Ecological Study of Mangrove Diversity in the Myawyit Coastal Area, Long-lone Township, Tanintharyi Region, Myanmar

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Abstract

The present study deals with the assessment of diversity and ecological factors of mangrove vegetation in the Myawyit coastal area. A total of 13 species representing 8 genera and 7 families were analyzed in the study area. To clarify the species diversity, the diversity indices were calculated by using Shannon-Wiener (H), Simpsons (D), and Shannon-Wiener evenness (E). These indices were 2.39, 0.74 and 0.67. All the diversity indices pointed out that the study site is floristically low diverse. Quantitative analysis of dominance and their relative values of frequency, density and basal area were calculated and summed to get Importance Value Index. *Avicennia alba* is found to be one of the ecologically dominant species. The species contributes the highest IVI value (99.91%) with relative density (42.01%), relative frequency (18.92%) and relative dominance (38.98 %). According to the Pearson's correlation, significant positive correlations were found between basal area and salinity ($p<0.05$), between species richness and soil texture (clay) ($p<0.05$).

Keywords: Diversity, Mangrove forest, Myawyit coastal area

Introduction

Mangrove forests are one of the main tropical and subtropical ecosystems that provide numerous functions and services. Mangroves are woody plants that grow at the interface between land and sea in tropical region where they exist in conditions of high salinity, extreme tides, strong winds, high temperatures and muddy, anaerobic soils. There may be no other group of plants with such highly developed morphological and physiological adaptations to extreme conditions (Alongi, 2004).

The vegetation ecology is the idea that a species adapts physiologically to physico-chemical gradients in the environment. Salinity is one of the most investigated gradients in mangrove distribution ecology. Mangroves, however, are not obligate halophytes. The studies conducted to date clearly demonstrate that many mangroves can grow over the broad range of conditions found across the intertidal zone. Data relating species distributions to soil salinities suggest that two groups of mangroves exist (Kathiresan and Bingham, 2001).

Stand height, density, and biomass accumulation appear to be related to climatic factors, particularly rainfall. A "complexity index," which combines measures of species richness, stem density, canopy height, and basal area, has been used to make geographic scale comparisons across the region. The least complex stands were in arid regions. High stem density, but low species richness, height, and basal areas marked these stands. Complex stands, characterized by tall canopies, high basal areas, and lower stem densities, were common in wet, high rainfall areas. Complementary results that are based on different methods are available from the Indo-Pacific region. Rainfall and freshwater run-off appear to be major determinants of stand structure (Lugo & Snedaker,1974).

Description of a forest's structure may include measures of species composition, diversity, stem height, stem diameter, basal area, tree density, and the age-class distributions

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and spatial distribution patterns of the component species in the forest. A noted feature of mangrove forest structure is the often-conspicuous zonation of tree species into monospecific bands parallel to the shoreline. Zonation has been a dominant theme in the voluminous literature on mangroves as well as in that on other vegetation types. The aim of the present study is to determine species diversity indices, and ecological significance of mangrove forest the study area in order to support sustainable mangrove forest management.

Methodology

Description of study area

Myawyit coastal area is located in Kanpani and Pyingyi village, Long-lone Township, Tanintharyi Region. It lies between 98˚ 03' 30'' and 98˚ 09' 0'' E longitude and between 14˚ 00' 30'' and 14˚ 06' 30'' N latitudes. The vegetation cover map of the study area is as shown in Figure 1.

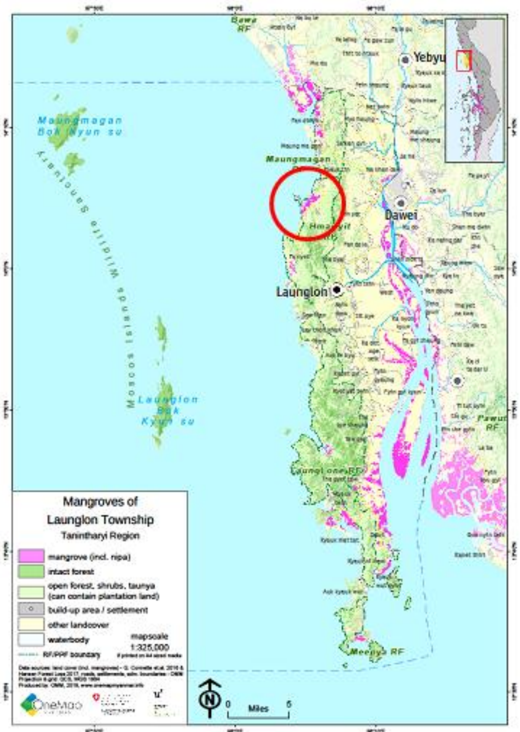

Figure 1. Location and land-cover map of Myawyit Coastal Area

The climate condition of the study area is warm and wet tropical climate for 2008-2018. The highest amount of rainfall is observed during August while April is the driest. The mean annual precipitation (MAP) is 5408 mm while the mean annual temperature (MAT) is 27°C.

