis* has the highest basal area (28.97 m^2ha^{-1}) followed by *R. mucronata* (26.54 m^2ha^{-1}) and *E. agallocha* (22.54 m^2ha^{-1}). The frequencies of different species revealed the degree of distribution of individual species in an area (Table 2). Relative frequency was highest for *A. officinalis* (15.33%) followed by *A. ilicifolius* (13.29%). Analysis of the abundance of species showed that *R. apiculata* has the least (3.50%) followed by *S. caseolaris* (4.14%) and *L. racemosa* (4.23%). *A. ilicifolius* showed highest abundance (25.87) and relative abundance (22.02%) (Table 2).

In ecological studies, species dominance is calculated based on the Important Value Index. IVI indicates the ecological importance of a species in a specified ecosystem (Curtis 1959). This can be used in the conservation of species, in that species having low IVI value sometimes requires protection preference. This is not the sole criteria for conservation planning. Species with low IVI but having regeneration is not considered threatened. IVI also indicates the niche breadth of a species in the ecosystem. The IVI for a species was often used to describe and compare the species dominance (Table 2). In the present study highest IVI value were recorded for *A. ilicifolius* (49.19) and was found to be the dominant species owing to high values of relative density and relative frequency, followed by *A. officinalis* and *R. mucronata* (47.88 and 43.94, respectively) (Table 2). *A. ilicifolius* and *A. officinalis* were the foremost dominant mangrove species based on the important value index in Kannur, Kerala (Vidyasagaran et al. 2011). The results indicate that *R. apiculata, B. sexangula, L. racemosa* and *S. caseolaris* are the least dominant mangrove species with lower IVI, revealing the rarity and sporadic distribution of those species.

Table 2. Phytosociological parameters of mangroves at Kannur

Name of species	Frequency	Density (stems/ha)	Basal area (m^2/ha)	Abundance	Relative frequency	Relative density	Relative basal area	Relative abundance	IVI
Rhizophora mucronata	61.2	3750	26.54	12.87	12.07	13.34	18.53	10.9	43.94
Avicennia officinalis	77.72	3659	27.97	11.21	15.33	13.02	19.53	9.54	47.88
Avicennia marina	64.32	3421	20.81	10.98	12.68	12.17	14.53	9.34	39.38
Kandelia candel	32	765	4.12	5.87	6.31	2.72	2.87	4.99	11.9
Sonneratia alba	31.56	987	7.87	6.78	6.22	3.51	5.49	5.77	15.22
Sonneratia caseolaris	19.45	354	2.65	4.87	3.83	1.26	1.85	4.14	6.94
Bruguiera cylindrica	30.09	954	4.23	6.12	5.93	3.39	2.95	5.21	12.27
Aegiceras corniculatum	40.34	1236	5.64	7.32	7.95	4.39	3.93	6.23	16.27
Excoecaria agallocha	53.32	3523	22.54	11.13	10.51	12.54	15.74	9.47	38.79
Acanthus ilicifolius	67.42	7953	10.87	25.87	13.29	28.31	7.59	22.02	49.19
Bruguiera sexangula	10.01	564	3.21	5.34	1.97	2.00	2.24	4.54	6.21
Lumnitzera racemosa	13.3	489	2.87	4.97	2.62	1.74	2.00	4.23	6.36
Rhizophora apiculata	6.23	437	3.86	4.12	1.22	1.55	2.69	3.50	5.46
Total	506.96	28092	143.18	117.45					

Diversity indices

Diversity indices can be used to characterize the species abundance relationship in a community. Shannon's diversity index is a simple measure to find out species diversity. The species diversity indices in the present study revealed that the mangroves of

Table 3. Diversity indices of different mangrove sites at Kannur

Name of thelocality	Shannonindex (H')	H' max	Equitability (J)	Simpson´sIndex (D)
Pazhayangadi	2.249 ±0.2	2.546±0.1	0.883±0.8	0.893±0.7
Kunhimangalam	2.527±0.3	3.124±0.1	0.808±0.5	0.920±0.5
Chemballikundu	2.343±0.1	2.621±0.2	0.893±0.2	0.901±0.1

Kannur had a high species diversity and better evenness. Shannon index was maximum in Kunhimangalam (2.527) and lowest in Pazhayangadi (2.249) (Table 3). It indicates that sites with higher Shannon–Weiner index had comparatively maximum number of species. An ecosystem with Shannon–Weiner index greater than 2 has been treated as medium to high diverse (Barbour et al. 1999). High species diversity indicates the maturity of an ecosystem (Odum 1969, 1971) and expected to have better ecosystem functioning (Harishma et al. 2020). The present study indicates, Simpson's dominance value for species was higher (0.920) at Kunhimangalam followed by Chemballikundu (0.901) and least at Pazhayangadi (0.893). The Simpson diversity indices of the sites at Kannur (0.893 to 0.920) are comparatively similar to the values of diversity of mangrove vegetation at Kollam District of Kerala (0.875) (Vijayan et al. 2015). The species evenness (Pielou 1966) or equitability ranged from 0.808 to 0. 893 (Table 3).

