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Diversity and Distribution of Mangroves in Kumbalam Island of Kerala, India

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Abstract: *The present investigation was carried on the diversity and distribution of mangroves in Kumbalam Island of Ernakulam district to study the present status of mangrove vegetation. In the present investigation, the diversity and distribution of mangrove vegetation were studied since 2010. In order to study the distribution pattern of mangrove species, Quadrat analysis was adopted in the study site. From the study, 7 species of true mangroves, 2 species of semi-mangroves and 8 species of mangrove associates were identified. In kumbalam, the major obstacle for the conservation of mangrove vegetation is the population pressure and most of the mangrove vegetation areas belonged to the private properties. The present study revealed that mangroves in Kumbalam Island are under threat. At present, all these species are at serious risk as no systematic attempt has been made to conserve them. Therefore, by emphasizing the need for urgent and determined to conserve Kumbalam mangrove ecosystem in situ.*

Key Words: *True mangroves, Semi-mangroves, Mangrove associates, dwindling populations and threats*

I. Introduction

Mangrove ecosystems are found all over the world in tropical and subtropical regions. Biodiversity is prevalent in the tropical estuarine system, particularly in the intertidal forested vegetation known as Mangrove (Mooney et al. 1995), which covers about 240 x 103 km^2 (Lugo et al. 1990; Twilley et al. 1992). The mangrove vegetation possesses many structural and physiological peculiarities and is composed of species with strongly marked characterised grouped under "true mangroves". There are also plants with less strongly marked characteristics, which are known as semi-mangrove (Tansley & Fritch, 1905). There is yet another group of plants, which grow adjoining the mangrove areas but thrive on the land which does not submerge by brackish water even during the high tides, but can withstand some amount of brackish water stagnation for the short period. These can be grouped as mangrove associated species (Basha, 1992).

India has only 2.66% of the world's mangroves, covering an estimated area of 4,827 sq. km. Kerala along the west coast of India has a coastline of 590 km and presently the mangrove area is estimated to be about 17 sq. km, of which 36% is either completely degraded or is degrading.

From the Cochin estuary, the occurrence of *Acanthus ilicifolius, Avicennia alba, Rhizophora sp and Bruguiera sp* in small numbers was reported by Kurien (1980). Ramachandran et al (1985, 1986) after very detailed survey along the entire Kerala coast reported 39 mangroves and mangrove associated species. Ramachandran et al (1985, 1986) observed that mangroves of Kerala were degraded and grew in isolated patches. According to Banerjee et al (1989) there are 32 species under 24 genera of 19 families are reported from Kerala. However, Basha (1991) has reported only 27 species under 21 genera of 17 families. According to authentic records about 70,000 ha of mangroves once fringed the backwaters of Kerala which now has become reduced to a few isolated patches consisting of a few species (Basha, 1992). The important mangrove patches existing now in Kerala are mangroves of Veli, Quilon, Kumarakom, Kannamali, Mangalavanam, Chetwai, Nadakkavu, Edakkad, Pappinisseri and Kunjimangalam which have been singled out for conservation and rehabilation (Suma, 1995). Sunil and Sivadasan (2002) conducted study on the mangroves of Central Kerala.

In Cochin, mangrove Islands are increasingly threatened by the population pressure and aquaculture operations (Thomas and Fernandes, 1994). Formerly, thriving shrimp production of Cochin back waters has fallen almost to nil as the after effects of extensive mangrove clearance (Mastaller, 1996). The flora is now restricted to small isolated strands along the banks of estuaries and back waters (Joy and Ammini, 1998). The total area of mangroves now existed in Kerala is estimated to be 1671 hectors (Suma, 2000). Suma and Joy (2002) conducted ecological studies on mangrove and associated flora in the Vypeen block of Kerala. Suma (2005) studied on the diversity of mangroves in Ernakulam district. The present investigation was carried out in Kumabalam Island on the distribution and abundance of mangrove vegetation and associated flora.

