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Species diversity and enumeration of shrub species in Pantai Sabak, Kelantan, Malaysia

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Abstract. Coastal forest plays a vital role in our ecosystem because of its numerous and varied human use. In Malaysia especially Kelantan, there is a lot of coastal forests that are not recognised or has been introduced as the forest that consists of much biological diversity that can be important and useful for the development and management of the forest. This study documented shrubs species that were found in Pantai Sabak, Kelantan where all shrubs species were identified and enumerated by using a systematic plot sampling method while relating it with soil composition and their characteristic. A total of 3752 shrubs plants representing 28 species belong to 24 genera from 17 families were identified within 0.05 hectare plots. Species diversity with Shannon-Wiener Diversity Index (H') with a value of 1.67, while H_{max} was 3.34 and Evenness Index (E_H) value was 0.50 for the entire study area. Family Capparaceae (1425) and Euphorbiaceae (1260) were dominant families grown in loam and silt soil and the least dominant represented by *Vitex rotundifolia* and *Ipomoea pes-caprae* species which grown in sandy soil. Only certain species can grow and be able to survive in different habitats where types of soil play an important role in the factors of the tree species that grow around Pantai Sabak which can be observed that during the study was conducted.

1. Introduction

The state of Kelantan is bordered by sandy beaches that extend north-west and south-east, where estuaries along the eastern coast of the Peninsular Malaysia are located at the mouth of several small and large rivers that flow into the South China Sea [1]. The coastal forest is a forest area that grows in the mouth of tidal rivers, seas or areas and it has the highest tide limits which can also be interpreted as growing forests on the coastline [2]. Many plant species are dominated in coastal forest and one of them is shrubs. Shrubs were generally known as a species that can adapt to every environment depend on their characteristic. In Malaysia, shrubs have been recorded as one of the vegetation types that can be found in coastal forest. Shrub morphology adaptation consists of three types of morphology that are adaptation of the roots, adaptation of the stems and adaptation of the leaves in the coastal forest. Most plants, particularly shrubs, are inhospitable in loose sediments, scarce freshwater and extremely saline conditions [3]. These species of shrubs usually grow close to the ground and displayed rather than growing tall. The roots that permit them to unfold, firmly anchor within the sand, and again balance out the erosion of the sand are known as profound taproots and root at their nodes [4]. Their roots usually have air and pores spaces which enable the oxygen to be transport to its roots [5]. Shrubs cover can be used as a forest health indicator that is directly linked to the ecological function and, at the same time,



it is easy to obtain field coverage data and is widely available from forest inventory data and research plot [6].

Not only shrubs have their importance, but there is also environmental influence on their adaptation to the environment. One of it is soil composition and it characteristic. The soil in Peninsular Malaysia are generally acidic, predominantly weathered from igneous rock (granite) into oxisols and ultisols. Based on [7], the degree of aggregation and aggregate stability has been influenced by soil organic matter, which can reduce bulk density and increase overall porosity and hydraulic conductivity in heavy clay soils, as well as seasonal changes, sampling distance, soil depth and plant part, may affect heavy metal concentrations. Soil composition is an important aspect of nutrient management for the plants to use in various production processes to create flowers, leaves, and fruits.

For this study, we have adopted the enumeration concept on all shrubs species that exist in Pantai Sabak, Kelantan and this concept is still a matter of debate among researchers. In recent years, there are a lot of coastal forests that are not recognised or has been introduced as the forest that consists of much biological diversity that can be important and useful for development and management of forest as well as it consists of many useful benefit that people could gain from the coastal forest. To be more specific, many species can be found in Pantai Sabak and some of them are recorded yet. A research by [8], has been experimented with trees enumeration and analysis of Dharoi Range Forest, Mehsana, India, which still lacked data in other countries, including Malaysia and there is less number of papers that establish about shrubs enumeration in coastal forest.

2. Materials and Method

2.1. Study Area

The study was conducted at Pantai Sabak, Kelantan which is located near the airport and industrial area in Pengkalan Chepa and 11 km from the middle of Kota Bharu. Pantai Sabak, Kelantan is lies between 6.178430°N and 102.322130°E (Figure 1). According to [9], during World War Two Sabak beach was chosen as one of the spots by the Japanese Army to land its initial invasion force on 8th December 1941 and until now Pantai Sabak was declared owned by Majlis Perbandaran Kota Bharu (MPKBri). This place close to the little village called Kampung Pantai Dasar, there is also a dumpsite area at Teluk Kitang near the Sultan Ismail Yahya Petra Airport, Kota Bharu and along Pantai Sabak which consist of solid waste disposal.

