SPECIES DIVERSITY OF FABACEAE AROUND UMK JELI CAMPUS, KELANTAN

by

NUR FATIN AQILAH BINTI MD AYUB

A report submitted in fulfilment of the requirements for the degree of Bachelor of Applied Science (Natural Resources) with Honours

FACULTY OF EARTH SCIENCE UNIVERSITI MALAYSIA KELANTAN

2019

DECLARATION

I declare that this thesis entitled “Species Diversity of Fabaceae around UMK Jeli Campus, Kelantan” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in any candidature of any other degree.

Signature :_____

Name :_____

APPROVAL

"I/ We hereby declare that I/ we have read this thesis and in our opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Applied Science (Natural Resources) with Honors"

Signature :_____

Name of Supervisor :_____

Date :_____

ACKNOWLEDGEMENT

Alhamdulillah, thanks to Allah for giving me this opportunity, the strength and the patience to complete my thesis. First and foremost I would like to express my sincere gratitude to my supervisor Dr. Radhiah Zakaria whose contribution in suggestions and encouragement, introduce me to the plant morphology, helped me to coordinate my final project especially in writing this report. I am thankful to Dr. Radhiah for her precious time in guiding me, answering my queries, correcting and improving the English in my report. Without her guidance and relentless help, this thesis would not have been possible. I also wish to express my sincere thanks to Universiti Malaysia Kelantan (UMK) Jeli Campus especially Faculty of Earth and Science for opportunity given to the final year students to do this project.

A special thanks to the lab assistance Miss Hasimah Binti Hassan for continuous guidance throughout the study process. Credits also to my family and friends for their help, knowledge encouragement and continuous support for me to completing this research. Lastly, thanks to those name who not have appeared that have been contributed in completion of this research.

Species Diversity of Fabaceae around UMK Jeli Campus, Kelantan

ABSTRACT

The study on species diversity and richness was conducted at Universiti Malaysia Kelantan (UMK) Jeli Campus including UMK new Faculty and UMK Taman Pinggiran. There are two methods used in this study which are plot sampling method where 25 quadrat are thrown randomly within the study area and general observation method by walking around the study area. The total of 27 species of Fabaceae from 19 genera were recorded. The Shannon Diversity Index (H') value of Fabaceae H' = 1.44 shows that the H' value is not too high for tropical research. *Desmodium triflorum* are the most diverse with H' = 0.37. The richness index of *Desmodium heterophyllum* recorded the highest value D_{mg} = 1.18 and the overall species richness value of Fabaceae are D_{mg} = 0.67. The comparison table of Fabaceae species recorded are constructed and divided into three subfamilies which are Caesalpinoideae, Mimosoideae and Papilionoideae. Dichotomous key for each subfamily are constructed based on the comparison table and able to be used for references. The data from this study can be used for future research.

Kepelbagaian Spesies Fabaceae Di Sekeliling Kawasan UMK Kampus Jeli, Kelantan

ABSTRAK

Kajian mengenai kepelbagaian dan kekayaan spesies telah dijalankan di Universiti Malaysia Kelantan (UMK) Kampus Jeli di mana kawasan adalah termasuk Fakulti baru UMK dan UMK Taman Pinggiran. Terdapat dua kaedah yang digunakan dalam kajian ini iaitu kaedah pensampelan plot di mana 25 kuadrat dicampak secara rawak dalam kawasan kajian dan kaedah pemerhatian secara umum dengan berjalan di sekitar kawasan kajian. Sebanyak 27 spesis Fabaceae daripada 19 genera dicatatkan. Nilai Indeks Shannon (H') keseluruhan Fabaceae ialah H’ = 1.44 menunjukkan bahawa nilai H 'tidak terlalu tinggi untuk penyelidikan hutan tropika. *Desmodium triflorum* adalah yang paling tinggi dengan nilai H' = 0.37. Indeks kekayaan untuk *Desmodium heterophyllum* mencatatkan spesies tertinggi dengan nilai D_{mg} = 1.18 dan Indeks kekayaan bagi keseluruhan Fabaceae adalah D_{mg} = 0.67. Jadual perbandingan untuk setiap spesies Fabaceae yang dicatatkan telah dibina dan dibahagikan kepada tiga subfamili iaitu Caesalpinoideae, Mimosoideae dan Papilionoideae. Kekunci dikotomi untuk setiap subfamili dibina berdasarkan jadual perbandingan dan boleh digunakan untuk rujukan. Data daripada kajian ini boleh digunakan untuk penyelidikan pada masa akan datang.

TABLE OF CONTENT

LIST OF TABLE

LIST OF FIGURE

LIST OF ABBREVIATIONS

d	Density
f	Frequency
FSB	Faculty of Earth Science
GPS	Global Positioning System
IVi	Importance Value Index
M	Meter
N	Nitrogen
N/A	Not available
PVC	Polyvinyl chloride
Rf	Relative frequency
Rd	Relative density
UMK	Universiti Malaysia Kelantan

LIST OF SYMBOLS

℃	Degree Celsius
º	Degree
=	Equal
×	Multiplication
%	Percent
Σ	Summation

LIST OF TERMS

Bifoliate	Leaves contain two leaves attached to the petiole at a single point.
Bipinnate	A pinnate leaf having two pairs of leaflets.
Bristly	Stiff hairs.
Glabrous	Without hairs, free from hairs, smooth.
Imparipinnate	Pinnate with an uneven number of leaflets.
Papilionaceous	Having an irregular corolla shaped resembles butterfly.
Petiolate	Having a petiole or leafstalk attaching the leaf blade to the stem.
Phyllodium	Leaves modification of branches resembling and performing functions similar to a true leaf.
Pilose	Sparse, soft and straight hairs.
Pinnate	A leaf resembling a feather.
Pubescent	Covered with a layer of fine short hairs or down.
Terete	Cylindrical and smooth-surfaced., slightly tapering at both ends, circular in cross section.
Tetrafoliolate	Having four leaflets.
Trifoliolate	Having three leaflets.

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Fabaceae are also known as legume, pea or bean family with the habitus from herbs to small trees and its abundant at temperate regions. There are also many species at tropical and subtropical regions (Morhardt & Morhardt, 2004).

According to Malik (2017), in late Palaeocene era which is approximately 56 million years ago, there have been reported that Fabaceae has a diverse fossil record and oldest fossils. From the study of this fossil, it suggested that the Fabaceae plants evolved areas near Tethys sea and also have associated closely with human civilization in Asia, Europe and America**.**

Fabaceae is the third largest angiosperm family consists of 751 genera with 19,500 species, behind only the Orchidaceae and Asteraceae (Lewis, Schrire, Mackinder & Lock, 2005). According to Pawlowski (2009), there are three subfamilies within Fabaceae which are Mimosoideae, Caesalpinioideae and Faboideae (Papilionoideae), identified by the differences in the flower structure. Fabaceae also can be identified by the bean pods and their compound leaves.

Fabaceae rich in nitrogen which is valuable to soil. The plant gain nitrogen from air and release it to soil as it is the plant that hosts nodule forming, nitrogen-fixing bacteria on its root structure (Considine, 2012). This family also important in

economic value as many genera include common food plants which are rich in protein and minerals and this plant also important for crops and pastures (Clarke & Lee, 2003). Due to its protein richness, Fabaceae has become staple diet in areas of Asia, Europe and America since 6000 BC (Malik, 2017).

1.2 Problem Statement

Nowadays, biodiversity are gaining attention rapidly in political, public, management, and arenas of scientific (DeLong, 1996). Species diversity plays important role to ecosystem health as if the species extinct, the entire ecosystem starts to loosen.

Fabaceae are large diverse family worldwide. However, the studies on species diversity of Fabaceae in Malaysia are still insufficient. University Malaysia Kelantan (UMK) Jeli Campus are university that situated in Kelantan, Malaysia. Apparently, there are no publications recorded on the species diversity of Fabaceae family at UMK Jeli Campus.

1.3 Objectives

The objectives in this study are:

1. To identify the diversity and richness of Fabaceae around UMK Jeli Campus.
2. To prepare checklist and identification key of Fabaceae around UMK Jeli Campus.

1.4 Scope of Study

This study is to focus on how diverse Fabaceae species can be found in the study areas. The areas selected to collect the data are UMK Jeli Campus, UMK new Faculty and UMK Taman Pinggiran, exclude new Agropark. This study also only focuses on wild species which are naturally growing. This study covers the Fabaceae species from herbs, shrubs to tall trees for data collection.

1.5 Significance of Study

The preparation of checklist and identification key of Fabaceae species that are collected can be used for future references purposes especially for UMK Jeli Campus students. Furthermore, the data on species diversity and richness in UMK Jeli Campus can be used for upcoming research.

CHAPTER 2

LITERATURE REVIEW

2.1 Classification

The name of Fabaceae is derives from Latin *'Faba'* means beans (Cappers & Bekker, 2013). Plantae is the kingdom for Fabaceae family. Fabaceae is a monophyletic family and closely linked with Quillajaceae, Polygalaceae and Surianaceae and this form order Fabales (Lim, 2012) and because it contains nitrogen-fixing plants, Fabales are closely related to a group of Rosid orders.

The morphology of Fabaceae plays important role to distinguish which subfamilies the species belong to. It is because every subfamily has its own characteristic to indicate their species. The leaves of Fabacae are usually compound which are pinnate (e.g. *Aeschynomene indica*), bipinnate (e.g. *Mimosa pudica*), finely bipinnate (e.g. *Mimosa invisa*) trifoliolate (e.g. *Uraria lagopodioides*) and rarely palmate (e.g. *Lupinus*). Some of the leaves are simple, spiral, often present in basal pulvini, some are leaflet folding responses (e.g. *Mimosa pudica*), generally stipulate, sometimes stipellate and some stipules spinose. The flowers of Fabaceae are usually bisexual and sometimes unisexual, actinomorphic or zygomorphic, hypogynous or perigynous, pedicellate or sessile. The calyx is 3 to 6 sepals, aposepalous or synsepalous. Corolla are 5, apopetalous or synsepalous. The stamens are 5 to 10 or

more with distinct or connate. Longitude anthers and solitary in style and stigma (Simpson, 2010).

Taxonomically, Fabaceae are divided into three subfamilies which are Caesalpinioideae, Mimosoideae, and Papilionoideae. Every subfamily has very different looks and this can used as the first distinction in determining the genus (Morhardt & Morhardt, 2004).

2.1.1 Caesalpinioideae

Subfamily Caesalpinioideae also known as peacock flower subfamily is very heterogeneous morphologically and ecologically. It can be characterised by the absence of unique flower. This group are the earliest-diverging elements of the family. It's around 150 genera with 2500 species (Doyle, 2001). The distribution are mainly tropical, some are arid and semi-arid area (Wickens, Goodin & Field, 2012). The habit is trees to shrubs, occasionally herbs and the leaves are usually pinnate or twice pinnate compound (Judd, Campbell, Kellogg, Stevens & Donoghue, 2008). Nodulation is rare and primitive in structure if occur. Releasing pollen as monads and the flower ± weakly zygomorphic, upper petal (banner) innermost; petals distinct are usually 5 or 10 stamens (Heywood, Brummitt, Culham & Seberg, 2007). Figure 2.1 shows the example of Caesalpinioideae where the flower represent peacock like.

