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Distribution and Zonation of Mangroves in the Northern Part of the Negombo Lagoon (Sri Lanka)

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Abstract : 14 typical mangrove species were encountered in this locality. The species diversity in the mangal of Negombo is remarkable. The overall scaled Simpson diversity index was 0.424. Some islets were completely covered by *Acanthus ilicifolius*, while the others had a *Rhizophora* border and a mixed vegetation, dominated either by *Avicennia marina* or *Bruguiera gymnorhiza*. The vegetation pattern and the elevation suggest that mud flat is the precursor of the mangal. *A. ilicifolius* may be the early colonizer in boggy soils. *A. marina* occurred on firm soils. The presence of a *Rhizophora* border on the shore may be due to its morphological adaptations in resisting water currents with the help of prop roots.

Daily variation in the tidal level was too small (neap tides 2 cm and spring tides 18.4 cm) to show a spectacular pattern in zonation. Soils from the mud flat, *Rhizophora* border and the interior of the islets showed the characteristic features of each region with respect to pH, organic matter, particle size, Na+ and Ca++ concentrations. Ca++ content was high in the mud flat but Na+ was the predominant exchangeble cation in the mangrove soil.

Measurements of diameters and heights of plants showed that *B. gymnorhiza* and *C. tagal* are in their early stages of growth while *L. racemosa* has been overexploited.

1. Introduction

Mangroves appear to be an evil smelling, treacherous bog, infested with mosquitoes. Recently the value of mangroves has been realized by many scientists. They are the breeding grounds of crustacean and fish larvae, and they constantly supply the coastal waters with nutrients. Mangroves in Sri Lanka in general, and those of Negombo in particular, are fast disappearing due to population expansion and industrial pressure. Aruchelvam[2] estimated the extent of mangroves in Sri Lanka to be 8,000 - 10,000 acres. In the eighties, the mangrove area may be less than 8,000 acres. Other than taxonomic studies and general descriptions, very little work has been done on the mangrove communities of Sri Lanka.

This paper is an attempt to study the distribution pattern and zonation of mangroves in selected islets in the northern part of the Negombo lagoon in relation to some environmental factors.

2. The Study Area

This study was carried out in selected mangrove islets (Figure 1) in the Negombo lagoon latitude 7° 11′ N, and longitude 79° 50′ E, in the west coast of Sri Lanka. The lagoon opens to the sea from the northern end while the southern end, receives fresh water from Ja-Ela, Dandugam Oya and a Dutch canal. The three islets, Islet I (Kakaduwa) Islet 2 (Mandagas alamba) and Islet 3 (Kadolnallala) had areas of 2.24 ha, 5.88 ha and 2.92 ha, respectively. Between Islet 1 and Islet 3 was the mudflat which was submerged only during the high tides.

3. Materials And Methods

After making superficial observations on the vegetation around the lagoon, it was thought best to select the uninhabited islands for this study. The vegetation pattern was constructed by chain surveying. In order to study the zonation in islet 1, a transect was chosen across the middle of the islet and different plant species occurring in 2×2 m^2 quadrats along the transect was noted as well as their heights and diameters at ground level.

Soil samples were collected from the mudflat, *Rhizophora* border and the interior of islet 1 and the salinity was determined by titration, organic matter by Walkly and Black method[4] Ca and Mg by titration with 0.005M EDTA and Na and K using a calibrated flame Photometer.

Tidal levels were measured daily at low tide and high tide for one year and the cumulative percentages in the water level for each month was calculated. From these results, the 50% submergence for each month was constructed as shown by the broken line in Figure 2.

This study was made from December 1976 to December 1977.

4. Results

Figure 1 gives the general distribution pattern of the vegetation in the northern part of the lagoon. Figure 3 gives the distribution of mangroves in detail in 3 selected islets. Table 1 shows the approximate areas of plant cover due to predominant vegetation type. Zonation of different plant species along a transect in islet 1 is shown in Figure 4 A and their heights and diameters given in Table 2. Some edaphic factors were also measured from the different zones in the environment with the view to correlate with zonation and the results are given in Table 3.