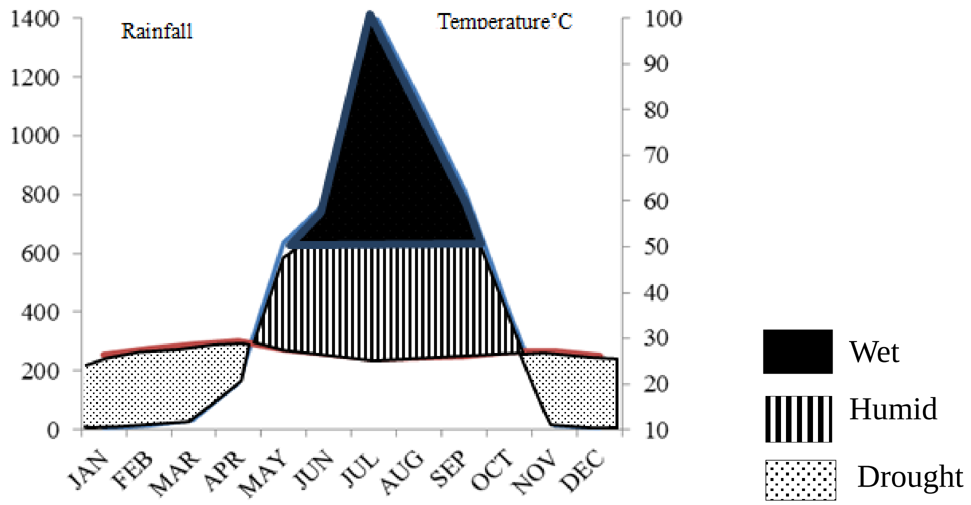

Figure 2. Climatic diagram of the study area (2008-2018)

Data collection

In order to clarify quantitative structure, appropriate numbers of plots (size may be varies depend on site condition) will be established in preliminary survey with the help of mapping. Seven plots of size 20 × 20 m were established through a quadrat sampling technique to determine the species diversity and importance value index in the study area. All sample trees will be investigated for their position, trunk girth at breast height (GBH), height of tree (H). Environmental factors such as elevation, soil type, temperature, rainfall, moisture, aspect and salinity will be measured in each plot to clarify the relationship between plant species diversity and site condition. Water salinity of all study plots were measured by using handy salinity meter ATAGO (S/Mill-E) (Table 1). Nature and anthropogenic disturbances will also be recorded.

Table 1. Location of sample plots

No. of plot	Latitude	Longtitude	Aspect	Coverage	Salinity
Plot-1	N 14° 04" 29.3'	E 98° 04" 36.9'	SW 245°	70%	1.50%
Plot-2	N 14° 04" 31'	E 98° 04" 36.3'	W 270°	60%	2.70%
Plot-3	N 14° 04" 65.7'	E 98° 04" 85.7'	WSW 225°	70%	2.50%
Plot-4	N 14° 04" 68.7'	E 98° 04" 84.2'	WSW 250°	50%	2.30%
Plot-5	N 14° 04" 65.1'	E 98° 04" 77.1'	SW 240°	60%	2.30%
Plot-6	N 14° 04" 18.5'	E 98° 04" 78.4'	NNW 345°	50%	0.05%
Plot-7	N 14° 04" 81.8'	E 98° 04" 69.3'	NNE 20°	75%	0.04%

Inside each plot, all trees with at least 5 cm in GBH were identified and measured the trunk (cm) and total height (m). We measured the trunk at 30 cm above the highest prop root for *Rhizophora* species, whereas the rest were measured at GBH (130 cm above ground).