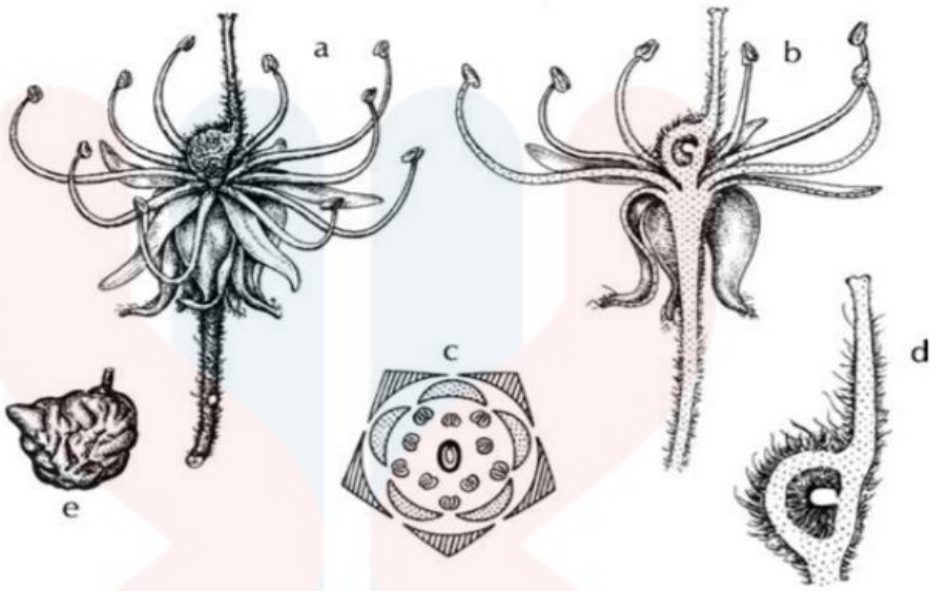


Figure 2.1: *Cynometra iripa*

Source: Tomlinson (2016)

2.1.2 Mimosoideae

Subfamily Mimosoideae have around 40 genera with 2500 species. The leaves are usually twice pinnately compound (Judd et al., 2008) and represent like feathers. This group have actinomorphic flower with typical five corollas distinct or basally fused which is valvate in bud. Sometimes, hypanthium is present usually with numerous, distinct or basally fused stamens (Simpson, 2010). Mimosoideae are mostly shrubs and trees, sometimes lianes or herbs. It has like little ball of stamens which resembles small brushes (Condit, Pérez & Daguerre, 2011). The stems usually have thorns. Figure 2.2 shows one of the examples under Mimosoideae.

Figure 2.2: *Mimosa pudica*

2.1.3 Papilionoideae

Subfamily Faboideae (Papilionoideae) have around 429 genera with 12,615 species. Usually it have pinnately compound to trifoliolate leaves, unifoliolate present occasionally (Judd et al., 2008). Flowers zygomorphic has distinct papilionaceous flower. It have five petals that very unequal where the uppermost are usually the largest following with two lateral smaller forms wings (often clawed) and the lowermost are usually united and clawed forms keel. It has normally 10 stamens (9+1 diadelphous) (Hsuan, 2003). The example of plant under subfamily Papilionoideae is shown in Figure 2.3.

Figure 2.3: *Psophocarpus tetragonolobus*

2.2 Economic Value

Fabaceae are multi-purposes which this is great to enhance their economic importance as food and forage plants. It is important sources of nutrients and provides supplementary proteins. The examples are *Vigna radiata* (mung bean) and grassland plants, *Melilotus* (sweet clover) (Eggli & Hartmann, 2002). A several that is commercially important including *Glycine max* (soybean), *Pisum sativum* (pea), *Medicago sativa* (alfafa), *Arachis hypogaea* (peanut) and *Cicer arietinum* (chickpeas) (Rahman & Parvin, 2010). However, not every genera are edible, some of the genera are highly poisonous such as *Abrus* and *Astragalus* (Judd et al., 2008).

Fabaceae in industrial also can produce oils, gums, dyes, inks and biodegradable plastics made of protein fraction extraction from processed Fabaceae. *Acacia farnesiana* is a Fabaceae flowers used in European perfume industry for Cassia perfume and Fabaceae also contain important timber tree (Eggli & Hartmann, 2002) for example *Koompassia malaccensis* which is a third most abundant timber tree in Malaysia (Praciak, 2013). *Cyamopsis* sp. and *Sesbania* sp. can produced galactomannan gums, which used in textiles sizing and paper, for thickener, and also in pill formulation (Graham & Vance, 2003). Dyes are derived from few genus such as *Indigo* sp. for indigo dye, *Haematoxylum campechianum* for black dye.

2.3 Medicinal Value

Fabaceae are also well known in medicinal resources. The second largest family in medicinal are Fabaceae, contain 490 species of medicinal plant, most use as traditional medicine (Gao, Yao, Song, Liu, Zhu, Ma & Chen, 2010). In traditional medicine folk, it is identified that by eating adzuki beans (*Vigna angularis*) on regularly basis can balances the kidney function (Koblin, 2008). In Malaysia medicinal plant also act as an option treatment for ill health or to maintain healthy. The leaves of *Abrus precatorius* are traditionally used as medicinal plant beliefs by local people in Malaysia to treat several ailments such as fever, ulcer and mouth cancer (Wan Suriyani, Tuan Nadrah Naim, Siti Farhanah & Norzila, 2017). The indigenous healers and traditional folks are using leaves of Fabaceae such as *Acacia nilotica* and *Mimosa invisa* to treat various skin disease, menstrual complications lung and gastric problems (Rahman & Parvin, 2014).

The role of Fabaceae plants in traditional diet are known to have phytoconstituents which able to help in cancer chemoprevention. This gained a lot importance due the existence of phytochemical groups which have anti-tumour properties. Consumption of Fabaceae plant in the routine diet is able to be in helping in reducing the rate of mortality due to breast cancer in Asian countries (Malik, 2017).

According to Graham & Vance (2003), in modern medicine, isoflavones that obtained in Fabaceae family are thought to be cancer risk reducer and able to lower cholesterol postmenopausal hormone, also replacement therapy are studied using soybean phytoestrogens. Fabaceae are also good choice of food for diabetes patient due to production of a hypoglycemic effect when eaten (Gepts, Beavis, Brummer, Shoemaker, Stalker, Weeden & Young, 2005).

Fabaceae has oestrogenic, antibacterial, antioxidant, anti-fungal, anti-feedant and insecticidal activities. Fabaceae can be used to treat polymenorrhea, anemia, ulcers and menorrhagia during the pregnancy. Fabaceae contain protein which can treat Kwashiorkor. Fabaceae also can remove normal bronchitis. Fabaceae also can prevent insomnia, stress and heart beat which is caused by nervousness. Furthermore, Fabaceae inhibit melanogenesis which regulate energy expenditure and metabolism. Other medicinal properties of Fabaceae are antiosteoporotic, anti-diabetic, anti-cancer, anti-nociceptive, anti-atherogenic, anti-inflammatory, anti-nephritic, laxative, sedative, digestive, chemo-preventive and neuroprotective (Wanda, Gamo & Njamen, 2015).

2.4 Cover Crops

Fabaceae cover crops give benefits to soil which can fix atmospheric nitrogen (N) for use by subsequent crops. Fabaceae also have ability for reduction or prevention

of soil erosion. Furthermore, it produces biomass and adds organic matter to the soil. Beneficial insects also can be attracted. Therefore, because of all of these benefits, many species of Fabaceae often used as cover crops to aid soil fertility (Clark, 2008).

Cowpea (*Vigna unguiculata*) is one of the cover crops examples. It is an annual legume and cultivated mainly in tropics or subtropics during warm seasons. Cowpea is one of Papilionoideae family. One of cowpea characteristics is resistance to biotic and abiotic stress which make cowpea important cover crops in tropics. The benefits of cowpea are water deficiency, low soil fertility, and weed control where cowpea plants quickly shade the soil to block out weeds (Baligar & Fageria, 2007). Another examples of Fabaceae cover crops are *Mucuna bracteata* mainly use at oil palm plantation (Goh & Chiu, 2007), *Calopogonium mucunoides*, *Pueraria phaseoloides* and *Centrosema pubescens* (Muhammad Aqeel Ashraf, Radziah Othman & Che Fauziah Ishak, 2017).

2.5 Crops Production

Fabaceae crops production plays important role in food, nutritional security and the food production are globally. Fabaceae are known as food sources that most valuable that consumed globally due to its important biological features. Fabaceae also ensure the food security nearly every part of the world. Fabaceae food crops are important because the diversified productions are for human consumption. This depends on how good the cropping system to produce the diversified food from Fabaceae (Shafique, Rehman, Khan & Kazi, 2014). Some example of Fabaceae food crops are soybean, peanut, vetches, pea, alfafa and clover (Sheaffer & Moncada, 2012).

The benefits comes from Fabaceae food crops can reduce malnutrition problem, shortage of food sources and chronic starvation (Angessa, 2006). Fabaceae consists of 27% of world major crop production (Emerich & Krishnan, 2009). Among the Fabaceae subfamily, subfamily Papilionoideae contains the most of cultivated food grain (Pratap & Kumar, 2011).

However, Fabaceae crop production can be effected to major stress which is from biotic and abiotic stress. Biotic stress damage the Fabaceae plant from other living organisms such as fungi, bacteria, viruses, other native or cultivated plants and ever-changing climate is the main threat to the development and growth of the crops. Abiotic stresses intrude the productivity of Fabaceae food crop and contribute to the big loss of economically importance every year. Abiotic stress includes heat, drought, salinity, water logging, herbicides and pesticides. Potential crop yields can be disrupted due to intense heat or frost (Shafique et al., 2014).

2.6 Plot Sampling

Plot sampling often used when the population of interest are distributed spatially over a landscape such as plants and wildlife (Gregoire & Valentine, 2007). The collection of the data for the study is often limited by cost and time. Therefore, data are obtained mostly by sampling. The good sampling techniques can give a small chances on sampling error. Quadrat are usually used for sampling vegetation because it is the simplest ways (Krahmer, 2016).

A quadrat is the sampling unit which is usually has an area of definite size and has a rectangular, square or circular shape. Quadrat method used can be randomly, regularly or subjectively in the study site depends on the study method used. The size

of quadrat may be differ ranges from 1m × 1m to 20m × 20m. An appropriate quadrat size are depends on the vegetation types or objectives of the study. Increasing the number of quadrat per plot does not necessarily increase the accuracy of the study but can give a better variability of the species population (Rao, 2009).

CHAPTER 3

MATERIALS AND METHODS

3.1 Study Area

UMK Jeli Campus is an education centre which is situated in Jeli, Kelantan and the campus covers an area of 270 acres at coordinate N05° 44.67' – N05° 45.08' and E101° 51.9' – E101° 52.4' (Figure 3.1). The plot sampling method of Fabaceae in the study area was carried out from July 2018 and ended at the middle of August 2018. UMK Jeli Campus are known to have variety of plants species from various family including Fabaceae. Thus, UMK Jeli Campus was selected to see the diversity of Fabaceae in this area.