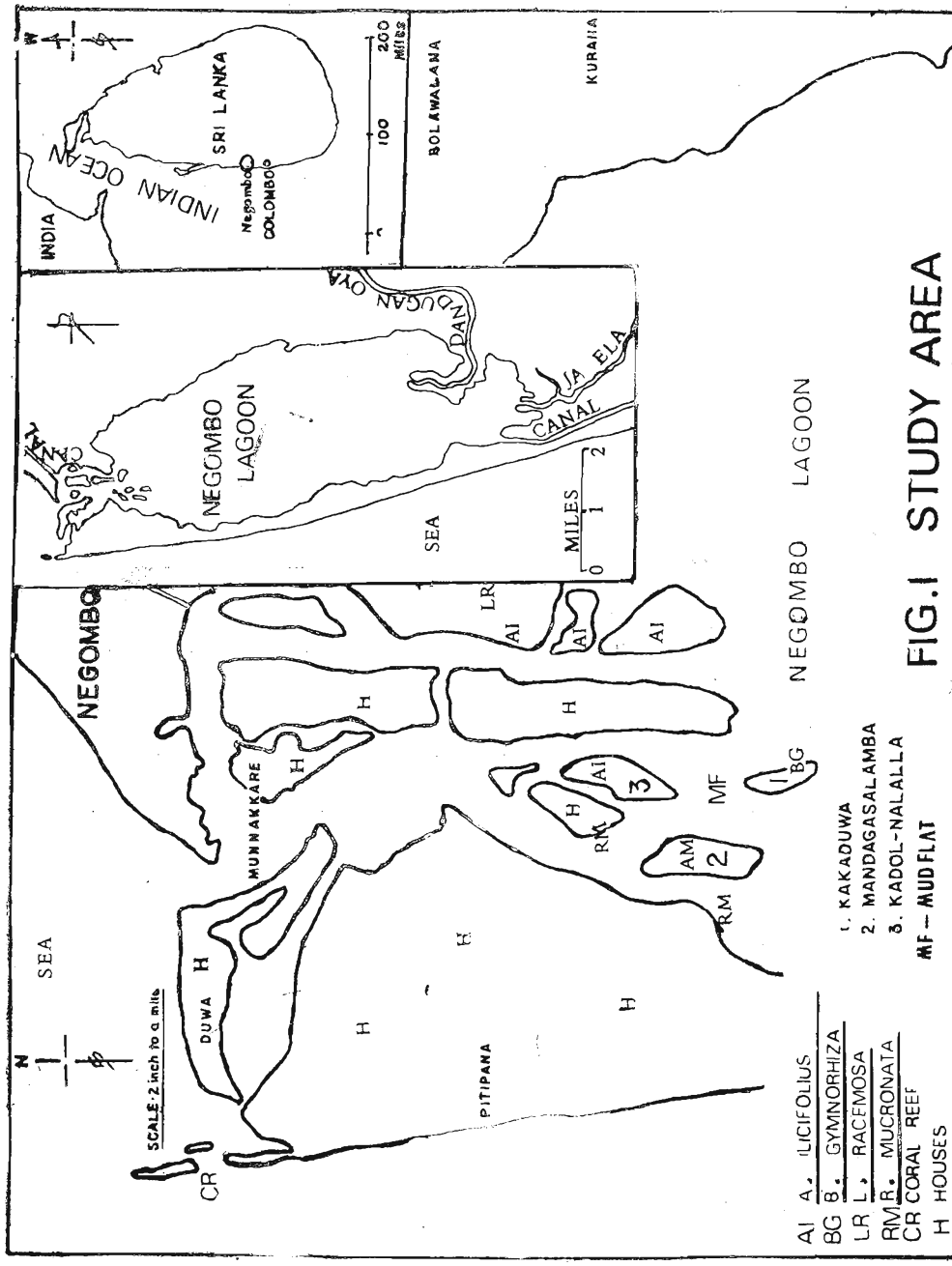

FIG.1 STUDY AREA

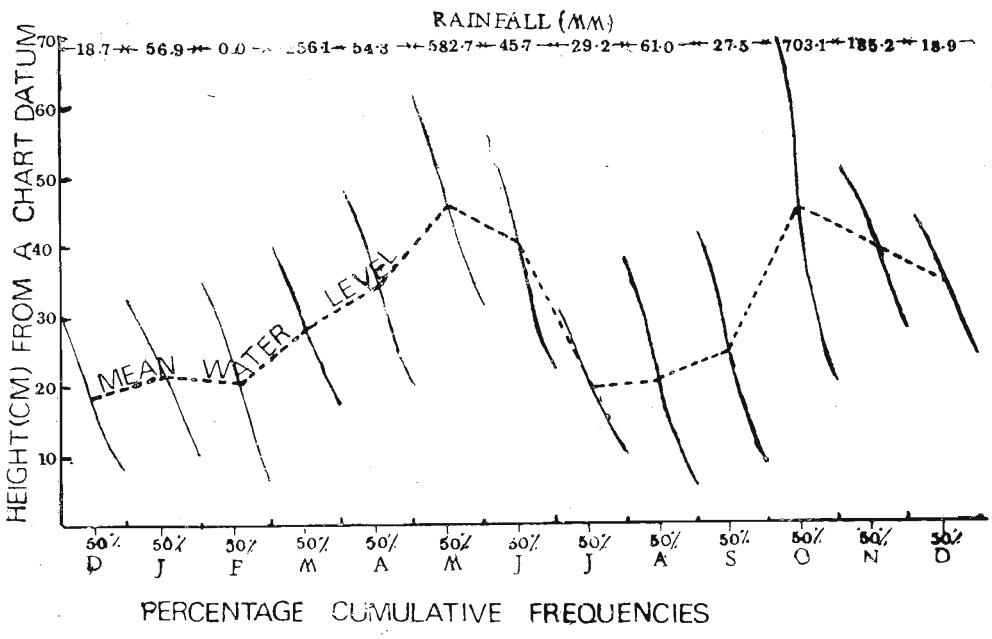

Figure 2. The range of tidal fluctuations for each month and the mean water level of the Negombo lagoon. Percentage cumulative frequencies were obtained from the daily measurements of high tide and low tide levels. (1977).

TABLE 1. The approximate area covered by the predominant vegetation types in the islets.

Vegetation type	ISLET 1 (Ha)	ISLET 2 (Ha)	ISLET 3 (Ha)
Rhizophora, around the islet	0.019	0.366	—
A. ilicifolius	0.390	0.030	1.810
L. racemosa	0.145	—	—
E. aggalocha	0.008	—	0.010
Grasses and sedges	0.003	0.032	—
B. gymnorhiza	1.678	2.206	—
A. marina	0.001	0.690	0.060
L. racemosa, gymnorhiza A. marina and C. tagal	—	2.554	—
Rhizpohora, Bruguiera and Acanthus ilicifolius	—	—	0.500
Aegiceras and Acanthus	—	—	0.390
C. inerme	—	—	0.080
Derris sp. with *Acanthus*	—	—	0.070

