FLORISTIC DIVERSITY AND STRUCTURAL DYNAMICS OF MANGROVES IN THE NORTH WEST COAST OF KERALA, INDIA

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Abstract: Mangrove vegetation is recognized worldwide as an epitome of most productive ecosystem and tuned with evergreen forest. The present investigation on floristic diversity of Mangroves of Malappuram district revealed that the presence of 11 species of true mangroves under 7 genera belonging to 5 families. Rhizophoraceae was the leading group with 5 species. Avicenna officinalis registered highest density (3045 stems/ha) and lowest for Rhizophora apiculata (53 stems/ha). Relative basal area was recorded highest for Sonneratia caseolaris (32.37%) followed by Avicennia officinalis (27.26%). Structural analysis of the mangroves of Malappuram unveiled that Avicennia officinalis having highest Importance value index (IVI) and Relative importance value index (RIVI) among the 11 species distributed all over. Diversity indices for six mangrove sites and for whole Malappuram district indicated that mangroves at Thalakkad-Pariyapuram constituted highest Shannon – Weiner index and Simpson's index (2.764 and 0.831) whereas Mangattiri – Etrikkadavu having lowest value (1.836 and 0.658) respectively. Species richness and species evenness reported for Malappuram was 1.07 and 0.845 respectively. Similarity indices for different mangrove locations in Malappuram were ranged from 0.20 to 0.70.

Keywords: Mangroves, Floristic diversity, Structural analysis, Diversity index

INTRODUCTION

Mangroves are the trees and shrubs that grow in saline coastal habitats in the tropical and subtropical region. The term 'mangrove' is used generally to describe both the plant communities they form and the habitat itself. The mangrove is one of the most productive ecosystems and a natural renewable resource (Kathiresan, 2003). Mangrove forests are ecosystems of great complexity, composed of phylogenetically isolated species, which are adapted in distinctive ways to the littoral ecosystems where climax salinity, circadian patterns of submergence, wave regime, and recurring disturbance create high stress surroundings (Twilley, 1995). Coastal mangrove habitat includes the inter-tidal Seaboards, backwater areas, inconsequential river mouths and shelter bays of the west coast of the World (Naskar & Mandal, 2008). The three most important physiological and morphological traits in mangrove plants are salt exclusion, vivipary and aerial roots, which facilitate adaptation of mangrove to bleak marshy ecosystem, no particular structural character can describe mangroves (Tomlinson, 1986). Only 0.12 percent of the Earth's land area or 0.037 percent of the World's surface covers by mangrove ecosystem (Ong, 2004). The mangrove ecosystem was found in more than 120 countries and territories across the world. Among 268 plant species that are found in intertidal mangrove areas in Southeast Asia, of which only 52 are regarded as 'true mangroves' (Giesen et al., 2007). In India, mangroves are present both on the western and eastern coastlines, covering an area of about 4639 km^2, occupying 0.14% of the land area (SFR, 2009). Kerala despite having a humid tropical climate and located on the western coast of the Indian peninsula has only vestiges of mangroves. Various studies showed that the extent of mangrove vegetation cover in Kerala is only 1,095 ha (Kurien, et al., 1994). In Kerala, only Kannur has good natural patches of mangrove than that in the other districts and accounts 755 ha. However, it has declined to 17 km^2 (Basha, 1991). Mangrove vegetation in Malappuram is mainly concentrated along the Tirur-Kadalundi river basin. Kadalundi-Vallikkunnu, Kerala's first community reserve is endowed with relatively good patches of mangroves. Pullooni, Murukummadu, Kuttayikadavu are few places where good patches are found. Anthropogenic activities like heavy sand mining, land filling for constructions in mangrove area, pose problems for the natural regeneration of mangroves (Sunil Kumar, 2002). However Pullooni of Tirur, Malappuram district is facing destruction of good patches of mangroves along with the species *Bruguiera sexangula* having decreasing population (Vidyasagaran & Madhusoodanan, 2014). Since, no literature exists specifically on mangroves of Malappuram in any aspects; the present paper is concentrates on the floristic composition, structural dynamics and diversity of mangroves of Malappuram district of Kerala.