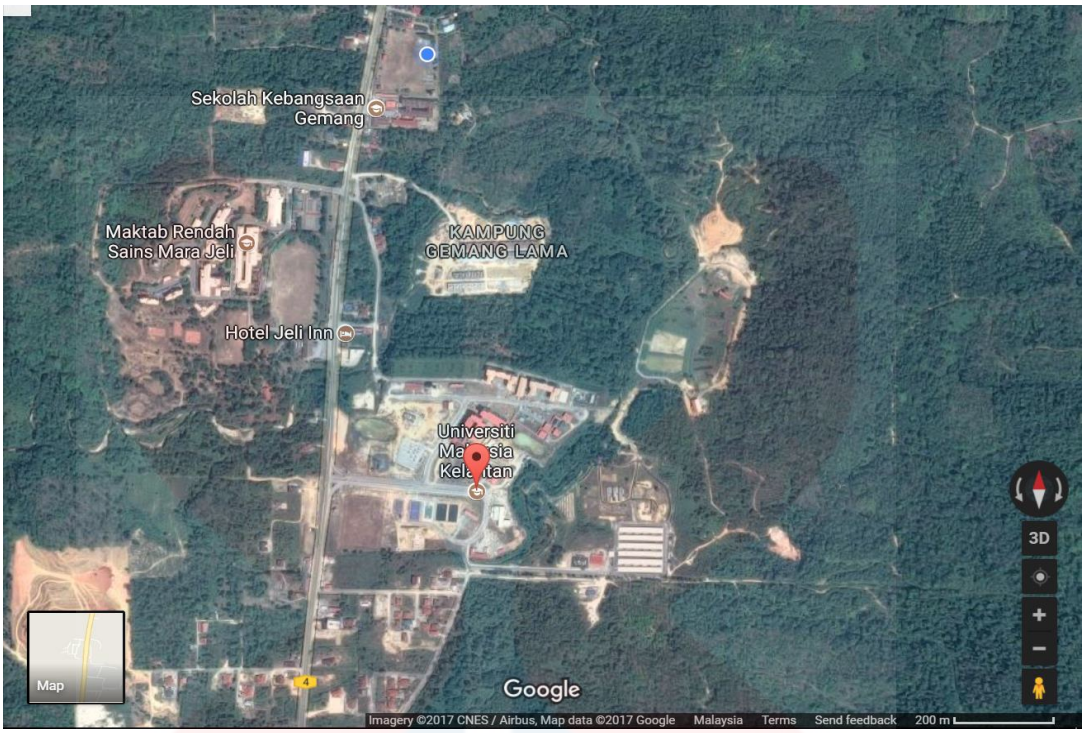


Figure 3.1: Aerial View of UMK Jeli Campus

Source: Google Earth (2018)

3.2 Materials

In this study the materials used was polyvinyl chloride (PVC) pipe and rope for plot, Global Positioning System (GPS) was used for location information such as latitude and longitude, ruler was used to measure the plant leaves. In preserving the specimens, ethanol 70% was used. Next, camera was used for taking the close-up plants picture. Ziplock bag was used to put specimen during collecting. For herbarium process, materials that used was trowel to take plant out from the soil, pressing board or pressing wood and newspaper for pressing the plant, rope to tie the pressing wood and paper for labels. Lastly the field book was used to record the details of specimens.

3.3 Methods

3.3.1 Plot Sampling

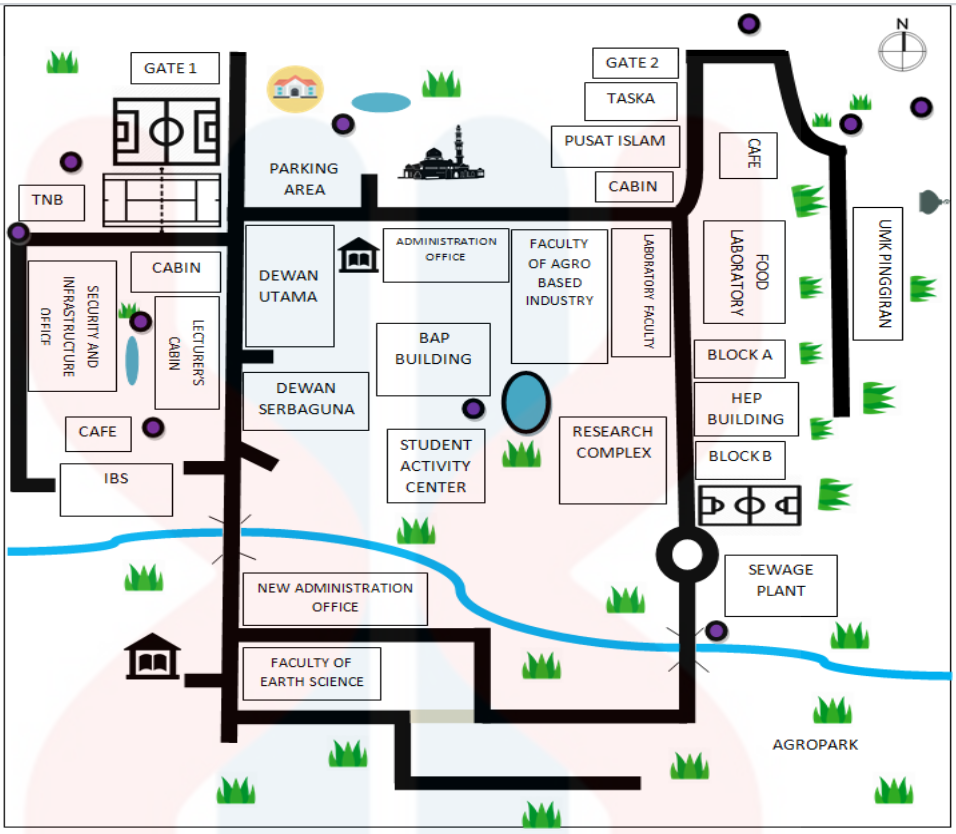
The plots for Fabaceae sampling was set randomly within the study area. The 25 quadrat plots with size 1m × 1m as shows in Figure 3.2 was set. Figure 3.3 shows quadrat 1m × 1m used in the plot sampling. The method used was by throwing the quadrat randomly within the study area (Figure 3.4) and the plot positions was recorded by using the GPS. The quadrat spots are shown at Figure 3.5 where the quadrats are thrown at those areas. At larger area, the number of quadrat had thrown are more than the number of quadrat thrown at small area. The species within the plot were collected and identified. The species of Fabaceae are scattered and cannot be found in one area only. Thus, random sampling method was used because it is the standard method of sampling of Fabaceae.

Then, the close up pictures of specimens collected were taken by using the camera. This plot method only focused on shrubs and herbs because of the small quadrat size which is only 1m × 1m. Thus, this plot method does not suitable for tall trees. The data collected was added to the Fabaceae checklist (Slingsby & Cook, 1986).

Figure 3.2: Size of plot

Figure 3.3: Quadrat 1m × 1m used in plot sampling

Figure 3.4: Random quadrat sampling



Legend

UMK Guesthouse	Road
Library	Bridge
Court	River
Football Court	Unpaved Road
Tennis Court	Quadrat Spot
Surau	Pond
UMK Mosque	Duck Pond
Bushes	

Figure 3.5: Map of the study area with quadrat spots without scale

3.3.2 General Observation

General observation was conducted to increased the Fabaceae diversity around the study area. The general observation method was done by walking around the study area to observe varies species of Fabaceae. This method focused more on tall and big trees and also covered the Fabaceae species that does not covered when using plot sampling method. Then, the data observe was added to the checklist of Fabaceae of the study area. All the species that found are collected and identified. The close up pictures of specimen collected were taken by using the camera.

3.3.3 Herbarium Specimens

Herbarium was done for each individual species collected. In the preparation of plants, the trowel was used to dig the soil to collect the Fabaceae species found. The plants were taken out with underground part without damage and put into the plastic bag. Ethanol 70% was put into the ziplock bag and flipped to make sure the ethanol covered all the part of plant. Next, during the collection process, the species chosen are healthy with complete feature such as leaves, flowers and roots make it easier to identify the species by their characteristics. After collecting species was done, the drying tools was prepared and start the main straightening. The plant was straighten carefully and then put within the newspaper. Then, the ready collection sheets was put into the pressing wood interleaving them with drying sheets. After finished putting the collection sheet, the other one pressing wood was used to press the collection sheets and tied up as tight as possible. The pressing wood with collection sheets were put in the oven with temperature 49 ºC to 50 ºC for five to seven days based on the thickness of the sample (Bridson & Forman, 2013).

The labelling is important to the herbarium. The label is provided with essential information for all the specimens. The information that included were herbarium name, scientific name, vernacular name, collector's name, collection date and GPS coordinates. For every specimens collected, the label was put at the bottom right corner when mounting. During mounting, the drying plants was attached to the A3 paper size sheet. The goal of mounting is to stabilize it. All separate parts of the plant was glued with narrow stripes of special glue paper (parallel to the upper edge of the sheet). At thick parts such as woody, attach them with needle and thread, leaving knots above. The A3 paper was turned over to check the mounting quality. The parts that hang down were attached with glue or thread (Bridson & Forman, 2013). After the herbarium processes were done, the herbarium collection was deposited at Natural Resources Museum in UMK Jeli Campus.

3.3.4 Species Identification

Species identification for species collected were carried out through several ways such as by comparing to other specimen in herbarium, compared with picture from botanical publications, refer to identification key from books such as Tree Flora of Malaya (Whitmore, 1972), Plant Systematic: a Phylogenetic and Approach (Judd et al., 2008) and Stern's Introductory Plant Biology (Bidlack & Jansky, 2010) or asking the botanists.

3.4 Data Analysis

3.4.1 Diversity Index

i. Shannon Diversity Index (H')

Shannon Diversity Index (H') is most widely used index of species diversity. Shannon Diversity Index is the index that commonly used in ecology and ecological monitoring. Shannon Diversity Index are popular index due to its simplicity and the sample size has little effect on the index (Spellerberg, 2008). The calculation of Shannon Diversity Index is as follows:

$$H' = -\sum_{i=1}^{s} Pi \ln Pi \quad (3.1)$$

Where

Pi = fraction of the entire population made up of each species

S = numbers of species encountered

ln Pi = the natural logarithm of this proportion

ii. Shannon Evenness Index (E')

Shannon Evenness Index (E') in term of evenness, it indicates relatives abundances of species and is based on Shannon diversity index (Fred & Fritz, 2013). Shannon Evenness Index is calculated by using the following formula:

$$E' = \frac{H'}{H_{max}} = H' / \ln S \quad (3.2)$$

Where

H' = Shannon's diversity index

H_{max} = the maximum value of H'

ln S = natural logarithm of the number of species

3.4.2 Species Richness Index (D_{mg})

Species richness can be used to refer to the number of species such as in a given area or in a given sample (Spellerberg & Fedor, 2003). To measure, it depends strongly on sampling size and effort. Margalef's index (D_{mg}) was used as a simple measure of species richness (Margalef, 1958). Margalef's index is calculated by using the following formula:

$$D_{mg} = (S - 1) / \ln N \quad (3.3)$$

Where

S = total number of species

N = total number of individuals in the sample

In = natural logarithm

3.4.3 Abundance Parameter

The frequency and density are calculated in abundance parameter.

i. Frequency (f)

Frequency expresses the degree of dispersion of individual species in an area or community (Antony & Lal, 2013). To calculate the frequency is by using the following formula:

$$f = \frac{\text{Number of quadrats in which the species occurred}}{\text{Total number of quadrat}} \quad (3.4)$$

ii. Density (d)

Density is refers to the numbers of plants rooted in each quadrat (Bainbridge, 2012). Density is known as the number of individuals of species per unit area (Antony & Lal, 2013). Density is calculated by using the following formula:

$$d = \frac{\text{Number of individuals of species}}{\text{Total area sample}} \quad (3.5)$$

3.4.4 Importance Value Index (IV*i*)

Importance Value Index (IV*i*) calculation is used. IV*i* is used to determine the overall importance of each species (Dash, 2001). IV*i* are calculated by using the formula:

$$(\mathrm{IV}i) = \frac{\mathrm{Rf} + \mathrm{Rd}}{2} \quad (3.6)$$

Where

Rf = relative frequency

Rd = relative density

i. Relative frequency (Rf)

$$\mathrm{Rf} = \frac{\text{Total frequency of a species}}{\text{Total frequency of all species}} \times 100\% \quad (3.7)$$

ii. Relative density (Rd)

$$\mathrm{Rd} = \frac{\text{Density of a species}}{\text{Total density of all species}} \times 100\% \quad (3.8)$$

3.4.5 Key Identification

Before making the key identification, the comparison table was prepared first consist of the comparison on the character of the Fabaceae species found such as habitats where they grow, the habitus how they grow, the leaves shape, the leaves apex and the stem characters. All the characters was written in the table form to compare

every character. From the data from comparison table, two different dichotomous keys were constructed, one for key to subfamily of Fabaceae and another one was for key to species for each subfamily. The comparison table make it easy to create the key identification. The key identification was constructed with the relevant information for the user in a structured form (Geesink, Leeuwenberg, Ridsdale & Veldkamp, 2013).