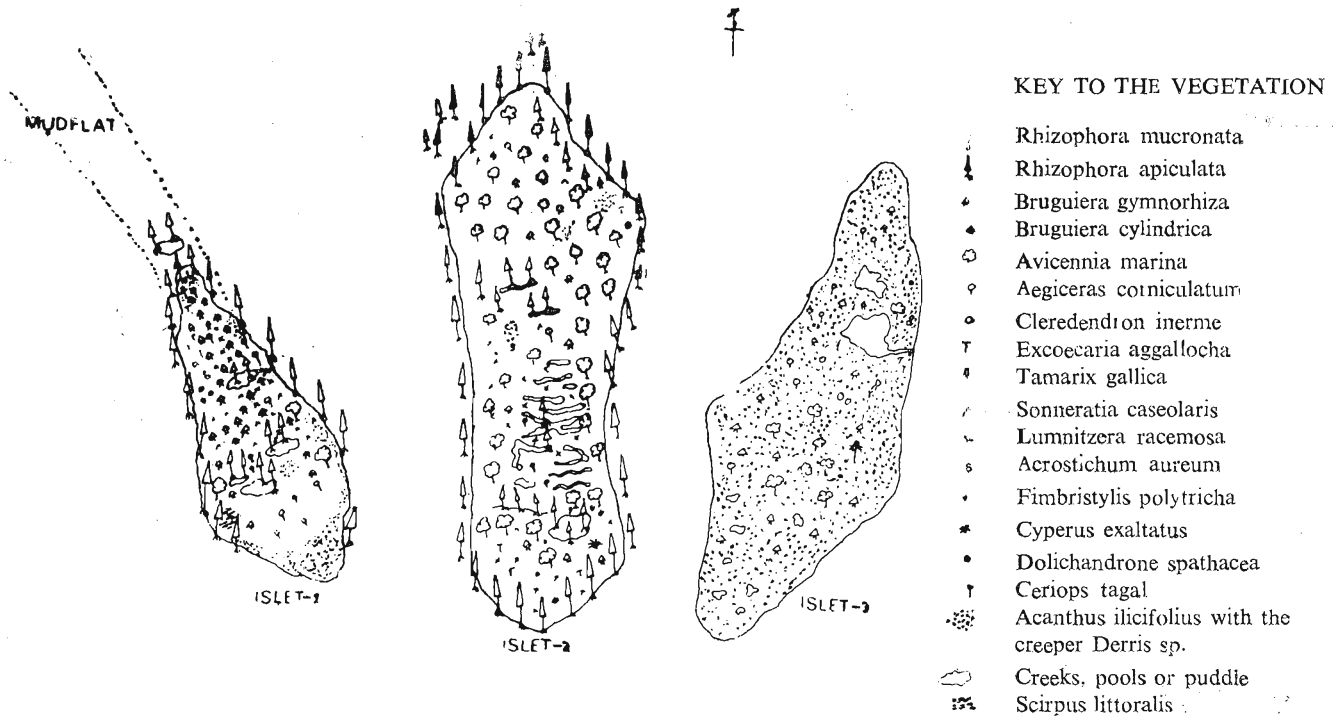

Figure 3. The vegetation of the islets, summarised from a detailed map obtained from a chain survey. Note that Fig. 2 does not indicate the position of the islets with respect to each other. The true position of the islets is given in Fig. 1.