II. Materials And Methods

Kerala lies towards the South-West coast of India, a segment barred by the Western Ghats. It extends between the latitudes $8^0$18' and $12^0$48' North and longitudes $74^0$52' and $74^0$24' East. Kumbalam is a coastal region located in the 9^0 54' 41.96" North and 76^0 18' 32.36" East of Ernakulum district. (Figure-1).

2.1. Analysis of true, semi and associated mangroves

For this study, collections were made at the natural habit of the plants. Small branches of the plants with leaves, inflorescence and fruits were collected and grouped according to the morphological characters. The collected plants were packed separately in polythene bags and brought to lab for analyzing taxonomically with the help of Flora of the Presidency of Madras (Gamble 1915-1936) and monographs.

2.2. Quadrat analysis (field study)

Quadrat analysis was done within the study site. The analytical characters of the plant community were studied in terms of qualitative and quantitative structures. Quantitative structure includes frequency, density and abundance.

For quadrat analysis, the study area was divided into 4 regions- North, South, East and West. Each region was again sub divided into 5 x5 sizes of 3 quadrats. Thus 12 quadrats were laid down in the study area. Identified the species present in the quadrats and record their numbers on each quadrat in a tabular column to find out the frequency, density and abundance.

Frequency, density and abundance were calculated as follows;

$$\textbf{Frequency} = \frac{\text{Total number of quadrats in which species occurred}}{\text{Total number of quadrat studied}} \times 100$$

Frequency: Frequency is the number of sampling units in percent in which a particular species occurs. After determining the percentage frequency of each species, various species are distributed among the five frequency classes. (Table-1).

No.	Frequency (%)	Frequency class
1	0-20	A
2	21-40	B
3	41-60	C
4	61-80	D
5	81-100	E

$$\textbf{Density} = \frac{\text{Total number of individuals of species}}{\text{Total number of quadrat studied}}$$

Density: Density represents the numerical strength of a species in a community. The number of individuals in the species in any unit area is its density. Density gives an idea of degree of competition.

$$\textbf{Abundance} = \frac{\text{Total number of individuals of species}}{\text{Total number of quadrats in which species occurred}}$$

Abundance: Abundance is the number of individuals of any species per sampling units of occurrence.

III. Observations And Results

The mangrove flora of Kumbalam island is composed of 7 true mangrove species, 2 semi-mangrove species and 8 mangrove associate species (Table-2, Table-3, Table-4) (Figure-2, Figure=3, Figure-4).

Table 2: List of True mangroves collected from the study site

No.	Genera	Family
1	*Acanthus illicifolius* L.	Acanthaceae
2	*Avicennia officinalis* L.	Avicenniaceae
3	*Bruguiera gymnorrhiza* Lamk.	Rhizophoraceae
4	*Excoecaria agallocha* L.	Eurphorbiaceae
5	*Kandelia candel* L.	Rhizophoraceae
6	*Rhizophora mucronata* Lamk.	Rhizophoraceae
7	*Sonneratia caseolaris* L.	Sonneratiaceae

Table 3: List of Semi mangroves collected from the study site

No.	Semi mangroves	Family
1	*Acrostichum aureum* L.	Acrostichaceae
2	*Derris trifoliata* L.	Papilionaceae

Table 4: List of Mangrove associates collected from the study site

No.	Associate species	Family
1	*Bacopa monnieri* L.	Scrophulariaceae
2	*Cayratia carnosa* L.	Vitaceae
3	*Cerbera odollam* G.	Apocynaceae
4	*Thespesia populnea* L.	Malvaceae
5	*Mariscus javanicus* H.	Cyperaceae
6	*Hibiscus tiliaceus* L.	Malvaceae
7	*Fimbristylis ferruginea* L.	Cyperaceae
8	*Morinda citrifolia* L.	Rubiaceae