CHAPTER 4

RESULT AND DISCUSSION

4.1 Floristic Composition

The study that carried out at Universiti Malaysia Kelantan (UMK) Jeli Campus recorded the total of Fabaceae species represents 27 species from 19 genera. It consists of three subfamilies which are Caesalpinioideae, Mimosoideae and Papilionoideae.

In this study, Papilionoideae shows the most diverse genera consists of 12 genera such as *Aeschynomene, Alysicarpus, Arachis, Calopogonium, Centrosema, Clitoria, Crotalaria, Desmodium, Stylosanthes, Uraria, Zornia* and Unknown genus. Followed by Mimosoideae with five genera of *Acacia, Archidendron, Leucena, Neptunia,* and *Mimosa*. Caesalpinioideae shows the least diverse genera consist of *Bauhinia* and *Cassia*.

Table 4.1 shows, among 19 genera of Fabaceae recorded in UMK Jeli Campus, *Desmodium* was the most diverse genera with four species. While *Aeschynomene, Acacia, Alysicarpus, Archidendron, Arachis, Calopogonium, Centrosema, Leucena, Neptunia, Cassia, Stylosanthes, Uraria, Zornia* and Unknown are the least diverse genera with one species each. The genera of *Bauhinia, Crotalaria* and *Clitoria* represent two species. The three species of genera *Mimosa* was considered more abundant than any other species of Fabaceae.

Table 4.1: The subfamily, genus and species of Fabaceae recorded around UMK Jeli Campus

Subfamily	Genus	Species
Caesalpinioideae	*Bauhinia*	*Bauhinia* sp. a
		Bauhinia sp. b
	Cassia	*Cassia alata*
Mimosoideae	*Acacia*	*Acacia mangium*
	Archidendron	*Archidendron jiringa*
	Leucena	*Leucena leucocephala*
	Mimosa	*Mimosa invisa*
		M. pigra
		M. pudica
	Neptunia	*Neptunia pubescens*
Papilionoideae	*Aeschynomene*	*Aeschynomene indica*
	Alysicarpus	*Alysicarpus vaginalis*
	Arachis	*Arachis glabrata*
	Calopogonium	*Calopogonium mucunoides*
	Centrosema	*Centrosema pubescens*
	Clitoria	*Clitoria laurifolia*
		C. ternatea
	Crotalaria	*Crotalaria mysorensis*
		C. pallida
	Desmodium	*Desmodium heterocarpon*
		D. heterophyllum
		D. triflorum
		Desmodium sp.
	Stylosanthes	*Stylosanthes guianensis*
	Uraria	*Uraria crinita*
	Zornia	*Zornia diphylla*
	Unknown	Species d

Based on this study, Table 4.1 shows Papilionoideae is the most diverse genera followed by Mimosoideae and Caesalpinioideae. However, the result obtained from this study is totally different with the result obtained by Ifo, Moutsambote, Koubouana, Yoka, Ndzai, Bouetou-Kadilamio, Mampouya, Jourdain, Bocko, Mantota, Mbemba, Mouanga-Sokath, Odende, Mondzali, Wenina, Ouissika and Joel (2018) at the Tropical Rainforest of the Congo Basin. The study of Ifo et al. (2018) shows that Mimosoideae are the most diverse in the study area with total 10 species followed by Caesalpinioideae with total five species and Papilionoideae with total four species. The highest number of species of Mimosoideae is due to the old age or maturity of the inventoried forest. Compared to UMK Jeli Campus, this area has been developed into university. In the developing process many plants and trees are cut down to build the faculty and building. Thus, it can affect the growth of plant of Mimosoideae species. Moreover, the area of both study area are different and have its own local climatic condition. Compared to trees, the study area of UMK Jeli Campus shows many of the species recorded are weed or shrubs due to the development and area at Tropical Rainforest of the Congo Basin shows most of the result are trees.

Table 4.2 shows, the total five species from four genera were recorded for the plot sampling method in this study. The genera recorded were *Alysicarpus*, *Calopogonium*, *Desmodium* and *Mimosa*. The overall total numbers of individuals from all genera recorded are 386 with the total quadrat thrown 25. *Desmodium* shows the highest number of individuals which is 188. The second highest was *Calopogonium* with 100 number of individuals, followed by *Mimosa* with number of individuals 51. *Alysicarpus* shows the lowest number of individuals recorded with only 47.

In this study, *Desmodium* shows the highest number of individuals (Table 4.2). According to Raul (1993), *Desmodium* are the weed that have the ability to compete for space and eliminating other species. *Desmodium* also can grow effectively under unfavourable environment. *Desmodium* may be able to compete excellently with or suppress obnoxious weed.

Desmodium are often used in the agriculture due to its other ability as nitrogen collector. In the study conducted by Hong, Xuan, Tsuzuki, Terao, Matsuo & Khanh (2004) stated that *Desmodium* shows the most promising weed control in paddy field as the paddy production increase without much injuries. Furthermore, introducing legumes crop cover such as *Desmodium* and *Calopogonium* into plantation able to increase the production, reducing erosion while increase soil organic matter and soil structure. *Desmodium* and *Calopogonium* also easily adapted to environment such as wet or dry tropical (Addison, 2003). This shows that the reason of *Desmodium* as the highest individuals and followed by *Calopogonium* in UMK Jeli Campus because of its ability to grow in any environmental condition.

Table 4.2: The numbers of genus, species and individuals recorded in quadrat sampling

Species	Number of genus	Number of species	Number of individuals
Alysicarpus	1	1	47
Calopogonium	1	1	100
Desmodium	1	2	188
Mimosa	1	1	51
Total	**4**	**5**	**386**

Table 4.3 shows 17 genera of Fabaceae collected in general observation method consists of 22 species. The genera of *Bauhinia, Crotalaria, Clitoria, Desmodium* and *Mimosa* represented by two species each. While *Aeschynomene, Acacia, Archidendron, Arachis, Centrosema, Leucena, Neptunia, Senna, Stylosanthes, Uraria, Zornia* and Unknown genus represented only one species each.

Table 4.3: The genus and species of Fabaceae in general observation

Genus	**Species**
Bauhinia	*Bauhinia* sp. a
	Bauhinia sp. b
Cassia	*Cassia alata*
Acacia	*Acacia mangium*
Archidendron	*Archidendron jiringa*
Leucena	*Leucena leucocephala*
Mimosa	*Mimosa invisa*
	M. pigra
Neptunia	*Neptunia pubescens*
Aeschynomene	*Aeschynomene indica*
Arachis	*Arachis glabrata*
Centrosema	*Centrosema pubescens*
Clitoria	*Clitoria laurifolia*
	C. ternatea
Crotalaria	*Crotalaria mysorensis*
	C. pallida
Desmodium	*Desmodium heterocarpon*
	Desmodium sp.
Stylosanthes	*Stylosanthes guianensis*
Uraria	*Uraria crinita*
Zornia	*Zornia diphylla*
Unknown	Species d

There are one unknown species which is species d (Table 4.3). This type of species are maybe rarely met before make it hard to identify. However, the flower shows a pea like shape indicates it under subfamily Papilionoideae. The leaves are trifoliate and red flower. The species are still being identified.

The species in Table 4.3 are wildly grown. Some of the species such as *Archidendron jiringa* can be found grow wildly or found domesticated as edible vegetable and planted in village (Ong, 2008). Other species can be used as medicine such as *Cassia alata* (Figure 4.1) where the leaves can be used to treat skin disease such as eczema, blotch or mycosis (Khare, 2008). *Cassia alata* are native at Nothern Tropical America and introduced in Peninsular Malaysia as medicinal plant (Lim, 2012). *Cassia alata* can be found wildly grown such as near roadside and due to its ability to treat skin disease it can be widely planted (Schmelzer, 2008). *Arachis glabrata* (Figure 4.2) are also wildly grow but often use as cover crops due to its ability to improved water and nutrient retention (Krishna, 2013). *Clitoria laurifolia* are native in Central and South America and have naturalised widely in tropics particularly South-East Asia. *Clitoria laurifolia* have been widely used as green manure and cover crop in rubber and coffee plantation and able to control erosion. The leaves have been use in Indonesia to cure pimple (Faridah & Van, 2007).

Figure 4.1: *Cassia alata*

Figure 4.2: *Arachis glabrata*

4.2 Species Diversity, Evenness and Richness

In this study, Shannon Diversity Index and Shannon Evenness Index were used to calculate the diversity of the species collected in the quadrat sampling. Shannon Diversity Index (H') and H_{max} are calculated to shows either the species are highly or less diverse. The Shannon Evenness Index (E') are calculated to shows minimum or maximum evenness of the species by using index number ranges from 0 to 1, where 0 indicates as minimum evenness of a species and 1 indicates as maximum. The species richness index is used to study the number of species presented in the study area (Smith & Wilson, 1996).

4.2.1 Diversity Index of Fabaceae

i. Shannon Diversity Index and Shannon Evenness Index

Table 4.4 shows the Shannon Diversity Index (H'), Shannon Evenness Index (E') and H_{max} of the quadrat in the study area. The overall H' value of Fabaceae are 1.44 indicates that the H' value are not too high based on tropical forest. *Mimosa pudica* shows the H' value of 0.27, whereas the value of H_{max} 1.61. *Calopogonium mucunoides* shows the H' value of 0.35, whereas the H_{max} value is still 1.61. *Desmodium triflorum* and *Desmodium heterophyllum* shows the H' value of 0.37 and 0.20, with each of it has the same H_{max} value 1.61. *Alysicarpus vaginalis* shows the H' value of 0.26 whereas the H_{max} value is 1.61. *Desmodium triflorum* shows the highest H' value. Thus, *Desmodium triflorum* are the most diverse species of Fabaceae at UMK Jeli Campus.

Table 4.4: Shannon Diversity Index (H'), Shannon Evenness Index (E') and Hmax of species in quadrat sampling

Species	Shannon Diversity Index (H')	Shannon Evenness Index (E')	H_{max}
Fabaceae	**1.44**	**0.89**	
Alysicarpus vaginalis	0.26	0.16	1.61
Calopogonium mucunoides	0.35	0.22	1.61
Desmodium heterophyllum	0.20	0.12	1.61
Desmodium triflorum	0.37	0.23	1.61
Mimosa pudica	0.27	0.17	1.61

The value of Shannon Evenness Index (E') also shows in the Table 4.4 with the overall E' value of Fabaceae 0.89. This shows that Fabaceae family has high evenness value due to the E' value near to one. The readings for the E' value of *Mimosa*

pudica is 0.17, whereas the readings of E' value of *Calopogonium mucunoides, Desmodium triflorum, Desmodium heterophyllum* and *Alysicarpus vaginalis* were 0.22, 0.23, 0.12 and 0.16 respectively. From the data in the Table 4.4, *Calopogonium mucunoides* and *Desmodium triflorum* are known to have high evenness due to the value of E' were the most nearest to the maximum evenness of a species value one compared to three other species.