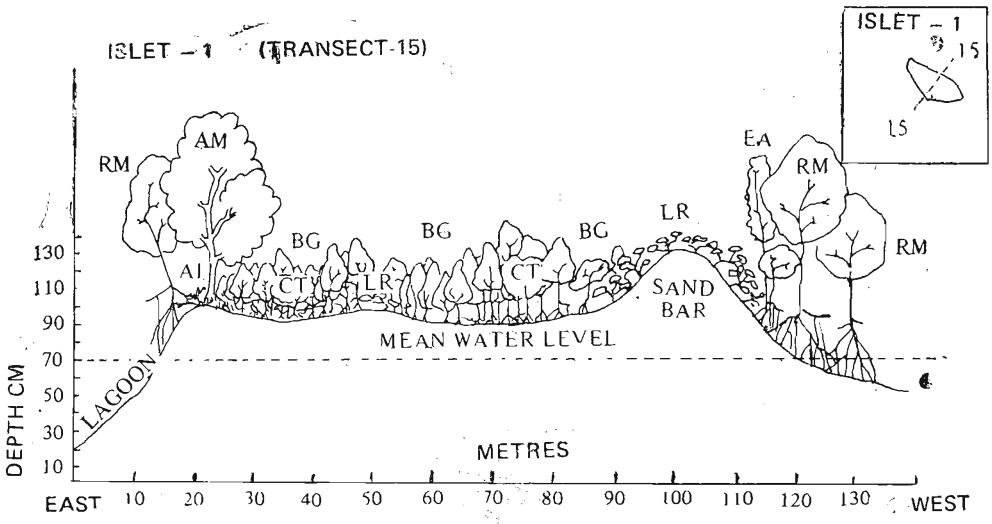

Figure 4A The elevation and plant zonation along transect 15 in islet 1. Heights of the plants do not correspond to the scale in the ordinate.

BG *B. gymnorhiza* CT *C. tagal*
AI *A. iliciifolius* LR *L. racemosa*
RM *R. mucronata* AM *A. marina*
EA *E. aggallocha*

TABLE 2. The heights and diameters of plants across the 25th transect in islet 1.

HEIGHTS IN METRES

class / species	0-8	8-16	16-24	24-32	32-40	40-48	48-56	56-64	64-72
B. gymnorhiza	75	76	18	—	1	4	5	1	—
R. mucronata	8	1	—	1	1	5	5	3	1
C. tagal	23	7	2	—	—	—	—	—	—
L.racemosa	1	15	11	—	—	—	—	—	—

DIAMETER IN CM

class / species	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18
B. gymnorhiza	165	30	1	—	—	—	—	—	—
R. mucronata	13	3	8	—	—	—	—	—	—
C. tagal	19	3	—	—	—	—	—	—	—
L. racemosa	—	4	9	9	2	2	—	3	1

TABLE 3. Some edaphic factors of the three habitats : mud flat, *Rhizophora* border and *Bruguiera*/mixed vegetation zone in islet 1.

Habitat	Organic Matter %	Soil pH 1 : 1	Conductivity/ μmhos/ cm	Exchangeable Cations m. eq./100 g air dry				Particle Size (USDA)						
				K	Na	Ca	Mg	Very coarse sand 2-1 mm	Course sand 1-.5 mm	Medium sand .5-.25 mm	Fine sand .25-.1 mm	Very fine sand .1-.05 mm	Silt .05-.002 mm	clay less than .002
Mudflat	0.53	8.1	3.06	0.36	10.0	32.72	5.48	2.32	8.95	8.04	15.15	57.38	2.02	6.1
Rhizophora Border	1.35	7.0	3.83	2.49	12.0	16.32	3.30	2.83	14.41	15.47	19.08	36.13	5.66	6.4
Bruguiera Mixed Vegetation Zone	4.88	5.8	10.20	0.73	44.0	8.03	11.9	2.74	15.38	13.08	16.93	29.94	11.9	6.4

5. Discussion

Out of the 28 mangrove species listed for Sri Lanka[1] 14 species were found in these islets. As these islets were not connected with the mainland, the entire community formed the mangal, with no hinterland vegetation. Compared to the other mangrove patches along the west coast of Sri Lanka, the mangroves of Negombo show high diversity in species composition. In Waikkal north of Negombo *Nypa fruticans* is abundant. *Xylocarpus granatum* and *Heritiera littoralis* occur in the mangroves of Chilaw. Mundel-Puttalam area is dominated by *Tamarix gallica*, *Acrostichum aureum*, *Excoecaria agalocha*, *Avicennia marina* together with the salt marsh vegetation. Aruwakkalu mangal has tall *Rhizophoras* and *A. marina* dominates the dry zone mangroves. In the south, *Nypa fruticans* though present is fast disappearing due to cocount fiber industry. Compared to the sparse vegetation elsewhere, the rich vegetation in the mangrove islets is clearly shown in Figure 3 and Table 1. Scaled Simpson index values showed a high degree of diversity along the shores of islet I. (Figure 4B)