Fig. 1: Map of study area

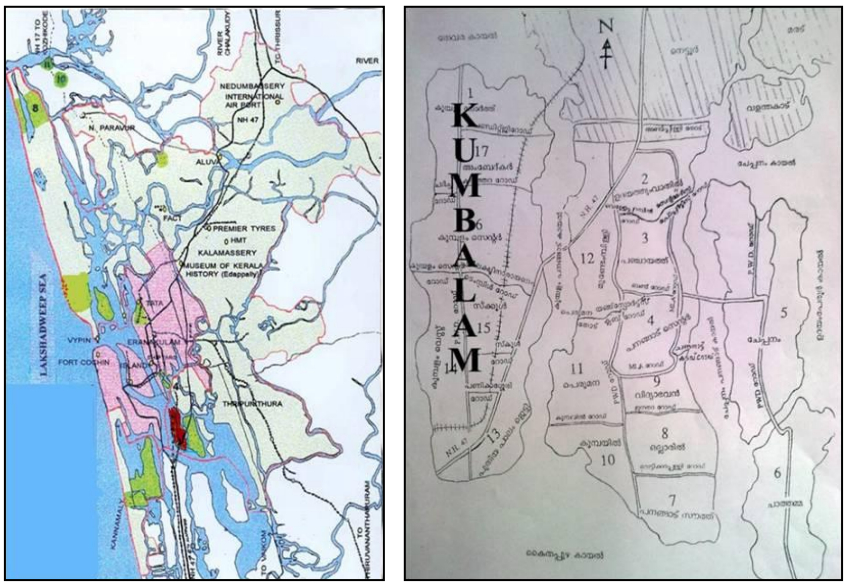


Fig. 1: a) Map of Ernakulam District; **b)**Map of Kumbalam Island

Fig. 2: List of True mangroves collected from the study site

Fig.-2: a)*Acanthus ilicifolius* L*;* ***b)****Avicennia officinalis* L*;* ***c)****Bruguiera gymnorrhiza* Lamk*;* ***d)****Kandelia candel* L*;* ***e)****Rhizophora mucronata* Lamk*;* ***f)****Sonneratia caseolaris* L*;* ***g)****Excoecaria agallocha* L.

Fig. 3: List of Semi mangroves collected from the study site

Fig. 3: a)*Acrostichum aureum* L*; **b)**Derris trifoliata* L.

Table 4: List of Mangrove associates collected from the study site

Fig. 4: a)*Bacopa monnieri* L; **b)***Cayratia carnosa* L; **c)***Cerbera odollam* G; **d)***Thespesia populnea* L; **e)***Mariscus javanicus* H; **f)***Fimbristylis ferruginea* L; **g)***Hibiscus tiliaceus L; **h)**Morinda citrifolia L.*

3.1. MANGROVE DISRIBUTION

3.1.1. STATION 1

In this study site, *Acanthus ilicifolius*, highly dominated than other true mangroves.

Frequency: On analyzing the frequency of the species, *Acanthus ilicifoilus*, *Avicennia oficinalis, Sonneratia caseolaris* and *Rhizophora mucronata* shows 100% are positioned in class E. While *Excoecaria agallocha* and *Kandelia candel* are positioned in D class. *Bruguiera gymnorrhiza* is positioned in B.

Density: The density analysis reveals that *Acanthus ilicifolius* is the densest species having the value 41.6, whereas *Avicennia officinalis* having 27 and Sonneratia caseolaris and *Rhizophora mucronata* comes next with the value 15.6 and 12.6 respectively. *Kandelia candel* (7), *Excoecaria agallocha* (5) and *Bruguiera gymnorrhiza* (0.6) are the following dense species.

Abhundance: Analysis of the abundance of species shows that, *Acanthus ilicifoilus* (41.6) is the most abundant species. *Avicennia oficinalis*(27), *Sonneratia caseolaris* (15.6), and *Rhizophora mucronata* (12.6), *Kandelia candel* (10.5), *Excoecaria agallocha* (7.5), *Bruguiera gymnorrhiza* (2).(Table -5).

3.1.2. STATION 2

In this study site, *Avicennia officinalis* highly dominated than other true mangroves.