However, *Desmodium heterophyllum* has the lower species evenness as the value are the nearest to the minimum evenness of a species value zero. In this study, the high E' value of *Desmodium triflorum* is due to many numbers of individuals were recorded in the quadrat of the study area.

4.2.2 Species Richness Index

Table 4.5 shows the richness index of species from the quadrat sampling data. In this study, *Desmodium heterophyllum* recorded as the highest richness index with the value 1.18 followed by *Alysicarpus vaginalis* 1.04, *Mimosa pudica* 1.02, *Calopogonium mucunoides* 0.87. *Desmodium triflorum* recorded the lowest value of richness index recorded 0.79. The overall Species Richness Index value of Fabaceae are 0.67.

Table 4.5: Species richness index of quadrat sampling

Species	D_{mg}
Fabaceae	**0.67**
Alysicarpus vaginalis	1.04
Calopogonium mucunoides	0.87
Desmodium heterophyllum	1.18
Desmodium triflorum	0.79
Mimosa pudica	1.02

4.3 Abundance Parameter

Abundance parameter consists of statistical data that calculate density (d), frequency (f), relative density (Rd), relative frequency (Rf) and Importance Value Index (IV*i*). Density of a species is the number of individuals in the area while frequency is the number of quadrat in which the species occurred (Jeelani, 2016). IV*i* is used to express the dominant of species in quadrat sampling. IV*i* utilises two characteristics which are Rd and Rf (Bebarta, 2002).

4.3.1 Abundance Parameter of Quadrat Sampling

Table 4.6 shows the data of overall density and frequency of quadrat sampling. *Desmodium triflorum* recorded the highest number of density with the value 0.41 with the numbers of individuals 158, followed by *Calopogonium mucunoides* with the density value 0.26 and number of individuals 100. The lowest density value recorded were *Mimosa pudica*, *Alysicarpus vaginalis* and *Desmodium heterophyllum* with the value of density 0.13, 0.12 and 0.08 respectively with the number of individuals 51, 47 and 30 respectively.

The highest value of density is correlated with the number of individuals. This have been prove in Table 4.6 where *Desmodium triflorum* shows the highest density value due to its highest number of individuals, followed by *Calopogonium mucunoides*.

On the other hand, frequency shows *Mimosa pudica* recorded the highest frequency value 0.84 with the number of quadrat counted 21 from 25 quadrat (Table 4.6). *Calopogonium mucunoides* recorded the second highest frequency value 0.48

with the quadrat counted 12 from 25 quadrat. *Desmodium triflorum* recorded the lowest frequency value 0.28 with the quadrat counted seven, followed by *Alysicarpus vaginalis* and *Desmodium heterophyllum* with the frequency value 0.16 as the number of quadrat counted four from 25 quadrat respectively.

Table 4.6: Density and frequency of species in quadrat sampling

Species	No. of Individuals	No. of quadrat occurred	Density (d)	Frequency (f)
Alysicarpus vaginalis	47	4	0.12	0.16
Calopogonium mucunoides	100	12	0.26	0.48
Desmodium heterophyllum	30	4	0.08	0.16
Desmodium triflorum	158	7	0.41	0.28
Mimosa pudica	51	21	0.13	0.84

Mimosa pudica shows the highest frequency value due to its highest number of quadrat counted. *Alysicarpus vaginalis* and *Desmodium heterophyllum* shows the lowest frequency value due its lowest number of quadrat counted. This shows that frequency was influenced by the number of the quadrat. These are shown in Table 4.6.

Table 4.7 shows *Mimosa pudica* recorded the highest IV*i* value 28.48. This shows *Mimosa pudica* is the dominant species from the quadrat sampling data, followed by *Desmodium triflorum* and *Calopogonium mucunoides* with the IV*i* value 27.76 and 25.45 respectively. *Alysicarpus vaginalis* and *Desmodium heterophyllum* recorded the lowest IV*i* value 10.25 and 8.05 respectively.

The dominant species of *Mimosa pudica* can be reflected to the highest number of relative frequency. In Table 4.7 it shows that *Mimosa pudica* has the highest number

of relative frequency compared to other four species. Thus, the IV*i* value of *Mimosa pudica* is high.

Table 4.7: Relative density, relative frequency and Importance Value Index of species in quadrat sampling

Species	Rd	Rf	IV*i*
Alysicarpus vaginalis	12.18	8.33	10.25
Calopogonium mucunoides	25.91	25.00	25.45
Desmodium heterophyllum	7.77	8.33	8.05
Desmodium triflorum	40.93	14.58	27.76
Mimosa pudica	13.21	43.75	28.48

4.4 Comparison Table

Comparison table consists of tabulation of characters which help to differentiate the unique characters of species. Comparison table have the flexibility which arranges the characters in sequences make it easier to locate the characters and make it easier to construct the dichotomous key (Cohn, 1994).

In this study, the comparison table constructed were clearly divided in three subfamilies of Fabaceae which are Caesalpinioideae, Mimosoideae and Papilionoideae. Therefore, the comparison table is based on those three subfamilies and focus on the characters of each subfamilies.

4.4.1 Caesalpinioideae

Table 4.8 shows the comparison between habitat, habitus and stem of Caesalpinioideae while Table 4.9 shows the comparison between the leaves of Caesalpinioideae and Table 4.10 shows the Comparison between of flower/inflorescences and fruit of Caesalpinioideae.

Table 4.8: Comparison table of habitat, habitus and stem of Caesalpinioideae

Species	Habitat	Habitus	Stem
Bauhinia sp. a	Wet soils, road sides, disturbed forest	Climbing	Quite woody
Bauhinia sp. b	Road sides, disturbed forest	Climbing, twining	Slender vine, climb and twine with other plants for support.
Cassia alata	Wet soils, road sides, floodplains	Shrub	Bark is thin and upright

Table 4.9: Comparison table of leaves of Caesalpinioideae

Species	Leaves								
	Type	**Arrangement**	**Shape**	**Apexes**	**Bases**	**Margin**	**Venations**	**Texture**	**Colour**
Bauhinia sp. a	Simple	Alternate	Obcordate 4-11 cm × 3.7-9.1 cm	Emarginate	Cordate	Entire	Pinnate	Rough. Papery, below is slightly hairy	Young leaves is purplish light green, mature leaves is dark green , below is slightly hairy
Bauhinia sp. b	Simple	Alternate	Reniform 5-7.3 cm × 3.4- 5.9 cm	Acute to emarginated	Cordate	Entire	Pinnate	Smooth	Green, young leaves are light green
Cassia alata	Once pinnately without terminal leaflet	Spiral	Oblong to elliptic 5-15 cm × 3-7 cm	Rounded	Rounded	Entire	Pinnate	Smooth, coarse	Front green, back light green

Table 4.10: Comparison table of flower/inflorescences and fruit of Caesalpinioideae

Species	Flower/ Inflorescences			Fruit
	Type	**Shape**	**Colour**	
Bauhinia sp. a	NA	NA	NA	NA
Bauhinia sp. b	NA	NA	NA	NA
Cassia alata	Axillary raceme	Ovate-orbicular to spathulate	Golden yellow	4-winged pod, green when young and dark brown when ripe

NA = Not Available

4.4.2 Mimosoideae

Table 4.11 shows the comparison between habitat, habitus and stem of Mimosoideae while Table 4.12 shows the comparison between the leaves of Mimosoideae and Table 4.13 shows comparison between flower/inflorescences and fruit of Mimosoideae.

Table 4.11: Comparison table of habitat, habitus, stem, flower and fruit of Mimosoideae

Species	Habitat	Habitus	Stem
Acacia mangium	Forests, roadsides	Tree	Woody, solid, branched, older bark are rough and hard
Archidendron jiringa	Forest	Shrub or tree	Bark grey or grey white, usually smooth, woody
Leucena leucocephala	Roadsides	Shrub to small trees.	Woody, weak and brittle.
Mimosa invisa	Wastelands, pastures, plantations, roadsides, disturbed forest	Shrub	Have four-angle, hooked prickled, erect
Mimosa pigra	Roadsides, waterways, wet soils	Shrub to small tree	Hairy and prickly stem, branched, erect
Mimosa pudica	Wastelands, pastures, plantations, roadsides	Herb, creeper	Prickly stem, branched, become woody with age, purplish
Neptunia pubescens	Roadsides, wet soils	Herb	Cylindrical, densely hairy, soft woody

Table 4.12: Comparison table of leaves of Mimosoideae

Species	Leaves								
	Type	**Arrangement**	**Shape**	**Apexes**	**Bases**	**Margin**	**Venations**	**Texture**	**Colour**
Acacia mangium	Simple	Alternate	Obovate 11-21 cm × 3-10 cm	Acute	Asymmetric to tapered	Entire	Pinnate	Smooth, raised or sunken veins	Dark green above and below
Archidendron jiringa	Pinnate	Alternate	Oblong to oval 8-15 cm × 4-5 cm	Obtuse to acuminate	Rounded	Entire	Pinnate	Papery when mature	Young leaves are purple
Leucena leucocephala	Bipinnate	Alternate	Oblong 0.9-1.8 cm × 0.2-0.45 cm	Obtuse to acute	Rounded	Entire	Pinnate	Smooth, thin	Green colour above and pale green below
Mimosa invisa	Bipinnate	Alternate	Lanceolate 0.5-0.7 cm × 0.1-0.15 cm	Acute	Rounded	Entire	Pinnate	Soft, smooth	Bright green
Mimosa pigra	Bipinnate	Alternate	Lanceolate 0.3-1.2 cm × 0.1-0.2 cm	Acute	Rounded	Entire	Pinnate	Papery, central leaf stalk is prickly	Green

Table 4.12 (Continued)

Mimosa pudica	Bipinnate	Alternate spiral	Oblong 0.3-1.1 cm × 0.1-0.15 cm	Acute	Rounded	Entire	Pinnate	Both leaflets surface are sparsely hairy	Green
Neptunia pubescens	Bipinnate	Alternate	Oblong 0.3-1.2 cm × 0.1-0.13 cm	Obtuse	Rounded	Entire	Pinnate	Hairy both surface	Green and purplish at edge

Table 4.13: Comparison table of flower/inflorescences and fruit of Mimosoideae

Species	Flower/ Inflorescences			Fruit
	Type	Shape	Colour	
Acacia mangium	Axillary solitary or paired	Loose spike	Whitish cream	Pods linear, coiled, slightly woody, dark brown at mature
Archidendron jiringa	Axillary Sessile	Scattered hairs in the distal parts	White	Leathery, purplish brown when ripen
Leucena leucocephala	Axillary capitulum	Grouped in compact globose head	Whitish, cream or pale yellow	Elongated, flattened pod with pointed tip, green when young, brown when mature
Mimosa invisa	Axillary raceme	Fluffy, ball shaped	Bright pink to pale pink	Flattened pod with small prickles at edge
Mimosa pigra	Axillary raceme	Fluffy, ball shaped	Pale pink	Elongated and flattened pod covered with bristly hairs and clusters, green colour and brown when mature
Mimosa pudica	Axillary raceme	Fluffy, ball shaped	Pink and light purple	Oblong, prickly and flat seed pod, covered with bristly hairs green when young and dark brown when mature
Neptunia pubescens	Axillary raceme	Fluffy, ball shaped	Yellow	Brown flattened pod (legume), splitting open when ripe.

4.4.3 Papilionoideae

Table 4.14 shows the comparison between habitat, habitus and stem of Papilionoideae while Table 4.15 shows the comparison between the leaves of Papilionoideae and Table 4.16 shows comparison between flower/inflorescences and fruit of Papilionoideae.