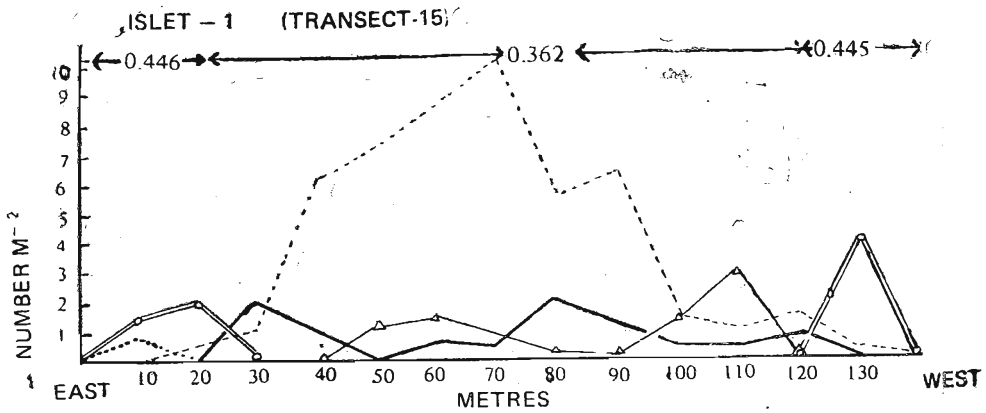

Figure 4B Population densities of different species along the transect. Scaled Simpson diversity indices (1-D) for the shores and the middle of the islet are also given. Overall density index for the transect is 0.424

- - - - - *B. gymnorhiza* ——— *C. tagal*
. . . . . *A. ilicifolius* Δ—Δ *L. racemosa*
═══ *R. mucronata* ●—● *A. marina*

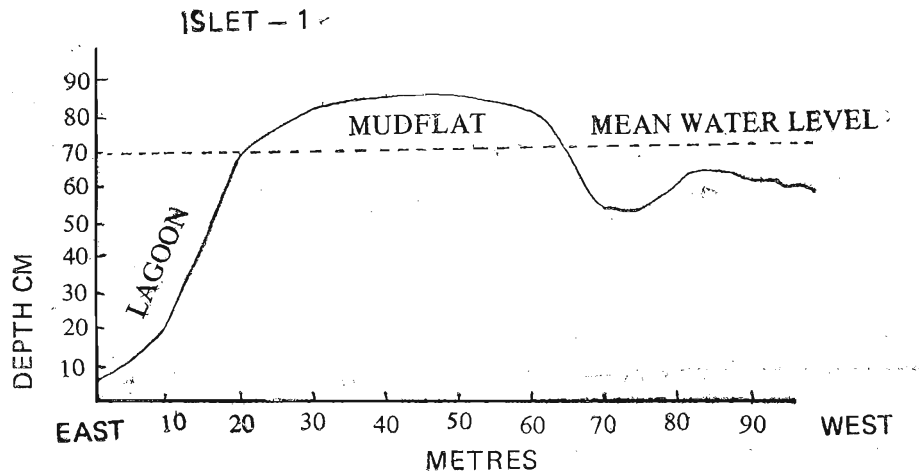

Figure 4C Elevation of the mudflat.

Zonation within the mangrove community has been fully established by early workers. Watson[19] recognized 5 zones in the Malayan mangroves on the basis of tidal inundation. De Haan[5] postulated 6 zones and suggested the soil salinity to be a major factor and tide to be a subsidiary factor. Walter and Steiner[18] Macnae and Kalk[13] and Macnae[12] working on the African mangroves realized 6 zones not on the basis of physical factors but on the basis of dominating species. Abeywickrama's generalization of 3 mangrove zones, namely *Rhizophora* or *Avicennia* zone, mixed vegetation zone and the littoral woodland vegetation, holds good for these islets except for the woodland vegetation. Presence of a *Rhizophora* border instead of an *Avicennia* border in islet I and islet 2 (Figure 3) may be due to the depth and slope as suggested[1],[11] as well as due to the lack of sandy soil and poor aeration.[18]