Frequency: *Acanthus ilicifoilus, Avicennia officinalis, Rhizophora mucronata* and *Kandelia candel* shows 100% frequency in this area and listed under the class E. *Excoecaria agallocha* (66.6%) was positioned under the class D. *Sonneratia caseolaris* (33.3%) was positioned under the class B. *Bruguiera gymnorrhiza* (0) was positioned under the class A.

Density: The density of the species *Avicennia officinalis* was 54, which is the highest among all other species. *Acanthus ilicifoilus* was the next dense species with a density value 43.3. *Rhizophora mucronata* was the next

dense species with a density value 26.3. The density value of *Kandelia candel* was 11.6 and other species show density values as follows: *Sonneratia caseolaris* (10) and *Excoecaria agallocha* (2.3), *Bruguiera gymnorrhiza* (0).

Abundance: *Avicennia officinalis* was the most abundant species with a value 54. The other species and abundance were – *Acanthus ilicifolius* (43.3); *Sonneratia caseolaris* (30); *Rhizophora mucronata* (26.3), *Kandelia candel* (11.6), *Excoecaria agallocha* (3.5), *Bruguiera gymnorrhiza* (0) (Table-6).

3.1.3. STATION 3

In this study site, *Acanthus ilicifoilus* highly dominated than other true mangroves.

Frequency: The percent frequency was higher in *Acanthus ilicifoilus, Avicennia officinalis, Rhizophora mucronata* and *Kandelia candel* (100%) having frequency class E. Next to it was *Sonneratia caseolaris* (66.6%) with frequency class D. *Excoecaria agallocha* was of (33.3%) and was placed on class B. *Bruguiera gymnorrhiza* was positioned in D.

Density: Density of, *Acanthus ilicifoilus* having high dense value 40. Next, *Avicennia officinalis* having the value 25. Density of other species *Rhizophora mucronata* (16), *Sonneratia caseolaris* (4.6), *Kandelia candel* (3.3), *Excoecaria agallocha* (0.3), *Bruguiera gymnorrhiza* (3.3)

Abundance: Study on the abundance reveals the status of each species as listed below: *Acanthus ilicifoilus (40); Avicennia officinalis* (25), *Rhizophora mucronata* (16), *Sonneratia caseolaris* (7), *Kandelia candel* (3.3), *Excoecaria agallocha* (1), *Bruguiera gymnorrhiza* (5) (Table - 7).

3.1.4. STATION 4

In this study site, *Acanthus ilicifoilus* highly dominated than other true mangroves.

Frequency : On analyzing the frequency of the species, *Acanthus ilicifoilus Avicennia oficinalis, Rhizophora mucronata,* and *Excoecaria agallocha* shows 100% were positioned in class E. Whereas *Sonneratia caseolaris* and *Kandelia candel* (33.3%) and are placed in class B. *Bruguiera gymnorrhiza* was positioned in class A.

Density: Density were *Acanthus ilicifoilus* (55.6); *Avicennia oficinalis* (26.6), *Rhizophora mucronata* (13.6), *Excoecaria agallocha* (4.3), *Kandelia candel* (2.6) *Sonneratia caseolaris* (1.3) and *Bruguiera gymnorrhiza* (0).

Abundance: Study on the abundance reveals the status of each species as listed below: *Acanthus ilicifoilus* (55.6); *Avicennia oficinalis* (26.6), *Rhizophora mucronata* (13.6), *Sonneratia caseolaris* (4), *Excoecaria agallocha* (4.3), *Kandelia candel* (8) and *Bruguiera gymnorrhiza* (0) (Table -8).

Table 5: Details of frequency, density and abundance of mangrove plants at Station 1-(North region).