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MATERIAL AND METHOD

Study Area

Malappuram is situated at 11.07^0 North latitude, 76.07^0 East longitudes having 44 meters elevation from sea level. Throughout the year, humidity is higher during morning hours and during monsoon

periods; Malappuram receives an annual average rainfall of 2952 mm and average temperature of 27.3^0C. The study was constituted in Pullooni, Thalakkad-Pariyapuram, Mangattiri-Etrikkadavu, Murukkummadu, Kuttayikkadavu, Kadalundi-Vallikkunnu region of Malappuram district.

Ecological data analysis

The study of distribution patterns of mangroves was carried out in six sites and the mangroves found to be varied in girth at breast height (GBH >10cm) were enumerated. The sites were divided into fifteen quadrates of each 5×5m size and analysis was carried out using quadrate method. In order to determine the quantitative relationship the structural parameters like density, frequency, basal area and their relative values, abundance and importance value index (IVI) were calculated on the basis of data obtained from quadrates by using standard Phytosociological methods (Curtis & McIntosh, 1950).

Density = Number of individuals/ha (Eq. 1)
× 100 (Eq. 2)
Basal area = G 2 /4π (Eq. 3)
G = girth at breast height (1.37m) (Eq. 4)
×100 (Eq. 5)
× 100 (Eq. 6)
× 100 (Eq. 7)
× 100 (Eq. 8)
× 100 (Eq. 9)
× 100 (Eq.10)

Plant diversity analysis

Measure of diversity is considered as indicators of the well-being of an ecosystem. To assess and compare the range and distribution of plant species in different locations, the following indices were calculated.

Shannon-Wiener Index (Shannon & Weiner 1963) was used for the calculation of species diversity:

H' = (Eq11)

Where, Ni was the total number of species i and N was the total number of all the species. The factor 3.3219 was used to convert the index value to $\log_2$.

Concentration of dominance was calculated by Simpson's Index (Simpson 1949):

Simpson's Index, D = (Eq. 12)

Where N_i and N were the same as explained above.

Equitability (e) was estimated following Pielou (1966):

Equitability, $e = H'/H_{max}$ (Eq. 13)

Where, $H_{max} = 3.3219\log_{10}S$, H'= Shannon index.

Species richness was estimated following Margalef (1958):

Species richness, d = S-1/lnN (Eq. 14)

Where S = total number of species, N = basal area of all species ($m^2 \cdot ha^{-1}$).

Beta diversity is often been used to indicate the habitat variation with regarded to species composition or the similarity index. It is estimated using Jaccard's index (Jaccard P, 1908). Jaccard's cluster diagram or dendrogram is been done using the software "Biodiversity Professional Ver.2".

Jaccard's Index, J_{ab} = 1- (Eq. 15)

Where, a= number of species present in one location, b = number of species present in another location, c = number of species that are common to both locations.

RESULT AND DISCUSSION

Species Composition

Species composition in different sites in Malappuram revealed the presence of 11 species of true mangroves belonging to 5 families (Table 1). Among families, *Rhizophoraceae* has the highest number of species (5), followed by *Avicenniaceae* and *Sonneratiaceae* each having two species and the families *Myrsinaceae* as well as *Euphorbiaceae* having one species each. Among the locations, Pullooni recorded the highest number of species (10) followed by Thalakkad-Pariyapuram (8 species) and the least was recorded in Kuttayikkadavu (5 species). Distribution of mangroves at different sites indicates that *Avicennia officinalis* and *Rhizophora mucronata* were found in all the six study sites, *Excoecaria agallocha, Kandelia candel* and *Bruguiera cylindrica* were noticed in five sites. *Bruguiera sexangula* were present in the four sites whereas three sites were occupied by *Aegiceras corniculatum*, *Sonneratia caseolaris* and *Avicennia marina.* However, *Rhizophora apiculata* and *Sonneratia alba* were found to be rare and confined in single site. Apart from the noted sites, Malappuram has many other small patches of mangroves which are also under threats of degradation. The species composition and the agents causing maximum destruction, depends upon the localities (Rao, 1986). Studies of Pichavarum mangroves of Tamil Nadu revealed that the presence of 110 species belonging to 60 genera and 35 families (Krishnamurthy *et al*. 1981).