CONCLUSION

This study reveals that Mangrove forest in Kannur have 13 species belonging to seven families. Family Rhizophoracae is the largest followed by Avicenniaceae and Sonneratiaceae. Almost all mangroves were dominated by *Acanthus ilicifolius* followed by *Avicennia officinalis* and *Rhizophora mucronata*. *Bruguiera sexangula, Lumnitzera racemosa* and *Sonneratia caseolaris* are the least diverse species in the Kannur. *A. ilicifolius* had maximum density (7953 stems/ha) and is the most common mangrove species with the highest Important value index (IVI) of 49.19. Shannon-Weiner Index of diversity ranged from 2.249 to 2.527. Kunhimangalam region was found to have more species richness with a Simpson dominance index of 0.920 and Shannon-Weiner index of 2.527. In the studied area, mangroves are declining rapidly as they are getting degraded for agriculture, aquaculture, tourism, urban development and over-exploitation. Land clearance for the construction of new sea ports, extension of existing sea ports and establishment of industrial units near the coast has also contributed to the depletion of mangrove cover in the district. Hence considering the importance of mangroves in this coastal ecosystem, there is an urgent need to protect the remaining mangrove areas.

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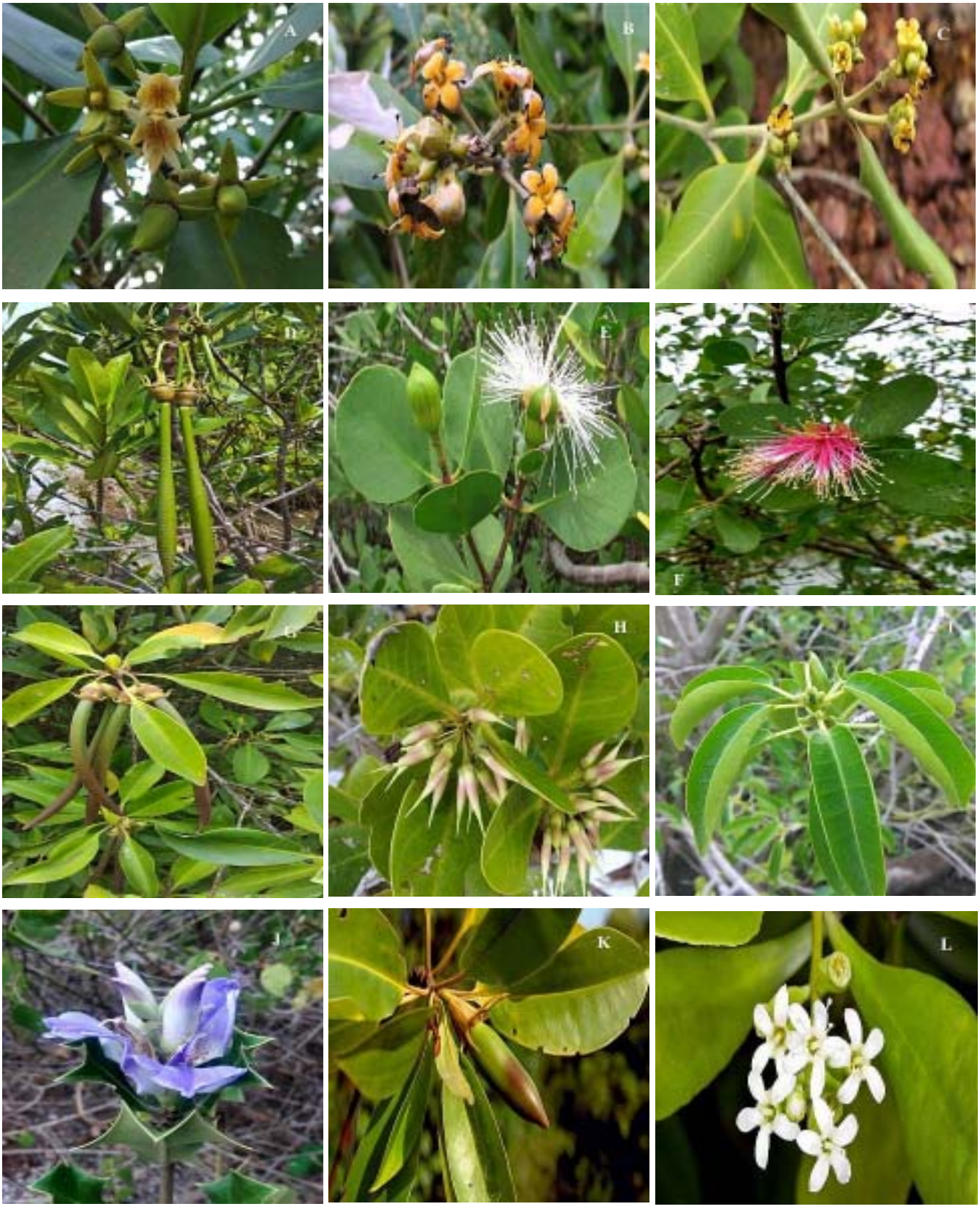
Annexure 1



A. Rhizophora mucronata; B. Avicennia officinalis; C. A. marina; D. Kandelia candel; E. Sonneratia alba; F. S. caseolaris; G. Bruguiera cylindrica; H. Aegiceras corniculatum; I. Excoecaria agallocha; J. Acanthus ilicifolius; K. B. sexangula; L. Lumnitzera racemosa