No.	Species	Quadrats laid down (5 m x 5m)			Density	Frequency (%)	Frequency class	Abundance
		1	2	3				
1	*Acantus ilicifolius*	40	45	40	41.6	100	E	41.6
2	*Avicennia officinalis*	21	35	25	27	100	E	27
3	*Bruguiera gymnorrhiza*	2	-	-	0.6	33.3	B	2
4	*Excoecaria agallocha*	11	-	4	5	66.6	D	7.5
5	*Kandelia candel*	4	17	-	7	66.6	D	10.5
6	*Rhizophora mucronata*	8	20	10	12.6	100	E	12.6
7	*Sonneratia caseolaris*	27	5	15	15.6	100	E	15.6

TABLE 6: Details of frequency, density and abundance of mangrove plants at Station 2-(South region)

No.	Species	Quadrats laid down (5 m x 5m)			Density	Frequency (%)	Frequency class	Abundance
		1	2	3				
1	*Acanthus ilicifolius*	42	45	43	43.3	100	E	43.3
2	*Avicennia officinalis*	32	62	68	54	100	E	54
3	*Bruguiera gymnorrhiza*	-	-	-	-	-	A	-
4	*Excoecaria agallocha*	-	2	5	2.3	66.6	D	3.5
5	*Kandelia candel*	2	3	30	11.6	100	E	11.6
6	*Rhizophora mucronata*	10	20	49	26.3	100	E	26.3
7	*Sonneratia caseolaris*	-	-	30	10	33.3	B	30

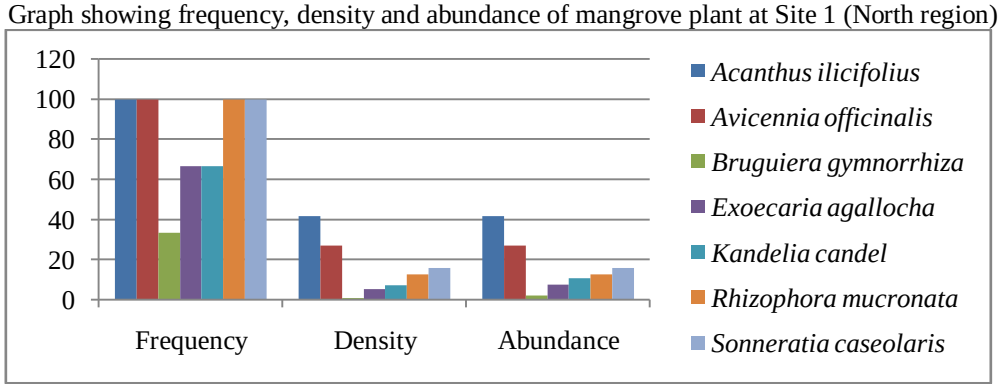
TABLE 7: Details of frequency, density and abundance of mangrove plants at Station 3-(East region)

No.	Species	Quadrats laid down (5 m x 5m)			Density	Frequency (%)	Frequency class	Abundance
		1	2	3				
1	*Acantus ilicifolius*	40	35	45	40	100	E	40
2	*Avicennia officinalis*	12	28	35	25	100	E	25
3	*Bruguiera gymnorrhiza*	6	4	-	3.3	66.6	D	5
4	*Excoecaria agallocha*	1	-	-	0.3	33.3	B	1
5	*Kandelia candel*	3	2	5	3.3	100	E	3.3
6	*Rhizophora mucronata*	20	16	12	16	100	E	16
7	*Sonneratia caseolaris*	-	8	6	4.6	66.6	D	7