Mangrove Vegetation Structure

Structural analysis includes not only the study of vegetation and its internal "social" relationship, but also provides information on classification of plant communities and their structure, composition, and successional relations. Phytosociological analysis of mangroves of Malappuram (Table 2) revealed that the highest density for *Avicennia officinalis* (3045 stems/ha) followed by *Sonneratia caseolaris* (2230 stems/ha) and lowest density was observed for *Rhizophora apiculata* (53 stems/ha). Relative density for *Avicennia officinalis* was found to be maximum (26.51%) and minimum was represented by *Rhizophora apiculata* (0.46%). Relative frequency was highest for *Avicennia officinalis* (26.62%) whereas, minimum value of 0.34% was found in two species each, *Rhizophora apiculata* and *Sonneratia alba* respectively. Relative basal area was recorded highest for *Sonneratia caseolaris* (32.37%) followed by *Avicennia officinalis* (27.26%) and minimum was

recorded in two species, *Rhizophora apiculata* and *Sonneratia alba* each with 0.44% respectively. Analysis of abundance of species shows that *Aegiceras corniculatum* has the highest value (8.78) and minimum value was represented by *Rhizophora apiculata* (1.00).

Figures

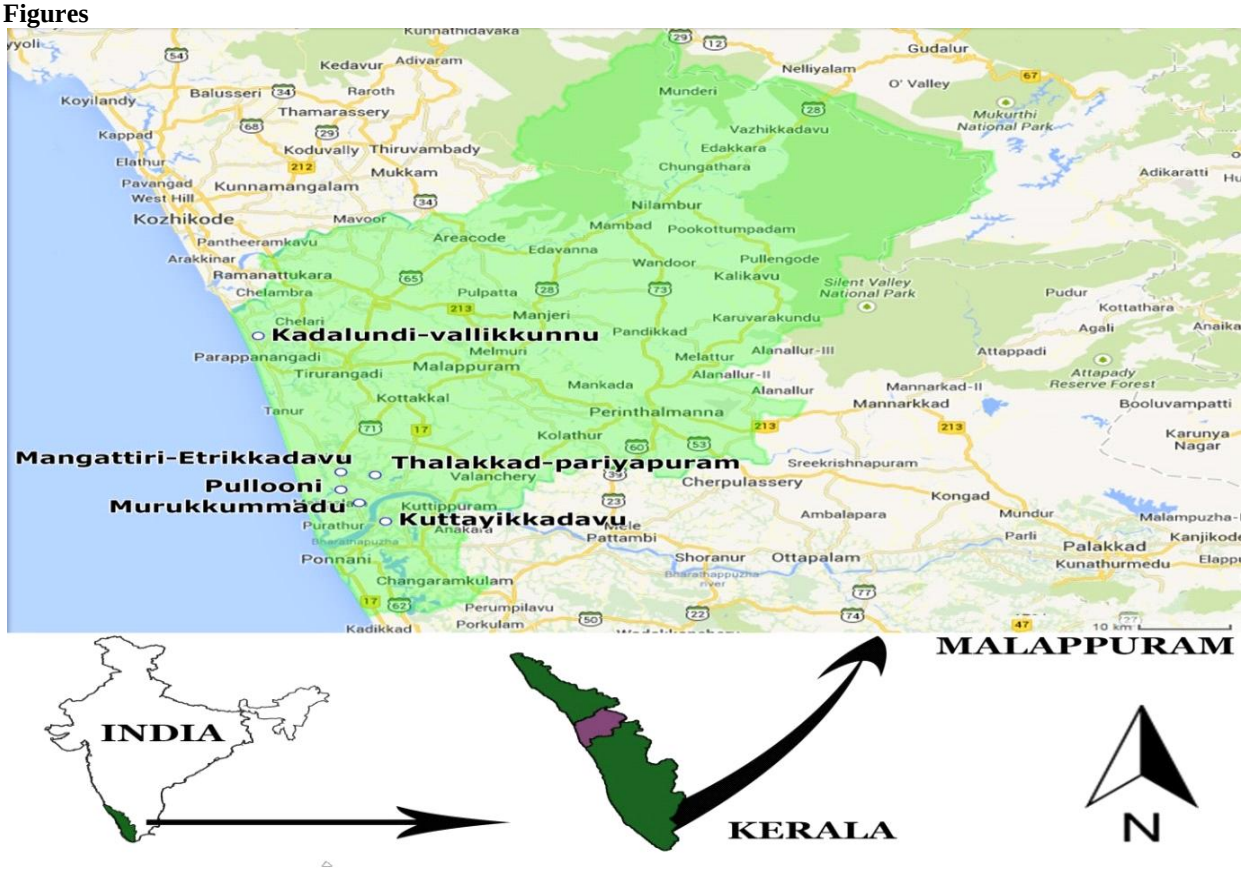

Figure: 1. Map of Kollam district showing different study locations
Figure 2: The density of mangrove species at Malappuram district of Kerala