2.2. Materials

Quadrat plots were established using ropes and PVC pipes in this study. Global Positioning System (GPS) was used to record the location of each plot established at Pantai Sabak. Meanwhile, the laser distance meter was used to determine the sampling area's horizontal distance and vertical height [10]. For the soil sampling method the auger, shovel, sealed plastic bag, was used to take a soil sample in the fieldwork area while for herbarium preparation, old newspaper, labelling tag to label the shrubs species, pressing herbarium board and stationary to record data in the field and 70% ethanol was also used in this study.

2.3. Plot Sampling

To find out shrubs species that can be found in this area, a study of shrubs enumeration in Pantai Sabak, Kelantan was conducted by using a systematic plot sampling method. The plot was set up 100 meters away from the coastline. A total area of 0.05 ha plots was established from 20 plots with a size of each plot was 5 m x 5 m. Each plot was divided into 4 subplots and was placed at a different location. The distance between each plot about 50 m -150 m.

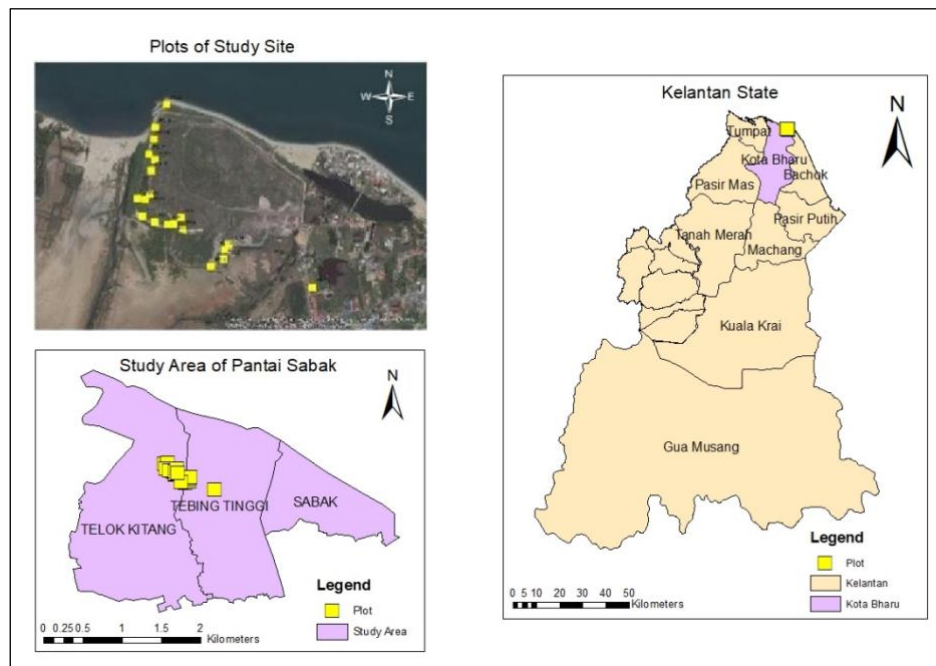


Figure 1. Study site plots during sampling.

2.4. Herbarium Specimen and Sample Collection

There are only certain shrubs species in each plot that has been removed from the ground for preservation as a voucher specimen and the specimen collection includes leaves, fruit, flowers and roots to ease the identification process. A numbered tag was therefore tied on the specimens using the labelling tags which included information such as exact location, altitude and collection date. Each specimen was placed in a fold of several newspaper sheets that stacked together to prevent the specimens from overlapping. The stacked specimens were pressed and transferred for preservation to the sealed plastic bags using 70% of ethanol to prevent damage.

The plant samples were then brought to the laboratory for preparing the specimen vouchers. They were placed into a new sheet of newspaper and were stacked and pressed once again before drying in the oven at 40°C to 45°C depending on the thickness of the specimens, using the oven at the Laboratory of Universiti Malaysia Kelantan Jeli Campus for three to seven days. Lastly, those specimens were labelled with essential data on mounting sheets.

2.5. Shrubs Identification

The herbarium specimens of all shrubs were prepared for identification by comparison with the properly-identified previous specimens of herbarium and referred to the plant books and plant species was confirmed by Dr Radhiah Zakaria, who was the botany expert. Finally, the herbarium specimen was kept for future references at the Natural Resources Museum, Universiti Malaysia Kelantan, Jeli Campus.