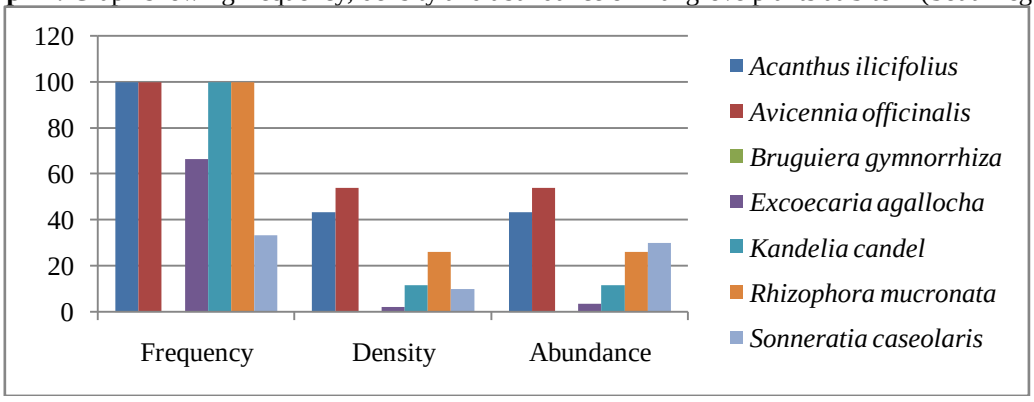
TABLE 8: Details of frequency, density and abundance of mangrove plants at Station 4-(West region)

No.	Species	Quadrats laid down (5 m x 5m)			Density	Frequency (%)	Frequency class	Abundance
		1	2	3				
1	*Acantus ilicifolius*	65	48	54	55.6	100	E	55.6
2	*Avicennia officinalis*	30	18	32	26.6	100	E	26.6
3	*Bruguiera gymnorrhiza*	-	-	-	-	-	A	-
4	*Excoecaria agallocha*	5	5	3	4.3	100	E	4.6
5	*Kandelia candel*	-	-	8	2.6	33.3	B	8
6	*Rhizophora mucronata*	14	12	15	13.6	100	E	13.6
7	*Sonneratia caseolaris*	4	-	-	1.3	33.3	B	4

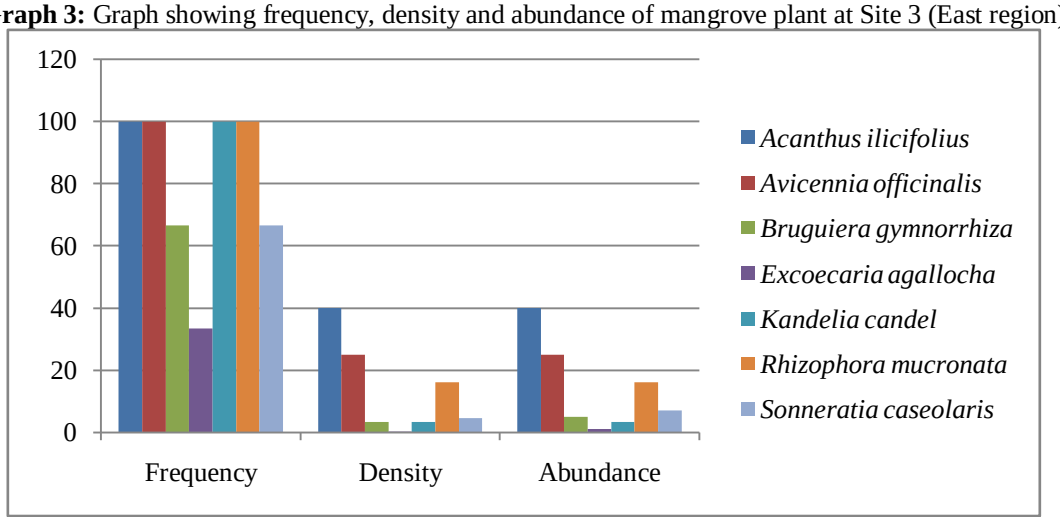
Graph 1: Graph showing frequency, density and abundance of mangrove plant at Site 1 (North region)