Table 4.14: Comparison table of habitat, habitus and stem of Papilionoideae

Species	Habitat	Habitus	Stem
Aeschynomene indica	Wet and muddy places, roadsides	Herb	Slender, branched, green or purple in colour, glabrous, stem base are swollen and spongy
Alysicarpus vaginalis	Roadsides, sunny exposed area and turf	Creeper, herb	Pubescent when young, becoming woody at base
Arachis glabrata	Sandy or clay soils, roadsides	Creeper, herb	Erect to decumbent unbranched
Calopogonium mucunoides	Roadside, open areas	Creeper, twinning herb	Slightly woody vine, densely pubescent
Centrosema pubescens	Naturalized along roadside, open areas	Climbing, twinning	Slender, fine short hairs
Clitoria ternatea	Roadsides, open spaces, disturbed areas, near rivers or lakeshores	Climber, trailer herb	Slender vine, fine short hairs, climb and twinning with other plants for support.
Clitoria laurifolia	Roadsides, riversides, red clay soils, open sites	Shrub	Semi-decumbent or erect
Crotalaria mysorensis	Roadsides, waste areas, disturbed areas	Shrub	Stem covered with densely long-hairy, terete
Crotalaria pallida	Disturbed areas with sandy soils, roadsides, riversides, waste areas	Herb or shrub	Branched, densely covered with hairs pressed against the stem surface
Desmodium heterophyllum	Riversides, roadsides, waste areas	Creeper , herb	Young stem covered in soft white hair, mature are hairless and woody

Table 4.14 (Continued)

Desmodium heterocarpon	Disturbed areas, roadsides, waste areas	Shrub	Much-branched, base quite woody, nearly glabrous to densely covered white hair
Desmodium triflorum	Sunny, disturbed areas, roadsides, waste areas	Creeper, herb	Much-branched, bristly hairy
Desmodium sp.	Disturbed areas, roadsides, waste areas	Shrub	Much-branched, base quite woody, soft hair, purplish green
Stylosanthes guianensis	Disturbed areas, roadsides, waste areas	Herb or sub shrub	Densely branched, glabrous to densely pilose, erect or semi-erect
Uraria crinita	Roadsides, open forest, waste places	Sub-shrub	Woody erect stem and cover with soft short gray hair
Zornia diphylla	Roadsides, waste areas	Creeper, herb	Erect or procumbent, branched, hairy, woody at base
Species d	Roadsides, waste areas	Sub-shrub	Erect, soft short hair

Table 4.15: Comparison table of leaves of Papilionoideae

Species	Leaves								
	Type	**Arrangement**	**Shape**	**Apexes**	**Bases**	**Margin**	**Venations**	**Texture**	**Colour**
Aeschynomene indica	Petiolate, odd-pinnate	Alternate	Oblong 0.3-1.2 cm x 1-3 mm	Rounded and mucronate	Obtuse	Entire	Pinnate	Papery	Green above, pale green below
Alysicarpus vaginalis	Simple, Once pinnate without alternate leaflet	Opposite	Obovate to oblong 1-2.3 cm × 0.3-1.4 cm	Rounded to obtuse	Rounded	Entire	Pinnate	Smooth, thin	Green with whitish streak along the midvein
Arachis glabrata	Tetrafoliolate	Alternate	Linear lanceolate 0.7- 2.1 cm × 0.6-1.3 cm	Acute or obtuse	Rounded	Entire	Veins parallel	Glabrous to sparsely pubescent	Green
Calopogonium mucunoides	Trifoliate	Alternate	Round to ovate 2-10 cm × 1.5-6.5 cm	Obtuse to almost rounded	Cuneate to rounded	Entire	Pinnate	Velvet	Green colour above and pale green below
Centrosema pubescens	Trifoliate	Alternate	Elliptic to ovate-elliptic 3.5-3.8 cm × 1.7-2 cm	Acute	Rounded	Entire	Pinnate	Slightly hairy especially lower surface, thinly papery	Dark green

Table 4.15 (Continued)

Clitoria ternatea	5- to 7-foliolate	Opposite and terminal leaflet	Elliptic to ovate 2.5-5 cm × 1.5-3.5 cm	Acute or rounded	Cuneate or rounded	Entire	Pinnate	Smooth	Green
Clitoria laurifolia	Trifoliate	Spiral	Ovate to oblong 3-10 cm × 1.8-2 cm	Rounded	Cuneate	Entire	Pinnate	Glabrous above, have pubescent underside	Green above, light green below
Crotalaria mysorensis	Simple	Alternate	Lanceolate 3.5-5.5 cm × 0.4-0.7 cm	Obtuse to acute	Cuneate	Entire	Pinnate	Both surfaces sparsely pilose	Green
Crotalaria pallida	Trifoliate	Alternate	Elliptic or obovte 2.5-5 cm × 0.6-3 cm	Rounded to acute	Cuneate or rounded	Entire	Pinnate	Hairless above, sparsely covered in silky hair	Green above, pale green below
Desmodium heterophyllum	Trifoliate	Alternate	Elliptic or obovate 1-2.2 cm × 0.5-1 cm	Slightly emarginate to rounded	Rounded	Entire	Pinnate	Smooth edges, densely covered in soft white hair	Light green to almost yellow watermark on surface, pale green below
Desmodium heterocarpon	Trifoliate	Alternate	Elliptic to obovate 3.5-4.0 cm × 1.3-1.7 cm	Rounded to obtuse	Rounded to cuneate	Entire	Pinnate	Smooth on the upper, hairy underneath	Light green to almost yellow watermark on surface, silvery green below

Table 4.15 (Continued)

Desmodium triflorum	Trifoliate	Alternate	Obovate 0.1-0.5 cm × 0.1-0.15 cm	Emarginate	Rounded	Entire	Pinnate	Lower surface appressed pubescent,	Green above, light green below
Desmodium sp.	Trifoliate	Alternate	Elliptic to ovate	Rounded to obtuse	Cuneate	Entire	Pinnate	Smooth on the upper, hairy underneath	Light green to almost yellow watermark on surface, yellowish green below
Stylosanthes guianensis	Trifoliate	Alternate	Ovate to lanceolate 0.1-3.5 cm × 0.5-1.2 cm	Acute	Cuneate	Entire	Pinnate	Scattered bristles	Green to dark green
Uraria crinita	Imparipinnate	Alternate	Ovate to oblong 6-15 cm × 3-8 cm	Acute, obtuse to rounded	Rounded to slightly cordate	Entire	Pinnate	Smooth	Green
Zornia diphylla	Bifoliolate	Alternate	Lanceolate to oblong 0.8-1.5 cm x 0.15-0.2 cm	Acute	Broadly-ovate	Entire	Pinnate	Globrous and pubescent	Green
Species d	Trifoliate	Alternate	Lanceolate	Acute or blunt	Rounded	Entire	Pinnate	Smooth	Green, young leaves is light green

Table 4.16: Comparison table of flower/inflorescences and fruit of Papilionoideae

Species	Flower/ Inflorescences			Fruit
	Type	Shape	Colour	
Aeschynomene indica	Axillary raceme	Papilionaceous	Whitish yellow	Flat, linear pod, curved or straight, green when young, brown at mature
Alysicarpus vaginalis	Terminal or axillary spike, subsessile	Papilionaceous	Reddish or light purple	Jointed cylindrical pod, green when young and dark brown to black when mature.
Arachis glabrata	Axillary sessile, solitary	Papilionaceous	Yellow	geocarpic, but usually scarce
Calopogonium mucunoides	Axillary pseudo-raceme	Papilionaceous	Purplish white	oblong-linear, flattened, hirsute
Centrosema pubescens	Axillary raceme	Papilionaceous	Light purple	Linear pod, long, flat, green when young and dark brown when ripe
Clitoria ternatea	Axillary solitary or 2 grouping	Papilionaceous	White	Pod linear-oblong, flat, sharply beaked, appressed hairy.
Clitoria laurifolia	Axillary raceme	Papilionaceous	Purplish white	Short beak with a longitudinal rib on each side, brown when mature.
Crotalaria mysorensis	Terminal raceme	Papilionaceous	Yellow	Oblong, pod inflated, hairless when mature, green when young and brown when ripe
Crotalaria pallida	Terminal long raceme	Papilionaceous	Yellowish golden	Pods cylindrical and inflated, green and short hair when young, brown and hairless at maturity
Desmodium heterophyllum	Axillary raceme	Papilionaceous	Purple	Short pods with wavy edges, green when young and brown when mature

Table 4.16 (Continued)

Desmodium heterocarpon	Terminal long raceme	Papilionaceous	Purple	Narrowly oblong, green when young, brown when mature
Desmodium triflorum	Axillary raceme	Papilionaceous	Reddish purple to purple	Slightly curved pods that are hairy, green when young and brown when mature
Desmodium sp.	Terminal long raceme	Papilionaceous	White	Erect, narrowly oblong, compressed and, turning from green to dark brown on maturity both, soft short hair
Stylosanthes guianensis	Axillary clusters at the end of stem	Papilionaceous	Yellow to orange	One seeded pod, green when young, brown at mature
Uraria crinita	Terminal raceme	Papilionaceous	Light purple to purple	Elliptic pod lightly covered in soft, short hairs, brown at mature
Zornia diphylla	Axillary raceme	Papilionaceous	Yellow	Hairy bristle
Species d	Axillary raceme	Papilionaceous	Red	Long, slim, flattened pod

4.5 Dichotomous key

Dichotomous key are constructed based on characters from comparison table. Key to subfamily of Fabaceae are constructed first. Then, key to species of each subfamily are constructed.

KEY TO THE SUBFAMILY OF FABACEAE

1. Flowers whether small or large usually individually conspicuous, arranged in various types of inflorescences, leaves simple or compound…..…….. Caesalpinioideae
1. Flowers usually small and individually inconspicuous, arranged in dense heads or clusters, regular, leaves simple or bipinnately compound…….…… Mimosoideae
1. Flowers usually papilionaceous shaped, It have five petals, 3 separate petals (larger standard, 2 wings) and 2 petals fused to form a keel, leaves simple, once pinnately. bifoliolate compound (often trifoliate leaflets OR with many leaflets)…….... Papilionoideae

SUBFAMILY 1. CAESALPINIOIDEAE

Leaves once or twice compound, even- or odd-pinnate; very small stipules; petals 5, slightly or markedly unequal.

KEY TO SPECIES OF CAESALPINIOIDEAE

1a. A shrub with golden yellow flower……..……..….*Cassia alata*

1b. A climbing with flower colour others……..……..……..2

2a. A climbing with woody stem; young leaves is purplish light green……..……..... *Bauhinia* sp. a

2b. A climbing and twinning; young leaves is light green……..……..……*Bauhinia* sp. b

SUBFAMILY 2. MIMOSOIDEAE

Leaves twice compound; flowers in heads or spikes; sepals united; stamens 5 to many, separate or the filaments all united toward base, exceeding the corolla.