Data analysis

Mangrove forest inventory data were processed using standard analysis procedures as described by Cintron and Novelli (1984) to derive forest stand characteristics: stand frequency distribution, density (stems ha^{-1}), basal area (m^2 ha^{-1}), relative density (Eq.1), relative frequency (Eq.2), and relative dominance (Eq.3). Ecological importance values index (IVI) of each species was determined by summing the respective relative density, relative frequency and relative dominance. Importance value index measures relative dominance of species by criteria of how often it occurred, number of species, and area it occupies in a community. The species that attained the highest IVI was considered the principal species:

$$\text{Relative density} = \frac{100ni}{\sum_{i=1}^{m} ni} \qquad (1)$$

$$\text{Relative frequency} = \frac{100Fi}{\sum_{i=1}^{m} Fi} \qquad (2)$$

$$\text{Relative dominance} = \frac{100\ Bai}{Ba} \qquad (3)$$

where ni is the number of trees sampled for species i; m is the number of species; Fi is number of plots in which species i occurred, multiplied by 100.

Species diversity is a measure of both species richness and evenness of a community. Species diversity varies greatly from one community to another. The diversity indices are better measures of the species diversity of a forest than the species density and mixture ratio and more information than species counts alone (Weident, 2000). Species diversity is often expressed by the Shannon-Wiener index (H), Evenness (E) and Simpson's index (D) (Magurran, 2004).

Species diversity index determined in this study using the Shannon-Wiener's Index (Shannon & Wiener, 1963), indicates a quantitative description of mangrove habitat in terms of species distribution and evenness. This species diversity index was used in several studies (Gevaña & Pampolina, 2009; Sharma *et al.*, 2010; Lumbres *et al.*, 2012) and was calculated using the following form:

$$H = -\sum P_i \ln P_i$$

Where, H is Shannon-Wiener diversity index, S is the number of species, and P_i is proportion of total sample belonging to the i^{th} species.

Shannon-Wiener diversity index places more weight on the rare species while Simpson's diversity index emphases on the common species (Weidelt, 2000).

Simpson's Index (D)

$$D = 1 - \sum_{i=1}^{s} (P_i)^2$$

Where, D is Simpson's diversity index, S is the number of species, and P_i is proportion of species i^{th} in the community.

Evenness (*E*)

Species evenness is the relative abundance of individuals within a species in an area. Evenness is how evenly organisms are among species. Evenness gives an impression of the species distribution in a stand. The value E is regard as a suitable dimension for recording the second diversity component evenness. E is between 0 and 1. The value 1 represents all species as equally abundant. The value of E gradually goes down to 0 when the number of species decreases. Increasing evenness values mean a rise in diversity. Evenness was calculated by Shannon-Wiener function (1963), as follow:

$$E = \frac{H}{H_{max}} \qquad H_{max} = log_2 S$$

Where, E is the Shannon's evenness (evenness measure, range 0 - 1), H is the Shannon-Wiener diversity index, H_{max} is the species diversity under conditions of maximal equitability, and S is the number of total species found in the sample plot.

Collection of soil sample

To collect soil sample, five points were systematically selected from each quadrat. Soil samples were collected from soil depth of 30 cm from all selected points of each study quadrat. Different soil samples were collected for the analysis of soil physical and chemical properties.

Analysis of soil sample

Soil samples were tested in the soil laboratory of the Department of Agriculture, Yezin in Naypyidaw, Myanmar. Three soil fractions (sand, silt, and clay) were determined using the pipette method. Soil moisture content was measured by taking the difference between the weight before and after oven-drying at 105 ˚C for 24 hours. Soil pH was measured using de-ionized water as a solvent (soil: water = 1: 2.5).

Statistical analysis

All statistical analysis for comparing the mean values of biomass and carbon storage was performed by SPSS version 16.0. A one way analysis of variance ANOVA was used to test the differences between the diversity indices and the ecological factors of the study area.

Results

The species diversity index mangrove forest in Myawyit coastal area was Shannon-Wieners index (H) =2.49, Simpsons index (D) = 0.74, Shannon-Wieners index (E) = 0.67 (Table 1). Species richness of the study area was 13.00 respectively. As a result of Shannon Wiener evenness (0.67) was evenly distributed among the species (Table 2).

Table 2. Species diversity indices in Myawyit coastal area

Description	Myawyit Costal Area
Shannon Wiener Index (H)	2.39
Shannon Index (D)	0.74
Shannon Wiener Evenness (E)	0.67
Species Richness	13.00

Among the sample plots, the highest density was *Avicennia alba* followed by *Avicennia marina*, *Lumnitzea littorea*, *Sonneratia caseolaris* and *Excoecaria agallocha*. This area shows that these five species are abundant in this coastal area (Table 3 and Figure 3).