Figure 3: Important Value Index of different mangrove species at Malappuram district
Figure 3: Diversity indices of Mangroves at Malappuram district

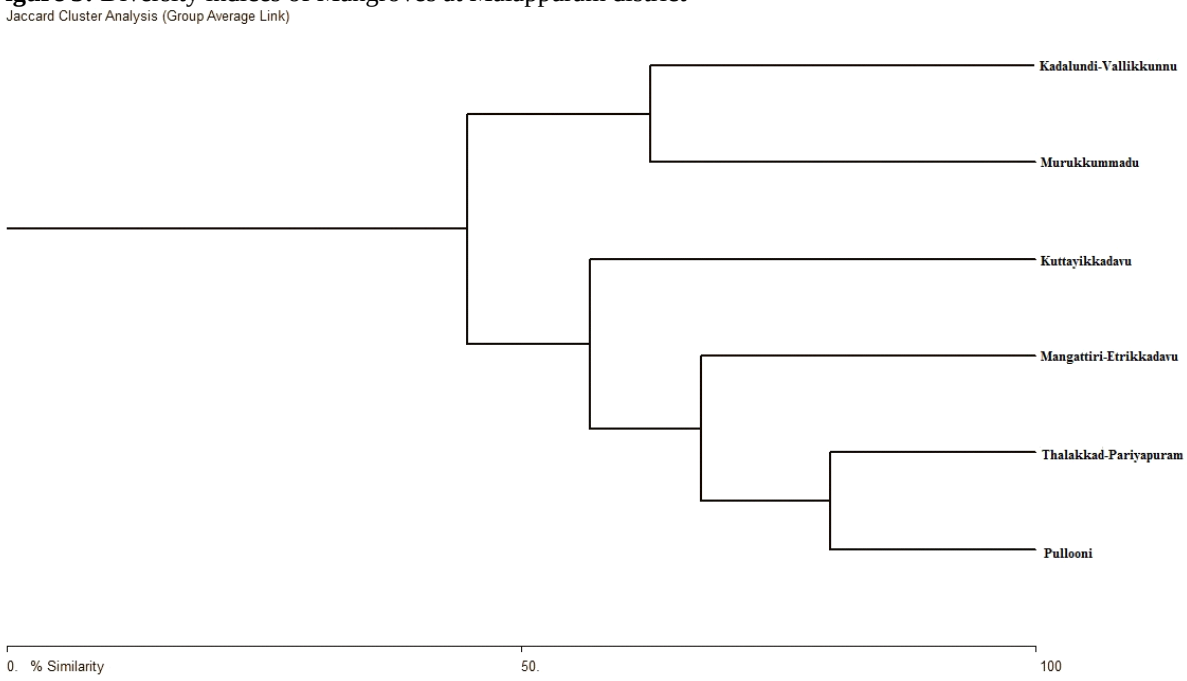

Figure 4: Dendrogram showing grouping of locations sampled during the study period

Species dominance was calculated based on the Important Value Index and was estimated as the sum of its relative basal area, relative frequency and relative density. In Malappuram district, highest IVI and RIVI value was recorded for *Avicennia officinalis* (80.39 and 26.80) was found to be the dominant species owing to high values of Relative density and Relative frequency, followed by *Sonneratia caseolaris* (61.68 and 20.56), whereas the uncommon species *Bruguiera sexangula* is belong to fifth position (28.77 and 9.59). The Phytosociological analysis of Puduvyppu, Kerala revealed that importance value index was highest for *Avicennia officinalis followed by Bruguiera sexangula* (Sureshkumar, 1993). The results indicate that *Avicennia marina*, *Rhizophora apiculata* and *Sonneratia alba* are the least mangrove species of Malappuram region (Table 2). The lowest IVI and RIVI were recorded for *Rhizophora* apiculata (1.24 and 0.41) revealing the rarity of the species. The structural analysis of the mangrove communities at different estuarine formations revealed that there is site specific domination of species which in turn supported by the adaptability of the species to specific site conditions (Vidyasagaran *et al., 2011*).