2.6. Soil Sampling

Another parameter was gathered in this study to analyse the soil. The soil sample was taken from four random locations within the plot to estimate the level of nutrients, pH and other factors affecting the ability of soil to support the plants. The result of the soil sample was also taken using Atomic Absorption Spectroscopic (AAS) to measure heavy metals. These were done to determine the heavy metal correlation with shrubs species. For soil analysis, several different extracting solutions used to determine extractable cation in soils.

3. Results and Discussion

3.1. Species Composition

The investigation was carried out to explore the existing shrubs species in Pantai Sabak, Kelantan. The study revealed the presence of some important shrubs in the area. The total numbers of shrubs that are found at Pantai Sabak, Kelantan are 3752 individuals of shrubs representing 28 species and 24 genera from 15 families from 0.05 ha as shown in Table 1.

Based on Table 1, the largest families found in this study are Capparaceae with one genus and one species from 1425 (37.98%) shrubs trees that have been recorded. Followed by the family Euphorbiaceae which is known as the second largest with four genera and four species from 1260 (33.58%) shrubs trees. The third-largest family that were recorded are Malvaceae with two genera and four species from 610 (16.26%) shrubs tree that growth in that area. There are one family that has the smallest number of genera and species with each family contained one genera, one species and one individual or 0.02% of shrubs which is known as Sapindaceae.

Table 1. Numbers of Genus and Species along with total individual of each shrubs family in the study area.

No.	Family	No. of Genus	No. of Species	No. of Individual
1	Capparaceae	1	1	1425
2	Euphorbiaceae	4	4	1260
3	Malvaceae	2	4	610
4	Verbenaceae	2	2	129
5	Fabaceae	3	4	84
6	Pedaliaceae	1	1	59
7	Nyctaginaceae	1	1	47
8	Convolvulaceae	1	2	37
9	Cyperaceae	1	1	26
10	Lamiaceae	2	2	40
11	Asteraceae	2	2	17
12	Asclepiadaceae	1	1	3
13	Cucurbitaceae	1	1	2
14	Vitaceae	1	1	2
15	Sapindaceae	1	1	1
Total		24	28	3752

Figure 2 shows the bar chart of the total number of individual for each plot illustrate that for 20 plots there are a total of 3752 individual and from the result in Plot 5 have the largest number of the individual which comprise of 493 individual. The second-largest plots that comprise of 330 individual are Plot 2 and the third largest belong to Plot 10 which has 291 individual. The smallest number of individual is Plot 20 that has a total of 46 individual. The different number of individual in each plot differs because each of these species has a different type of habitat and immune to a different type of soil. As for Plot 5 which has the largest number of individual, the type of soil is more to silt soil while plot 20 it comprises of sandy soil.

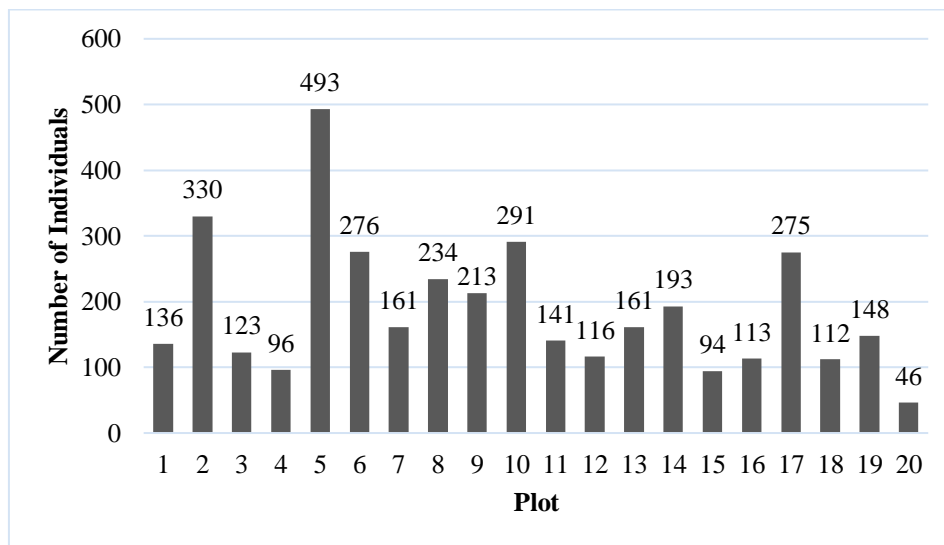


Figure 2. Total number of individuals shrub species in each plot.