Table 3. Density and relative density of the study area

No	Scientific Name	Family	Density	Relative Density (%)
1	*Avicennia alba*	Avicenniaceae	68.71	42.01
2	*Avicennia marina*	Avicenniaceae	37.43	22.88
3	*Lumnitzea littorea*	Combretaceae	20.43	12.49
4	*Sonneratia caseolaris*	Sonneratiaceae	12.57	7.69
5	*Excoecaria agallocha*	Euphorbiaceae	10.00	6.11
6	*Avicennia officinalis*	Avicenniaceae	7.71	4.72
7	*Aegiceros corniculatum*	Myrsinaceae	3.86	2.36
8	*Rhizophora mucronata*	Rhizophoraceae	1.00	0.61
9	*Ceriops dacandra*	Rhizophoraceae	0.71	0.44
10	*Rhizophora apiculata*	Rhizophoraceae	0.43	0.26
11	*Aegiceros floridum*	Myrsinaceae	0.29	0.17
12	*Ceriop targal*	Rhizophoraceae	0.14	0.09
13	*Acanthus ilicifolius*	Acanthaceae	0.14	0.09

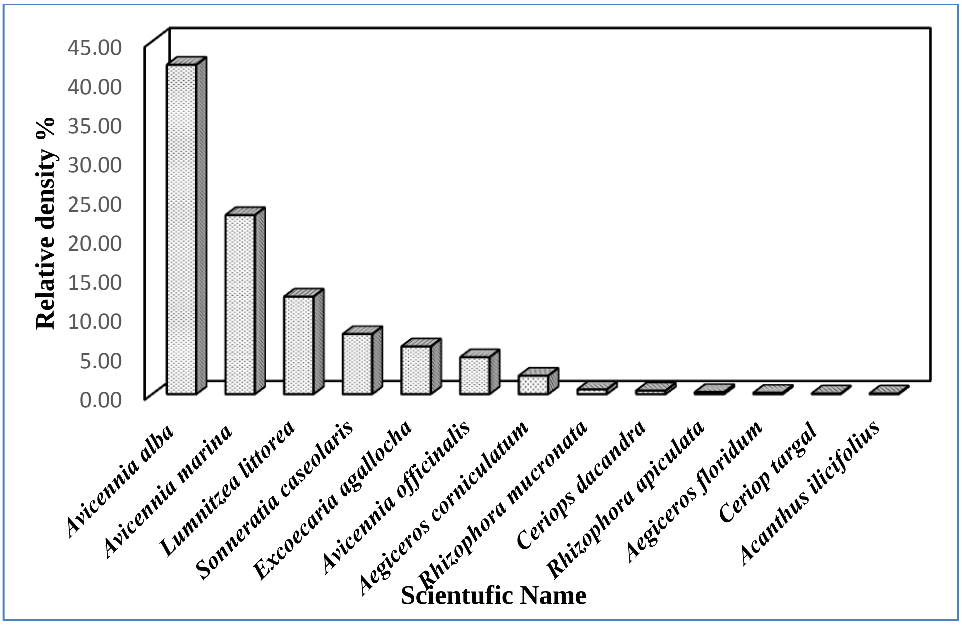

Figure 3. Relative density of the study area

Relative frequency is the frequency of one species compared to the total frequency of all the species. According to the results, *Avicennia alba* (18.92 %) was the highest relative frequency, followed by *Avicennia marina* and *Lumnitzea littorea* (13.51 %) are equally. Therefore, these species occur everywhere in the coastal area (Table 4 and Figure 4).