Figure 4 shows clearly the high population density of *R. mucronata* along the border and the high density of *B. gymnorhiza* towards the interior. *Lumnitzera racemosa* prefers elevated areas as indicated in the same figure. From table 2 it is clear that most of the *B. gymnorhiza* and *C. tagal* plants have small diameters and are short. The fact that *L. racemosa* are short and bushy with large diameters indicate that they have been overexploited. The heights of mangroves observed in these islets are far short compared to the mangroves of Puerto Rico[8], Malaysia[6] and India.[10] It should be noted that variation in vegetation pattern occurs within the islet and a single transect is insufficient for any generalization. But the occurrence of a *Rhizophora* border is true for any transect taken from islet 1 or islet 2.

On evaluating the reasons for zonation, the approach has to be one of *reductio ad absurdum*. Since zonation is not so spectacular the necessary environmental factors could be accounted for, by their absence. In the lagoon the mean spring tide fluctuation was 0.184 m and the mean neap tide fluctuation was 0.020m. From Figure 2 it is clear that seasonal variation in water level due to rains become an important factor than the daily tidal variation. Tide appears to be an important factor for zonation, since zonation is clear in areas where tidal fluctuation is high. For instance 8m tidal variation was recorded for well zoned mangrove areas of Australia, 5 m for Malaysia and 3.5 for Mozambique.[12] The soil salinity did not show much variation at different stations in the same islet as it showed with different seasons. The presence of *Rhizophoras* along the shore may be due to their morphological adaptation to withstand water currents by their proproots. However the *Bruguiera* mixed vegetation in the interior of the islets showed high precentage of organic matter, high Na content and low pH compared to the *Rhizophora* border (Table 3).

The vegetation pattern in the islets and the mud flat shows some trends in the succession of the mangrove communities. The mud flat as a precursor of saltmarsh communities in temperate countries has been fully established.[7,9,15] From the low elevation of the mudflat (Figure 4) compared to the elevation of islet 1, it is possible to conclude that mud flat is the precursor of mangrove communities in this locality. Islet 3 is often submerged with poorly consolidated soil and dominated by *A. ilicifolius*. This vegetation type disappears gradually with the elevation as seen from Table 1. Islet 2 as well as islet 1 are completely submerged during the rainy season in May and October. Islet 2 has a *Rhizophora* border of tall trees (Height 7 ± 2 m and diameter 12 ± 5 cm) compared to the *Rhizophora* border of islet 1 (Height 5 ± 2m and diameter 5 ± 3 cm).*A. marina* formed the predominant vegetation in islet 2 with different heights as trees (4-7m), shrubs (2-4m) and saplings (less than 2 m) similar to the observations of Bruce *et al* (1975) on *A. marina* in Australia. From the vegetation type, elevation and the size of the plants the chronology of colonization may have been in the following series.

MUD FLAT ——→	ISLET 3 ——→	ISLET 1 ——→	ISLET 2
	A. ilicifolius	*Rhizophora*	*Rhizophora* border
	type of vegetation	border with *B.gymnorhiza* mixed, vegetation	with *A. marina* mixed, vegetation

After the primary community established itself on the mud flat, the prop roots, knee roots and pneumatophores may have accelerated sedimentation.[3,16,17]

In the same locality were seen pure strands of *Rhizophora* seedlings emerging from mud flats. These were not a result of natural succession but planted by the fishermen with the view of reclaiming land and harvesting timber.

With the changes in the soil structure and elevation of the mud flat and the mangal proper, not only the vegetation but faunation too has shown marked differences. While *Macrophtalums depressus* and a few other Ocypodid crabs occurred on the mud flat, the mangal was dominated by the Sesarmid crabs as exemplified by *Chiromantes darwinensis, C.indiarum, C. bidens, Neoepisesarma versicolor, Neosermatium smithi* and *Neosermatium malbaricum*[14]. Due to the absence of a vegetation on the mud flat the fauna generally associated with the mangrove leaves, stems and roots were not found in the mud flat.

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