3.2. Species Abundance

Table 2 shows that *Cleome viscosa* or known as Asian Spider Flower has the highest number of abundance 109.62 S/N due to the highest number of species which comprise 1425 individual that occurs in a total of 13 plots. Species abundance is characterized in which different species inhabited by variations with changes in the size of a given piece of land. This variation is because species abundance is positively contributed when a large piece of land contains adequate environmental condition [11]. This is because this species is a rapidly growing herb of warm and humid habitats that prefers well-drained soil which is in light sandy and medium loam soil.

The second-highest on the list are *Croton bonplandianus* (Ban Tulusi) with 77.13 S/N and a total of 1234 individual occur in 16 plots. The third highest number can be seen in *Sesamum radiatum* (Back sesame) that has 59.0 S/N with a total of 59 individual occur in one plot. Moreover, the lowest abundance can be seen in *Sida cordifolia* (Heart – Leaf Sida) with 6.40 S/N and a total of 32 individual in 5 plots. This species abundance varied based on the total number of individual of all species in the quadrat and the number of the quadrat in which the species occurred.

Table 2. Species abundance for the given vegetation.

Plant Species	Total no. of Individuals of a species in all quadrat (S)	Number of quadrats in which the species occur (N)	Abundance (A) = S/N
<i>Cleome viscosa</i>	1425	13	109.62
<i>Croton bonplandianus</i>	1234	16	77.13
<i>Sesamum radiatum</i>	59	1	59.0
<i>Sida acuta</i>	561	10	56.1
<i>Ipomoea pes-caprae</i>	31	1	31.0
<i>Senna obtusifolia</i>	65	4	16.25
<i>Boerhavia coccinea</i>	47	3	15.67
<i>Hypolytrum nemorum</i>	26	2	13.0
<i>Lantana camara</i>	114	12	9.50
<i>Sida cordifolia</i>	32	5	6.40

3.3. Density

Density can be defined as the total number of individual divide by the total number of plot studied. Family Capparaceae has the highest density value which comprises 71.25 S/Q followed by family Euphorbiaceae, the second-largest density value with 63.0 S/Q. The third-largest family that has 30.5 S/Q can be seen in the family Malvaceae. While the smallest density value with 1.30 S/Q is family Cyperaceae. Table 3 shows the density of shrubs for ten families in plot sampling.

Table 3. The density of Family for the given highest vegetation.

Family	Number of Individual (S)	Number of sampling unit sampled (Q)	Density (S/Q)
Capparaceae	1425	20	71.25
Euphorbiaceae	1260	20	63.0
Malvaceae	610	20	30.5
Verbenaceae	129	20	6.45
Fabaceae	84	20	4.20
Pedaliaceae	59	20	2.95
Nyctaginaceae	47	20	2.35
Lamiaceae	40	20	2.00
Convolvulaceae	37	20	1.85
Cyperaceae	26	20	1.30

3.4. Diversity of Shrub Species

The diversity of a tree species in the study area were gained by using Shannon-Wiener Index and Shannon Equitability (Evenness). The H' value stated in Table 4 shows that there was a 1.67 value of diversity for all species in twenty plots and 3.34 for H_{max} , respectively. According to [12], Shannon index values are often found to fall from 1.5 to 3.5 in actual populations. A value close to 4 would imply a uniform distribution of the number of individuals among all species.

Furthermore, the value of the Evenness Index (E_H) for trees species was 0.50. The value was almost to the 1.0 Evenness Index maximum ranged and the uniformity of the species was concluded between 0 and 1 where the value 1 refers to an absolute uniformity [12]. Even though there are not many species in the area, the area is still considered to be medium evenness.

Table 4. The list of diversity index and value of H' , E_H and H_{max} .

Diversity Index	Value
Shannon-Wiener Index (H')	1.67
Evenness Index (E_H)	0.50
H_{max}	3.34

3.5. Soil Composition

Based on Table 6 the results indicate that the types of soil texture were different between each plot. There are a total of four soil sample were taken at different location because each place has a different soil texture. As it can be seen, the soil texture for Plot 1 and Plot 4 is the same which is silt soil, followed by Plot 10 which is known as loam soil and lastly for Plot 20 known a sandy soil. The growth of tree species in an area might happen depends on the types of soil textures in the origin environment but the main factors of the germination of tree species influence the surrounding factors [13].

As shown in Table 5, Plot 10 was dominance by loam soil. Loam soil is known as the ideal plant-growing environment for a soil mixture as an average soil texture that usually contains the higher nutrient and humus compared to other soil types. Based on the evidence, the highest number of individual are belong to Plot 10 (291) as it was influenced by the types of soils in the plotting site.