Table 4. Frequency and relative frequency of the study area

No	Scientific Name	Family	Frequency	Relative Frequency (%)
1	*Avicennia alba*	Avicenniaceae	1.00	18.92
2	*Avicennia marina*	Avicenniaceae	0.71	13.51
3	*Lumnitzea littorea*	Combretaceae	0.71	13.51
4	*Sonneratia caseolaris*	Sonneratiaceae	0.57	10.81
5	*Excoecaria agallocha*	Euphorbiaceae	0.43	8.11
6	*Avicennia officinalis*	Avicenniaceae	0.43	8.11
7	*Aegiceros corniculatum*	Myrsinaceae	0.29	5.41
8	*Rhizophora mucronata*	Rhizophoraceae	0.29	5.41
9	*Ceriops dacandra*	Rhizophoraceae	0.29	5.41
10	*Rhizophora apiculata*	Rhizophoraceae	0.14	2.7
11	*Aegiceros floridum*	Myrsinaceae	0.14	2.7
12	*Ceriop targal*	Rhizophoraceae	0.14	2.7
13	*Acanthus ilicifolius*	Acanthaceae	0.14	2.7

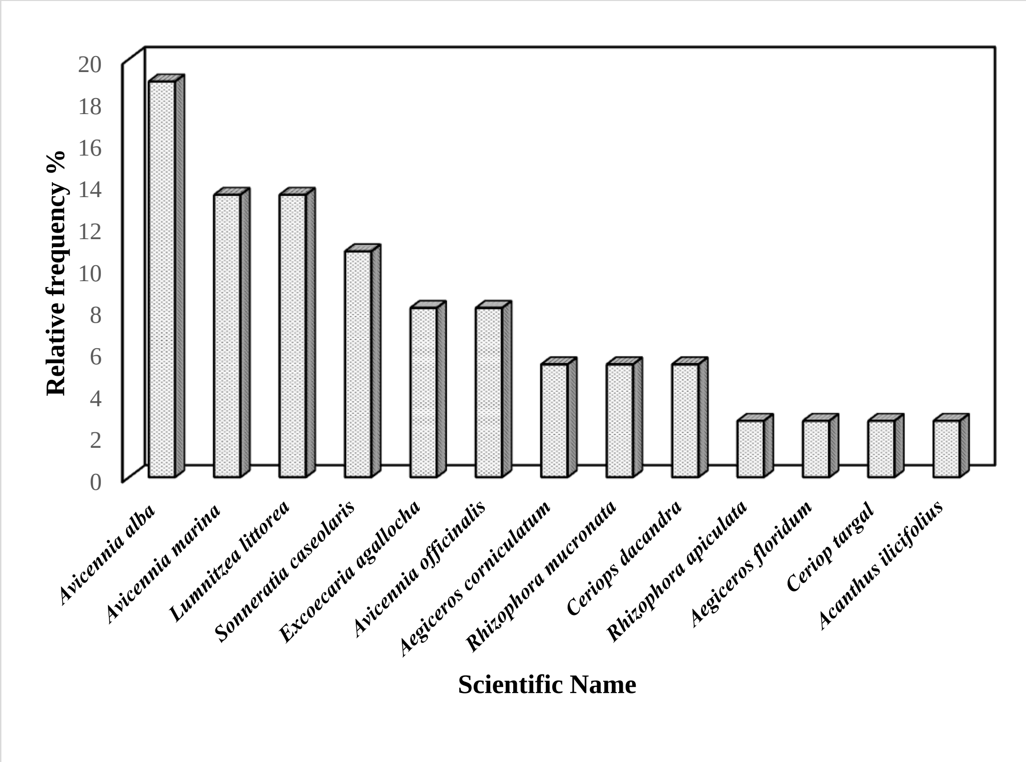

Figure 4. Relative frequency of the study area

According the result of relative dominance, the most common tree species were *Avicennia alba* (38.98 %), *Avicennia marina* (38.98 %) and *Lumnitzea littorea* (12.95 %). So, the *Avicennia alba* and *Avicennia marina* species have larger basal diameter and occupied the area more than the other species (Table 5 and Figure 5). *Excoecaria agallocha* species (2.9344) is the highest mean basal area, followed by *Rhizophora mucronata* (0.3083) (Table 5).

Table 5. Mean basal area and relative dominance of the study area

No	Scientific Name	Mean Basal Area	Relative dominance (%)
1	*Avicennia alba*	0.1796	38.98
2	*Avicennia marina*	0.0615	23.67
3	*Lumnitzea littorea*	0.2896	12.95
4	*Sonneratia caseolaris*	0.0753	9.29
5	*Excoecaria agallocha*	2.9344	7.29
6	*Avicennia officinalis*	0.0754	4.37
7	*Aegiceros corniculatum*	0.0195	1.4
8	*Rhizophora mucronata*	0.3083	1.28
9	*Ceriops dacandra*	0.0217	0.48
10	*Rhizophora apiculata*	0.038	0.22
11	*Aegiceros floridum*	0.0171	0.06
12	*Ceriop targal*	0.0072	0.01
13	*Acanthus ilicifolius*	0.0002	0.00016