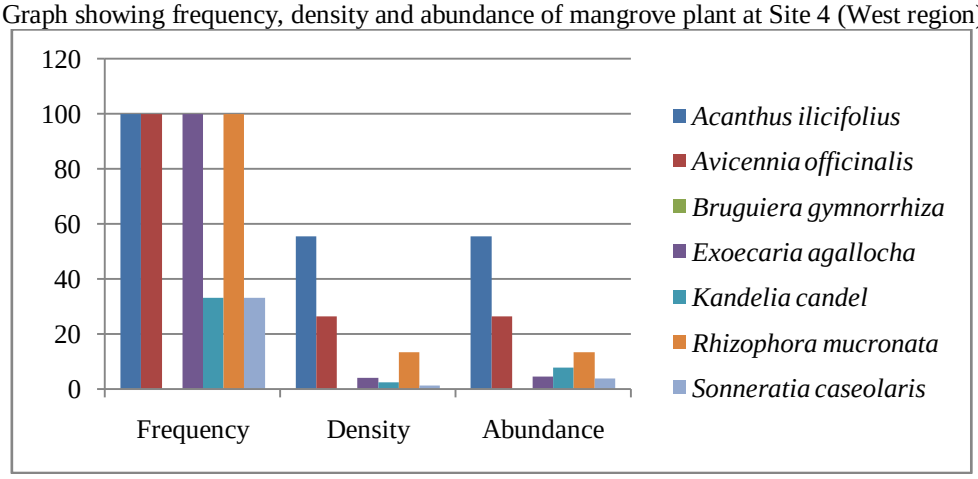
Graph 2: Graph showing frequency, density and abundance of mangrove plants at Site 2-(South region)



Graph 3: Graph showing frequency, density and abundance of mangrove plant at Site 3 (East region)



Graph 4: Graph showing frequency, density and abundance of mangrove plant at Site 4 (West region)



IV. Discussion

The station Kumbalam, near Tripunithura, is more or less completely surrounded by Cochin back waters and this station, is extended upto Panangad. This area is thickly populated and mangrove ecosystem of this region is subject to population pressure. Extensive land filling has affected the mangrove vegetation. This wetland is situated in the banks of Vembanadu Lake which meet the Arabian Sea in the West. The study shows that this region is characterised by the presence of *Acanthus-Avicennia- Rizophora- Sonneratia- Excoecaria* combination in which there are trees of 5-6 m height. In the present study, 7 species of true mangroves, 2 species of semi mangroves and 8 species of associate plants were identified. The pattern of distribution of all the stations were discontinuous and in patches of varying extent.

Acanthus ilicifolius has been reported to be occurring in varied habitats in the East and West coasts (Mudliar et al, 1954). According to him, it was forming large formation at the edge of the backwaters of Chirakkal, Tellicherry, Kasarkode and Udipi of Kerala and Karnataka states, which is similar to the distribution in the present study. Rao and Sasthry (1974) reported it as occupying along with *Excoecaria agallocha*. Mukherjee (1975) described *Acanthus ilicifolius* as occupying reclaimed areas along embankments and edges of creeks, which also resembled the study area.

Avicennia officinalis species is abundant in Kumbalam village. The most important invader species of environment is *Avicennia officinalis* and *Avicennia marina*, being of hardly nature and high range of adaptability. *Avicennia* seems to be the early colonizer followed by *Rhizophora*, *Derris* and *Acantus* (Mohanan, 1997). It possesses certain adaptive traits for reproduction and survival such as an efficient mechanism of persistence by arrival of widely dispersed propagules (Haig et al, 1986; Tomlinson, 1986). In the present study, *Derris trifoliata* and *Acrostichum aureum*, are the semi mangroves were found to be closely associated with true mangrove species especially *Avicennia officinalis*.

Maximum density of species in the present study was observed at Kumbalam, where theoretical species diversity was calculated as 1 bit/individual and actual computed diversity was 0.96 bits/individual. Around 96% of the possible species diversity was present at this station. It is clear that the maximum possible diversity will occur when all the species show equal probabilities to occur with exactly equal dominance in the ecosystem

(Suma, 2005). Such type of ecosystem will be more complex, stable and less predictable in the terms of species (Trivedy et al, 1987).