KEY TO SPECIES OF MIMOSOIDEAE

1a. Leaves modification of branches (phyllodium)…..…….*Acacia mangium*

1b. Leaves compound, not modified from branches.…….2

2a. Herb; flower yellow……...……...*Neptunia pubescens*

2b. A shrub to small tree; flower colour others...……...……...…….3

3a. Leaves pinnate, young leaves purple……*Archidendron jiringa*

3b. Leaves bipinnate, young leaves greenish…….4

4a. Mostly small trees with whitish cream to yellowish flower……...……. *Leucena leucocephala*

4b. Mostly sub-shrub to shrub with pinkish flower……5

5a. A shrub to small trees, erect to slender…….6

5b. Sub-shrub, creeper with purplish stem……..*Mimosa pudica*

6a. A shrub to small trees, hairy and prickly branched stem……...……..*Mimosa pigra*

6b. Mostly shrub with four angled, hooked prickled……....*Mimosa invisa*

SUBFAMILY 3. PAPILIONOIDEAE

Leaves once compound with 3–many, odd- or even-pinnate; stipules various; sepals united; petals 5 and very unequal: uppermost petal (= standard) usually largest, two lateral (= wings) smaller and separate, two lowest (= keel) smaller and united except at base; stamens 5–10; filaments separate or united

KEY TO SPECIES OF PAPILIONOIDEAE

1a. Leaves bifoliate……...……..*Zornia diphylla*

1b. Leaves with three or more leaflets……..…….2

2a. Creeper, twinning herb; flower purplish white……..*Calopogonium mucunoides*

2b. A herb to subshrub; flower colour others……...……..3

3a. Inflorescence terminal long raceme, flower yellowish golden……...……*Crotalaria pallida*

3b. Inflorescence mostly axillary raceme; flower colour others…….4

4a. Trailer herb; flower white with purple watermark……..…*Clitoria ternatea*

4b. Mostly sub-shrub to shrub; flower colours others……..…….…….5

5a. Sub-shrub; leaves imparipinnate……..……..*Uraria crinita*

5b. Mostly shrub, leaves trifoliate……..…….……...6

6a. Shrub with purple flower……..……...*Desmodium heterocarpon*

6b. Mostly herb with yellowish flower……..……7

7a. Leaves tetrafoliate; flower yellow……..……*Arachis glabrata*

7b. Leaves compound with purplish flower……...……8

8a. Stem semi-document to erect; flower purplish white…..*Clitoria laurifolia*

8b. Stem twinning; flower colour others……..…….9

9a. Stem covered with fine short hair; flower light purple……...…….*Centrosema pubescens*

9b. Stem bristly hairy with fine short hair; flower colour others……10

10a. Mostly creeper to herb; flower reddish purple to purple……..……*Desmodium triflorum*

10b. Mostly shrub with yellowish flower……..……11

11a. A shrub; stem covered with densely long hair……..*Clotalaria mysorensis*

11b. A herb or sub-shrub; stem glabrous……..…….12

12a. Stem glabrous to densely pilose; flower yellow to orange……...……...*Stylosanthes guianensis*

12b. Stem pubescent; flower others……...……13

13a. Fruit cylindrical pods with jointed at the tip…..……..*Alysicarpus vaginalis*

13b. Fruit short pods without jointed at the tip……..……14

14a. Young stem covered in soft short hair, matured stem hairless; fruit short pod with wavy edges……..……*Desmodium heterophyllum*

14b. Stem mostly covered with soft short hair; fruit long pod without wavy edges……...……...15

15a. Sub-shrub with red flower……...……species d

15b. A herb or shrub; flower mostly whitish……..……...16

16a. A herb; stem slender, branched; flower whitish yellow……..……...*Aeschynomene indica*

16b. A shrub; stem much branched, base quite woody; flower white……..……...*Desmodium* sp.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Based on the study conducted at UMK Jeli Campus, the data analysed shows the Shannon Diversity Index and Shannon Evenness Index of Fabaceae calculated are H' = 1.44 and E' = 0.89. The H' value shows that the diversity of Fabaceae are not too high for tropical research. In term of E', Fabaceae indicates as maximum evenness due to the E' value near to one. The highest H' and E' recorded for species are *Desmodium triflorum* are the most diverse species with H' = 0.37 and have the high evenness value with E' = 0.23. The Species Richness Index of Fabaceae calculated are D_{mg} = 0.67. *Desmodium heterophyllum* has the highest D_{mg} = 1.18. The less diverse of Fabaceae may due to competitors with other family such as Asteraceae and Cucurbitaceae. Furthermore, due the development of building and other landscape in UMK Jeli Campus area, it affect the diversity of Fabaceae species. The total five species recorded in plot sampling shows *Desmodium triflorum* are the most diverse. This may due to the ability of *Desmodium triflorum* to compete for space with other species and able to grow in unfavourable condition.

The total 27 species from 19 genera of Fabaceae were recorded within the study area. The checklist and key identification of the total 27 species Fabaceae around UMK Jeli Campus are successfully constructed. The key identification of Fabaceae was

constructed according to three subfamilies which are Caesalpinioideae, Mimosoideae and Papilionoideae. The key identification of Fabaceae are able to be used by people who interested in botanical field as references and upcoming research for further study.

5.2 Recommendation

There are several recommendations that should be consider for further study such as increasing the study area in UMK Jeli Campus such as include the area at new Agropark and Agropark forest to add more data of species diversity and richness at UMK Jeli Campus. Increasing the area may have possibilities to have new species that can be added into the checklist. Furthermore, this study only 25 quadrat thrown due to limited time of the study. For further study, the number of quadrat thrown should be added. By adding the number of quadrat thrown can increase the data on diversity index and richness index. On the other hand, there is a lack of reading resources due to lack of books and journals about Fabaceae and botany to be used as reference sources. UMK Jeli Campus library should purchase more books and online journals regarding botany and Fabaceae to make it easier for students who want to do future research. There are a lot of research on Fabaceae with other families but only a few journal or research paper that study on Fabaceae subfamilies make it hard to make comparison especially to compare Species Richness Index. There should be more study on Fabaceae subfamily about diversity index and richness index. Thus, make it easier to compare in future study.

REFERENCES

Addison, H. J. (2003). *Shade tolerance of tropical forage legumes for use in agroforestry systems.* Australia: University of Tasmania.

Angessa, T. T. (2006). *Towards Improved Vegetable Use and Conservation of Cowpea and Lablab: Agronomic and Participatory Evaluation in Northeastern Tanzania and Genetic Diversity Study*. German: Cuvillier Verlag.

Antony, J. R. & Lal, S. B. (2013). *Forestry Principles and Applications*. India: Scientific Publisher (Ind).

Bainbridge, D. A. (2012). *A Guide for Desert and Dryland Restoration: New Hope for Arid Lands*. United States of America: Island Press.

Baligar, V. C. & Fageria, N. K. (2007). Agronomy and Physiology of Tropical Cover Crops. *Journal of Plant Nutrition, 30*(8), 1287-1339.

Bebarta, K. C. (2002). *Planning for forest resources and biodiversity management: Principles, organization and methodology*. New Delhi: Concept Publishing Company.

Bidlack, J. & Jansky, S. (2010). *Stern's Introductory Plant Biology*. New Delhi: McGraw-Hill Education.

Bridson, D. & Forman, L. (2013). *The Herbarium Handbook*. United State of America: Royal Botanic Gardens, Kew.

Cappers, R. T. & Bekker, R. M. (2013). *A Manual for the Identification of Plant Seeds and Fruits*. Groningen: University of Groningen.

Clark, A. (2008). *Managing Cover Crops Profitably (3rd Ed.)*. United States of America: DIANE Publishing Company.

Clarke, I. & Lee, H. (2003). *Name that flower: The Identification of Flowering Plants*. Carlton, Vic: Melbourne University Press.

Cohn, T. J. (1994). *A Plea for Tabulated Deskription, Keys and Illustration. Journal of Orthoptera Research*, (3), 55.

Condit, R., Pérez, R. & Daguerre, N. (2011). *Trees of Panama and Costa Rica*. Princeton, NJ: Princeton University Press.

Considine, D. M. (2012). *Foods and Food Production Encyclopedia*. New York: Springer Science & Business Media

Dash, M. C. (2001). *Fundamentals of Ecology*. India: Tata McGraw-Hill Publishing Company Limited.

DeLong, D. (1996). Defining Biodiversity. *Wildlife Society Bulletin (1973-2006), 24*(4), 738-749.

Doyle, J. (2001). Leguminosae. *Encyclopedia of Genetics*, 1081-1085.

Eggli, U. & Hartmann, H. E. K. (2002). *Illustrated Handbook of Succulent Plants: Dicotyledons*. Berlin Heidelberg: Springer Science & Business Media.

Emerich, D. W. & Krishnan, H. B. (2009). *Nitrogen Fixation in Crop Production*. United States of America: American Society of Agronomy.

Faridah Hanum & Van, D. (2007). *PROSEA: Plant Resources of South-East Asia 11, Auxiliary Plants*. Bogor: Yayasan Obor Indonesia.

Fred, B. S. & Fritz, L. K. (2013). *Ecosystem Management: Selected Readings*. New York: Springer Science & Business Media.

Gao, T., Yao, H., Song, J., Liu, C., Zhu, Y., Ma, X. & Chen, S. (2010). Identification of medicinal plants in the family Fabaceae using a potential DNA barcode ITS2. *Journal of Ethnopharmacology, 130*(1), 116-121.

Geesink, R., Leeuwenberg, A. J. M., Ridsdale, C. E. & Veldkamp, J. F. (2013). *Thonner's analytical key to the families of flowering plants*. London: Springer Science & Business Media.

Gepts, P., Beavis, W. D., Brummer, E. C., Shoemaker, R. C., Stalker, H. T., Weeden, N. F. & Young, N. D. (2005). Legumes as a Model Plant Family. Genomics for Food and Feed Report of the Cross-Legume Advances through Genomics Conference. *Plant Physiology*, *137*(4), 1228-1235.

Goh, K. J. & Chiu, S. B. (2007). *Mucuna bracteata: A Cover Crop and Living Green Manure*. Petaling Jaya: Agricultural Crop Trust (ACT).

Google Earth (2018). Aerial View of UMK Jeli Campus from https://www.google.com/maps/place/Pejabat+UMK/

Graham, P. H. & Vance, C. P. (2003). Legumes: Importance and Constraints to Greater Use. *Plant Physiology, 131*(3), 872-877.

Gregoire, T. & Valentine, H. (2007). *Sampling Strategies for Natural Resources and the Environment*. Hoboken: CRC Press.

Heywood, V. H., Brummitt, R. K., Culham, A. & Seberg, O. (2007). *Flowering plant families of the world*. Buffalo, NY: Firefly Books.

Hong, N. H., Xuan, T. D., Tsuzuki, E., Terao, H., Matsuo, M., & Khanh, T. D. (2004). Weed Control of Four Higher Plant Species in Paddy Rice Fields in Southeast Asia. *Journal of Agronomy and Crop Science*, 190(1), 59–64.

Hsuan, K. (2003). *Orders and families of Malayan seed plants*. Singapore: Singapore University Press.

Ifo, S., Moutsambote, J., Koubouana, F., Yoka, J., Ndzai, S., Bouetou-Kadilamio, L., Mampouya, H., Jourdain, C., Bocko, Y., Mantota, A., Mbemba, M., Mouanga-Sokath, D., Odende, R., Mondzali, L., Wenina, Y., Ouissika, B. and Joel, L. (2018). *Tree Species Diversity, Richness, and Similarity in Intact and Degraded Forest in the Tropical Rainforest of the Congo Basin: Case of the Forest of Likouala in the Republic of Congo*. International Journal of Forestry Research, 2016, 1–12.

Jeelani, M. (2016). *Lake Ecology in Kashmir, India: Impact of Environmental Features on the Biodiversity of Urban Lake*. New Delhi: Springer International Publishing.

Judd, W. S., Campbell, C. S., Kellogg, E. A., Stevens, P. F. & Donoghue, M. J. (2008). *Plant systematics: A phylogenetic approach*. Sunderland: Sinauer Associates.

Khare, C. P. (2008). *Indian medicinal plants*. New York: Springer Science & Business Media.

Koblin, S. (2008). *Food for life: Applying macrobiotic principles and practices to create vital health for body, mind and spirit*. Bloomington: Author House.