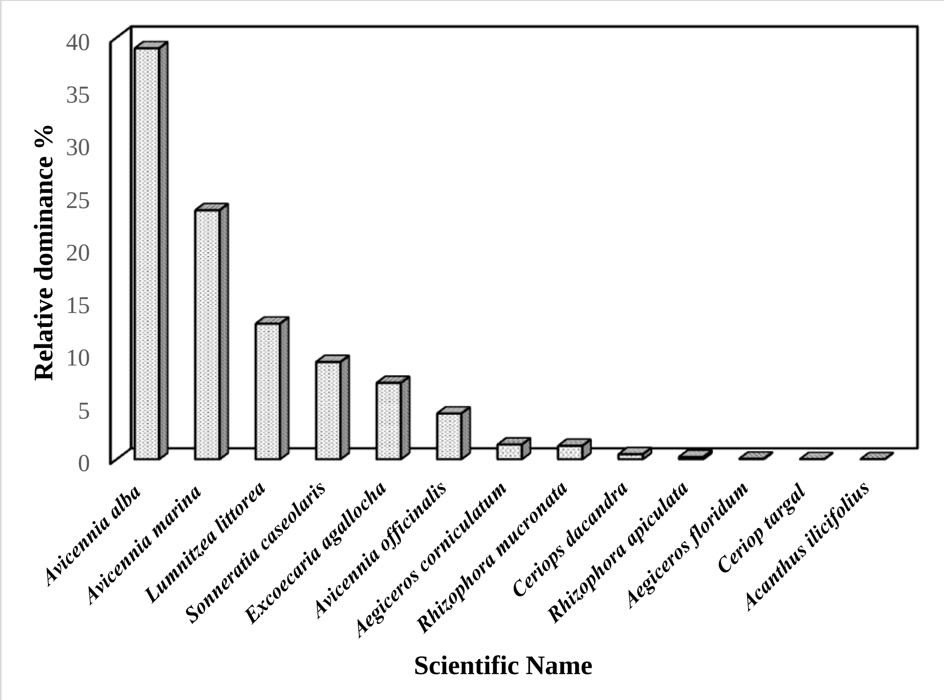

Figure 5. Relative dominance of the study area

Ranking of ecological significance by IVI of mangrove forest in the study area was given in Figure 6. As a combination results of the relative density, frequency and dominance of all recorded mangrove species, the highest IVI was *Avicennia alba* (99.91 %). The second most dominant species is *Avicennia marina* (60.06 %) and *Lumnitzea littorea* (38.95 %).

The results of Pearson's correlation between the diversity indices and the ecological factors of the study area are shown in Table 6. According to the Pearson's correlation, significant positive correlations were found between basal area and salinity ($p<0.05$), between species richness and soil texture (clay) ($p<0.05$). The significant negative correlations was found between Simpson Index and potassium ($p<0.05$) of the study area.