Diversity indices and Species Richness

Diversity indices can be used to characterize the species abundance across a community. Shannon's diversity index is a measure to describe species diversity and Simpson's index represent the probability of occurring two randomly chosen individuals belonging to same species. Plant diversity indices of six mangrove sites and indices for whole Malappuram showed that Thalakkad-Pariyapuram constituted highest Shannon–Weiner index and Simpson's index (2.764 and 0.831) whereas Mangattiri–Etrikkadavu having lowest value of these indices respectively (1.836 and 0.658). In the present study, mangroves of Malappuram district had Shannon index as 2.923 (Table 3). An ecosystem with H' value greater than 2 has been considered as medium to high diverse in terms of species (Cottom & Curtis, 1956). Thus Malappuram has logically high species diversity. The present study indicates, Simpson index of diversity of mangroves for whole Malappuram as 0.843. Simpson index of Kannur was reported as 0.854 (Jose, 2003). The species evenness or equitability value for mangroves of Malappuram district recorded (0.845) is tuned with that of evergreen forest reported by various authors as, Agastyamalai region, 0.89 (Varghese & Balasubramanyan, 1999) and Western Ghats, 0.9 (Arunachalum, 2002). The species richness of mangroves at Malappuram district revealed as 1.07. Among the study sites, relatively higher value was reported in Pullooni (0.984) and lower value in Kuttayikkadavu (0.450).

Similarity Indices

Beta-diversity index depends upon the number of species shared by two assemblages and the number of species varies specifically to each of them. This index in the present study revealed that the highest value of β-diversity was registered between Mangattiri–Etrikkadavu and Kadalundi–Vallikkunnu (0.70) abided by Kuttayikkadavu and Kadalundi–vallikkunnu (0.67). The reduced level of similarity (0.20) was recorded between Pullooni and Thalakkad–Pariyapuram. The higher similarities for mangroves in internal and central cities are resulted from the better organic carbon content of soil than that of fringes, where low plant growth diversity is seen (Brahmaji, 1998). Figure 4 describe the results of hierarchical clustering or dendrogram which display the level of similarity among different sites of Malappuram.

CONCLUSION

Floristic diversity indicated that the study area constituted 11 species of true mangroves under 7 genera belonging to 5 families. *Rhizophoraceae* is the largest family in Malappuram district having 3 genera in which Rhizophora and Bruguiera are major genera's with 2 species each. The pattern of distribution of mangrove species in all the locations were discontinuous and in patches of varying extent. *Avicennia officinalis* and *Rhizophora mucronata* was found in all the sites abided by *Excoecaria agallocha, Kandelia candel* and *Bruguiera cylindrica*, were found in the five sites. Least diverse species in Malappuram are *Rhizophora apiculata* as well as *Sonneratia alba* and confined only in single site however the species *Bruguiera sexangula* which is rare in kerala found in four sites. Structural analysis of mangroves of Malappuram unveiled the domination of *Avicennia officinalis* having highest IVI and RIVI values owing to high values of Relative density and Relative frequency. Diversity indices for six mangrove sites indicated that Mangrove at Thalakkad-Pariyapuram constituted highest Shannon–Weiner index as well as Simpson's index and Mangattiri– Etrikkadavu having lowest value of these indices. In the present study Shannon – Weiner index of diversity (H max) ranged from 3.322 – 2.321 were observed. Variation in species richness in mangroves of different study sites was observed. Species evenness value for mangroves of Malappuram recorded as 0.845. The cluster analysis revealed that the presence of local characteristics even though the study areas are submitted to similar regional conditions. The area supports a rich diversity of mangroves with an uncommon species *Bruguiera sexangula* having decreasing population trend. In order to protect and conserve the mangrove patches in Malappuram district which facing acute threat from development activities, the respective authority should take necessary actions.

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