Compare to Plot 20 it has only 46 species and Plot 1 and plot 4 has 136 and 96 species. Most of the tree species grow well in loam soil compared to silt and sandy soils. Thus, it can be seen that Family Euphorbiaceae was dominant in Plot 10 of the study area.

Table 6 indicates that the concentration of elements that available in the soil which consist of two types of heavy metals that are Copper (Cu) and Zinc (Zn) and three types of micronutrient was analysed which known as Calcium (Ca), Potassium (K) and Magnesium (Mg) by using AAS software. The results were more focused on Copper and Zinc where it has optimum limits of 10 mg/L and 0.60 mg/L. For Copper element, it can be seen that all four plot does not reach the optimum limit. While for Zinc, Plot 4 and Plot 10 has reached the optimum limit with 3.274 mg/L and 4.393 mg/L. This indicates that these two plots have been contaminated were it has exceeded their optimum limits. Plants only need a small amount of heavy metal to survive. For Calcium (Ca), Plot 20 has the highest mean concentration with 512.5 mg/L compared to the other three. Calcium (Ca) were needed in large amount to help plants to grow. Next, for Magnesium (Mg) the highest mean concentration was also going to Plot 20 with 18.25 mg/L. For Potassium (K), the result has been reversed where Plot 10 has the highest mean concentration with 26.56 mg/L. These three micronutrients were needed in large amount for their growth and act as fertilizer to plants.

Many species from the Euphorbiaceae family are dominant in the loam soils for the overall results. The soil's texture is significant, particularly its ability to hold water and nutrients. This can endorse the product of loam soil types with 291 of the number of individuals contained in Plot 10. Plot 1 and 4 are surrounded by silt soils. Silt is an intermediate sediment medium between sand and clay that can hold onto nutrient better than sandy soil. Family Verbenaceae and Pedaliaceae have been dominant for both plots in this type of silt soil. Plot 20 recorded only 46 species in the sandy soil. Sandy soils tend to be leached more frequently and are not suitable for many species. In this plot, *Vitex rotundifolia* and *Ipomoea pes-caprae* belong to the dominant species.

Table 5. Types of soils texture with different plot sampling.

Position	Type of soil	Dominance Plant	Total number of plant species
Plot 10	Loam soil	<i>Croton bonplandianus</i>	291
Plot 1	Silt soil	<i>Lantana camara</i>	136
Plot 4	Silt soil	<i>Sesamum radiatum</i>	96
Plot 20	Sandy soil	<i>Vitex rotundifolia</i> <i>Ipomoea pes-caprae</i>	46

Table 6. Table of Soil Parameter Value for each selected plot.

Soil Parameter	Plots			
	Plot 1 Means ^a ± SD ^b (mg/L)	Plot 4 Means ± SD (mg/L)	Plot 10 Means ± SD (mg/L)	Plot 20 Means ± SD (mg/L)
Calcium (Ca)	33.02 ± 0.486	194.7 ± 0.48	165.9 ± 0.71	512.5 ± 2.35
Copper (Cu)	0.089 ± 0.0040	0.226 ± 0.0019	0.432 ± 0.0024	0.052 ± 0.0027
Potassium (K)	14.94 ± 0.329	23.31 ± 0.098	26.54 ± 0.343	7.143 ± 0.0506
Magnesium (Mg)	9.714 ± 0.2898	13.58 ± 0.081	16.47 ± 0.078	18.25 ± 0.037
Zinc (Zn)	0.237 ± 0.0022	3.274 ± 0.0388	4.393 ± 0.0232	0.047 ± 0.0009

^aMean = Indicate three repeated reading from one sample using AAS software

^bSD = Indicate three repeated reading from one sample using AAS software

4. Conclusion

Generally, shrubs are not fully recognized and well established compared to other types of plants found particularly in Kelantan in the coastal forest. To conclude the overall results, it shows that a total of 3752 individuals were listed as a shrubs species. The family that was dominant in Pantai Sabak is Family Capparaceae with 37.98% and the least dominant is Family Sapindaceae with 0.02%. While for shrub species, *Cleome viscosa* and *Croton bonplandianus* have been identified as dominant among all 28 species found in all quadrants. The diversity of shrubs is affected by a multitude of environmental factors, but soil quality was the main factor in this study area that was found mainly to assess the diversity of shrubs. In this study, it can be concluded that soil types at different locations affect what types of shrubs can grow. Capparaceae family normally grows in silt soil, while most of the Euphorbiaceae family mainly grow in loam soil and the least species that grow on sandy soil are *Vitex rotundifolia* and *Ipomoea pes-caprae*. This has shown that the soil types influence the growth of different species.

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