Bruguiera gymnorrhiza is found to be very less population in this region, whereas *Rhizophora mucronata* is found to be dominant. MacNae (1968) had opined that complete zonation would be found only in the areas having considerable intertidal range. So, tidal inundation is the most significant factor for controlling the distribution of *Rhizophora mucronata.* Drury (1864) and Rama Rao (1914) also mentioned *Bruguiera malabarica* as occurring along the Malabar Coast. From the descriptions of above authors, it is clear that once there existed all the three species as one and the same, ie, *Bruguiera cylindrica* (Basha, 1992). Ramachandran and Mohanan (1987) studied about the mangroves in Kumarakom estuary and observed the presence of mixed population of *Rhizophora apiculata* and *Bruguiera gymnorrhiza* bordering the estuary. According to Basha (1992), mangrove vegetation along the coast line is generally the association of *Rhizophora* species and *Bruguiera* species where soil in this zone gets inundated by the sea water twice in a day.

A few species like *Excoecaria indica* and *Bruguiera parciflora* are very rare in Kerala and restricted distribution in both coasts (Malabar and Travancore) indicating fast disappearance of the species due to speedy conservation of land for alternate land use (Basha,1992). Rao (1973) reported *Excoecaria agallocha* along with *Acanthus ilicifolius*. Similar pattern of distribution was noticed in the present station. In the present study, *Excoecaria agallocha* is rarely found in Kumbalam.

Kandelia candel is an important mangrove species found frequently in this region. The earlier workers might have misidentified the species *Kandelia candel* from this region and this species might have become fully extinct. This particular plant shows very fast disappearance from the mangrove locations of Cochin. There are no attempts for conservation of mangroves. So, back water connection channels and creeks to the mangrove habitat are now more or less totally hindered by the land filling activity. As a result, water bodies are completely dried off.

Some species like *Sonneratia caseolaris* shows abundance in Travancore coast, but were seen rarely in restricted localities at Malabar (Blasco, 1975). The species *Sonneratia caseolaris* is frequently found in this region. It shows that this plant is rapidly disappearing from the region because of low tidal actions.

When comparing with the true mangroves in Central Kerala, i.e., 15 species of true mangrove (Sunil and Sivadasan, 2002; Anupama and Sivadasan, 2004), the present study area possess seven true mangrove species (About 46%). Suma (2005) observed 2 true mangroves from Kumbalam Island, while in the present investigation, 7 true mangroves were observed.

4.1. Semi - mangroves and mangrove associated plants

In the present study, *Acrostichum aureum, Acanthus ilicifolius* and *Derris trifoliata* are found to be closely associated with true mangrove species especially *Avicennia officinalis*. None of the mangrove associated species is observed in common to all stations. Suma (2005) observed 2 semi-mangroves and 3 mangrove associates from Kumbalam Island, while in the present investigation, 2 semi-mangroves and 8 species of mangrove associates. No speciality, specificity or relationship between the occurrence of mangrove associated species and mangrove species were observed (Suma, 1995).

V. Summary And Conclusion

From the investigation, 7 species of true mangroves, 2 species of semi mangroves and 8 species of mangrove associates were identified. Quantitative structure of the true mangroves was studied in the terms of frequency, density and abundance. It reveals that *Acanthus ilicifolius* showed maximum frequency, density and abundance. Compared to the Sundarbans of West Bengal, Kerala has a very few areas of mangrove forest. About 46% of the true mangroves species are present in the Kumbalam village.

About 40% mangrove areas has been depleted in recent times (Satheeshkumar et al, 2011). There is an urgent need for conservation of the remaining mangrove area. The coastal and estuarine habitats have been under tremendous human induced stresses due their immense economic, recreational and transport services. Increase in human population in estuarine areas will further increase the pressure on mangroves. Thus, these habitats need better management and legal enforcement of protection rules. The investigation helps us to understand the regeneration and recruitment patterns of different species and, therefore, is an important conservation tool for sustainable management of natural resources. At present, all these species are at serious risk as no systematic attempt has been made to conserve them. Therefore, by emphasizing the need for urgent and determined to conserve Kumbalam mangrove ecosystem *in situ*.

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