Krahmer, H. (2016). *Atlas of weed mapping*. United Kingdom: John Wiley & Sons Ltd.

Krishna, K. (2013). *Agroecosystems: Soils, Climate, Crops, Nutrient Dynamics and Productivity*. Toronto: CRC Press.

Lewis, G., Schrire, B., Mackinder, B. & Lock, M. (2005). *Legumes of the world. Richmond*. United Kingdom: Royal Botanic Gardens, Kew.

Lim, T. K. (2012). *Edible Medicinal and Non-Medicinal Plants*. New York: Springer Science & Business Media.

Malik, S. (2017). *Biotechnology and Production of Anti-Cancer Compounds*. Cham: Springer International Publishing.

Margalef, R. (1958). *Temporal Succession and Spatial Heterogeneity in Phytoplankton*. Berkeley: University of California Press.

Morhardt, S. & Morhardt, J. E. (2004). *California desert flowers: An introduction to families, genera, and species*. Berkeley, CA: University of California Press.

Muhammad Aqeel Ashraf, Radziah Othman & Che Fauziah Ishak (2017). *Soils of Malaysia*. Boca Raton, FL: CRC Press.

Ong, H. (2008). *Vegetables for health and healing*. Kuala Lumpur: Utusan Publications & Distributors Sdn. Bhd.

Pawlowski, K. (2009). *Prokaryotic Symbionts in Plants*. Berlin: Springer Science & Business Media.

Praciak, A. (2013). *The CABI Encyclopedia of Forest Trees.* United Kingdom: CABI.

Pratap, A. & Kumar, J. (2011). *Biology and Breeding of Food Legumes*. India: CABI.

Rahman, A. H. M. M. & Parvin, M. I. A. (2014). Study of Medicinal Uses on Fabaceae Family at Rajshahi, Bangladesh. *Research in Plant Sciences, 2*(1), 6-8.

Rao, V. (2000). *Principles of weed science*. United States of America: Science Publishers.

Raul A. S. (1993). *Response of a Topical Legume-Grass Association to Systems of Grazing Management and Levels of Phosphorus Fertilization*. Florida: INIAP Archivo Historico.

Ross I. A. (2003). *Medicinal Plants of the World: Volume 1: Chemical Constituents, Traditional and Modern Medicinal*. New York: Springer Science & Business Media.

Schmelzer, G. (2008). *Medicinal plants*. Netherlands: PROTA Foundation.

Shafique, A., Rehman, S., Khan, A. & Kazi, A. G. (2014). Chapter 1 - Improvement of Legume Crop Production under Environmental Stresses through Biotechnological Intervention *Emerging Technologies and Management of Crop Stress Tolerance*. San Diego: Academic Press.

Sheaffer, C. C. & Moncada, K. M. (2012). *Introduction to Agronomy: Food, Crops, and Environment*. New York: Cengage Learning.

Slingsby, D. & Cook, C. (1986). *Practical Ecology*. London: Macmillan Education Ltd.

Simpson, M. G. (2010). *Plant systematics*. Burlington, MA: Academic Press.

Smith, B., & Wilson, J. B. (1996). A Consumer Guide to Evenness Indices. Oikos, 76(1), 70.

Spellerberg, I. F. (2008). Shannon–Wiener Index. *Encyclopedia of Ecology,* 3249-3252.

Spellerberg, I. F. & Fedor, P. J. (2003). A tribute to Claude Shannon (1916-2001) and a plea for more rigorous use of species richness, species diversity and the 'Shannon-Wiener' Index. *Global Ecology and Biogeography, 12*(3), 177-179.

Tomlinson, P. (2016). Family: Fabaceae (Leguminosae).In The Botany of Mangroves (pp. 251-261). Cambridge: Cambridge University Press.

Wanda, G., Gamo, F. & Njamen, D. (2015). *Medicinal Plants of the Family of Fabaceae used to Treat Various Ailments in Fabaceae: Classification, Nutrient Composition and Health Benefits.*

Wan Suriyani Wan-Ibrahim, Tuan Nadrah Naim Tuan Ismail, Siti Farhanah Mohd-Salleh & Norzila Ismail (2017). GC-MS Analysis of Phytochemical Compounds in Aqueous Leaf Extract of Abrus Precatorius Universiti Putra Malaysia Press *Pertanika J. Trop. Agric. Sci. 41 (1): 241 - 250 (2018).*

Whitmore, T. C. (1972). *Tree flora of Malaya*. Kuala Lumpur: Longman Malaysia.

Wickens, G. E., Goodin, J. R. & Field, D. V. (2012*). Plants for arid lands: Proceedings of the Kew International Conference on Economic Plants for Arid Lands held in the Jodrell Laboratory, Royal Botanic Gardens, Kew, England, 23-27 July, 1984.* London: Springer Science & Business Media.

APPENDIX A

FYP I and FYP II Planning

FYP I	
25th March 2018 – 9th April 2018	Completion of chapter 123.
10th April 2018	Research proposal submission.
24th April 2018 – 25th April 2018	Research proposal presentation.
5th July 2018	FYP I report submission.

FYP II	
17th July 2018 – 5th August 2018	Dilution of ethanol 100% into 70% concentration for preserving sample.
	Plot sampling method by throwing quadrat 1m × 1m randomly within selected area.
	General observation method by walking in the study area.
	Herbarium process (drying and mounting).
1st October 2018 – 9th December 2018	Final report writing.
10th December 2018	Final report submission.
18th December 2018 – 9th December 2018	FYP II presentation.
10th January 2019 – 17th January 2019	Final report completion and hardbound submission.

APPENDIX B

Data of 25 Quadrat Thrown in UMK Jeli Campus

Scientific Name	Quadrat																									Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
Alysicarpus vaginalis																			10	13	11	13				47
Calopogonium mucunoides				14	11	12			11	4	3	5	7	3	6	12		12								100
Desmodium heterophyllum							8	5									12		5							30
Desmodium triflorum							26	43									39		13	21	9	7				158
Mimosa pudica	7	1	6		2	2	3	2	3	3	2	1	2	3	1	1	2	5	1				1	2	1	51
TOTAL																										**386**

APPENDIX C

Several Species Collected in UMK Jeli Campus Study Areas

Scientific name: *Cassia alata* Linn.

Subfamily: Caesalpinioideae

Description: Bark thin and upright, leaves pinnate, flower golden yellow.

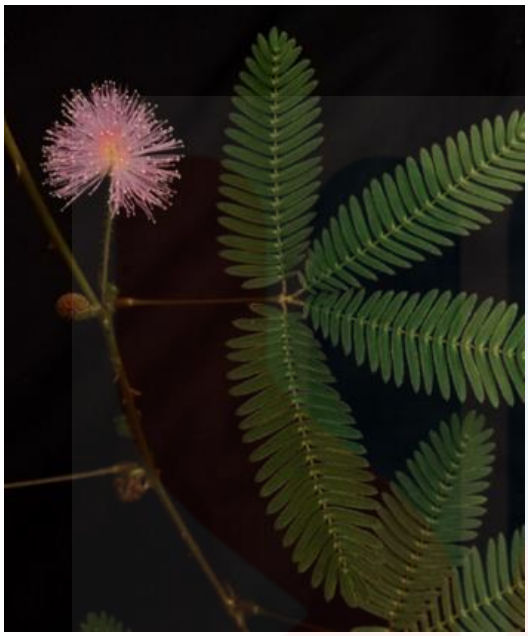
Native: Tropical America (Northern); introduced in Malaysia.

Scientific name: *Mimosa invisa* Martius ex Colla

Subfamily: Mimosoideae

Description: Stem four-angle, hooked prickled; leaves bipinnate, bright green; flower: bright pink to pale pink, ball shaped.

Native: Central America to Brazil, invasive weed in Malaysia.



Scientific name: *Mimosa pudica* L.

Subfamily: Mimosoideae

Description: Stem prickly, purplish; leaves bipinnate, spiral, green; flower ball shaped, pink and light purple.

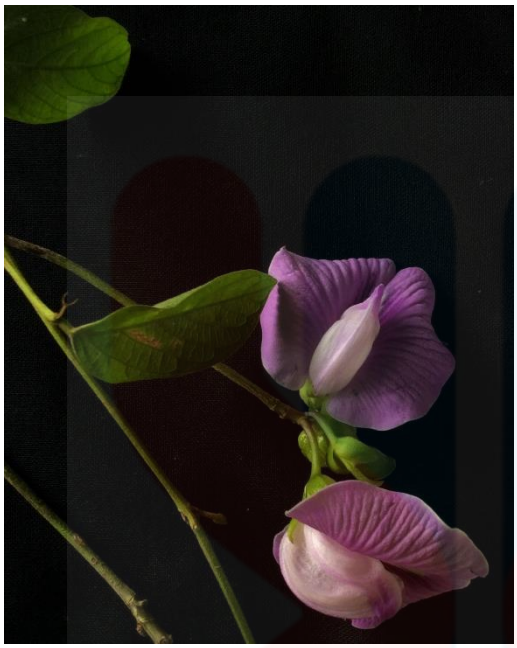
Native: South America.

Scientific name: *Crotalaria pallida* Aiton.

Subfamily: Papilionoideae

Description: Covered with hair pressed against stem surface; leaves trifoliate; flower yellow, terminal long raceme.

Native: Tropical Asia and Africa.



Scientific name: *Centrosema pubescens* Benth.

Subfamily: Papilionoideae

Description: Climbing, stem covered with fine short hair; leaves trifoliate; flower light purple.

Native: South America.

Scientific name: *Clitoria ternatea* Linn.

Subfamily: Papilionoideae

Description: Climbing, stem covered with fine short hair; leaves trifoliate, dark green; flower white with purple mark.

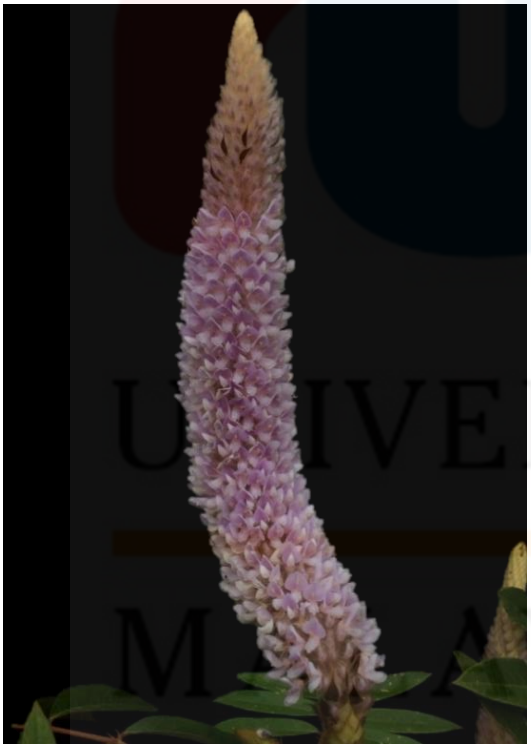
Native: Tropical equatorial Asia (Indonesia and Malaysia), introduced in Africa, Australia and America.

Scientific name: *Clitoria laurifolia* Poir.

Subfamily: Papilionoideae

Description: Stem semi-decumbent or erect; leaves spiral; flower purplish white with purple mark.

Native: Central and Tropical South America.



Scientific name: *Uraria crinita* L.

Subfamily: Papilionoideae

Description: Stem covered with soft short grey hair; leaves imparipinnate; flower light purple to purple.

Native: Himalayas, Bangladesh, Cambodia, China India, Indonesia, Java, Laos, Malaysia, Myanmar, Philippines, Ryukyu Islands, Singapore, Sri Lanka, Sumatra, Taiwan, Thailand and Vietnam.