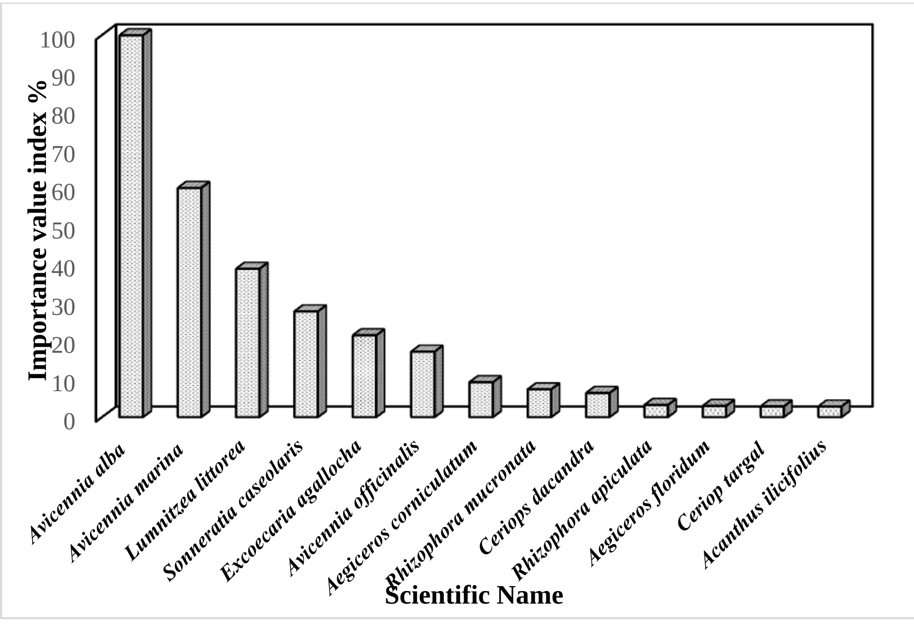

Figure 6. Importance value index of the study area

Table 6. Pearson's correlation between diversity indices and ecological factors of the study area

Variables	SWI	Salinity	pH	N	P	K	Sand	Silt	Clay
Shannon Wienner Index	1	-0.866	0.654	-0.949	-0.928	-0.976	0.952	-0.991	0.067
Simpson Index	0.98	-0.966	0.943	-0.879	**-0.999***	-0.844	0.914	0.745	-0.616
Shannon Evenness	0.92	-0.65	0.995	0.893	-0.872	0.734	0.976	-0.978	0.259
Species Richness	0.688	-0.879	0.717	-0.852	-0.762	-0.995	0.9	-0.276	**0.897***
Basal Area (m^2 ha^{-1})	-0.627	**0.854***	-0.423	0.912	0.559	0.96	-0.75	-0.911	0.351

** Correlation is significant at the 0.01 level.* Correlation is significant at the 0.05 level.

Note: pH= Soil pH, N= Total nitrogen, P= Available phosphorus, K= Potassium

Discussion and Conclusion

The species diversity index of Myawyit coastal area was relatively lower than the Yam-Ma-Zuu-Aww coastal area, Long-Lone Township (Thanda Soe, 2016) analysed by the method of Shannon-Wieners index (H), Simpsons index (D) and Shannon-Wieners index (E). Kirui *et al*., (2012) and Weidelt, (2000) reported that changes in species richness in mangrove forest were likely to reduce resilience of mangrove ecosystem and make it vulnerable to natural and anthropogenic activities. Tomlinson, (1986) and Lugo & Snedaker, (1974) agreed that species richness influenced by temperature, tidal amplitude, rainfall, catchment area, human disturbance and frequency of cyclones.

Thirteen mangrove species were found in the study area with *Avicennia alba*, *Avicennia marina*, *Lumnitzea littorea* and *Sonneratia caseolaris* was the highest relative frequency compared to other species. *Excoecaria agallocha* and *Rhizophora mucronata* species have the highest mean basal area in the study area. Hamad *et al*., (2014) reported that high frequency of these species might be attributed to their high regeneration capacity despite their high use preference for building pole and fire wood.

The importance value index is imperative to compare the ecological significance of species and stated that the species with the greatest importance value were the leading dominants of the mangrove forest. Mangrove species of dominance value index indicated *Avicennia alba* and *Avicennia marina* cover large area in the study area (Figure 6). This might be attributed to the fact that most of *Avicennia alba* and *Avicennia marina* species large in size, an indication that the species is less preferred for cutting as compared to the species of the family Rhizophoraceae and therefore has opportunities to grow into large tree. Golley *et al*., (1975) and Smith, (1992) agreed with that forest ecological characteristics such as canopy height, tree density, and dominance value species may be influenced primarily by climatic factors such as rainfall and by nutrient input. According to the Pearson's correlation, significant positive correlations were found between basal area and salinity ($p<0.05$), between species richness and soil texture (clay) ($p<0.05$). These results agreed with that the growth of mangroves species can be identified based on salinity tolerance data, one has a very broad range and the other has a narrower range of salt tolerance (Feller and Marsha, 2005).

A very low diversity index was observed in the natural mangrove forest in Myawyit coastal area. This area attributed to the dominance of few species, specifically those belonging to the family Avicinniaceae. So, climatic factors, particularly rainfall, are important determinants of species richness, stand structure, and growth dynamics in mangrove forests. Physiological responses to other environmental gradients in the study area (e.g., soil texture, nutrients, salinity) do not appear to be sufficient to influence observed zonation patterns. Biotic factors such as predation on propagules are important influences on the distributional patterns of some groups of mangroves and in certain geographic regions. Competitive interactions may be important in determining some aspects of forest structure, but much more experimental and long-term observational work is needed.

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