DIVERSITY AND COMPOSITION OF WILDFLOWERS AROUND UNIVERSITI MALAYSIA KELANTAN, JELI CAMPUS, KELANTAN

by

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

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DECLARATION

I declare that this thesis entitled “Diversity and Composition of Wildflowers around Universiti Malaysia Kelantan, 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 candidature of any other degree.

Signature :……..

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APPROVAL

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

Signature :……..

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Diversity and Composition of Wildflowers around Universiti Malaysia Kelantan, Jeli Campus, Kelantan

ABSTRACT

The diversity of Angiosperms in Malaysia is widely studied but currently, there are no published data regarding the abundance of wildflowers in Kelantan. Thus, a study on the diversity and composition of wildflowers was conducted around Universiti Malaysia Kelantan, Jeli Campus, Kelantan (UMKKJ). The main objective is to determine the diversity and composition of wildflowers by using the random quadrat sampling method and supported by general observation method as additional data. A total of 31 families, 88 genera and 103 species of wildflowers found in UMKKJ with Asteraceae and Fabaceae were the families with a large contribution. Species discovered by using general observation method were 73 species comprised of 27 families and 65 genera. Next, there were 30 species wildflowers belonging to 13 families and 28 genera found inside the quadrat. The sufficient data were obtained within $60m^2$ by quadrat sampling in UMKKJ generated from the species-area curve. Shannon Diversity Index recorded the value 2.554 with Richness and Evenness Index were 3.841 and 0.751 respectively. Based on the overall results, wildflowers in UMKKJ was moderately diverse and evenly distributed.

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ABSTRAK

Kepelbagaian Angiosperma di Malaysia telah dikaji dengan luas tetapi pada masa kini, tiada data yang diterbitkan mengenai kelimpahan bunga liar di Kelantan. Oleh itu, kajian mengenai kepelbagaian dan komposisi bunga liar telah dijalankan di sekitar Universiti Malaysia Kelantan, Kampus Jeli, Kelantan (UMKKJ). Objektif utama kajian ini adalah untuk menentukan kepelbagaian dan komposisi bunga liar dengan menggunakan kaedah persampelan kuadrat secara rawak dan disokong oleh kaedah pemerhatian umum sebagai data tambahan. Sebanyak 31 famili, 88 genera dan 103 spesies bunga liar telah dijumpai di UMKKJ dengan Asteraceae dan Fabaceae adalah famili penyumbang terbesar. Spesies yang ditemui dengan menggunakan kaedah pemerhatian umum ialah 73 spesies yang terdiri daripada 27 famili dan 65 genera. Seterusnya, terdapat 30 spesies bunga liar yang terdiri daripada 13 famili dan 28 genera yang dijumpai di dalam kuadrat. Data yang mencukupi diperoleh dalam lingkungan $60m^2$ oleh persampelan kuadrat di dalam UMKKJ yang dihasilkan dari keluk kawasan-spesies. Indeks Kepelbagaian Shannon merekodkan nilai 2.554 dengan Indeks Kekayaan dan Indeks Kesamarataan masing-masing sebanyak 3.841 dan 0.751. Berdasarkan hasil keseluruhan, bunga liar di UMKKJ mempunyai kepelbagaian pada kadar sederhana dengan taburan yang sama rata.

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LIST OF ABBREVIATIONS

UMK	Universiti Malaysia Kelantan
UMKKJ	Universiti Malaysia Kelantan, Jeli Campus
GPS	Global Positioning System
ITIS	Integrated Taxonomic Information System
IUCN	International Union for Conservation of Nature
EX	Extinct
EW	Extinct in the Wild
CE	Critically Endangered
EN	Endangered
V	Vulnerable
NT	Near Threatened
LC	Least Concern
DD	Data Deficient
NE	Not Evaluated

LIST OF SYMBOLS

cm	Centimeters
ºC	Degree Celsius (Temperature)
E	Evenness Index
IV*i*	Importance Value Index
>	Greater than
km	Kilometers
D_{mg}	Margalef Richness Index
m^2	Meter square
ln	Natural logarithm
%	Percentage
P*i*	Relative abundance of each individual species to the total species
R*d*	Relative density
R*f*	Relative frequency
H’	Shannon Diversity Index
d	Species density
f	Species frequency
Σ	Summation of species
H_{max}	The maximum value of Shannon Diversity Index
N	Total number of individuals in the sample
S	Total number of species in community

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

There are several ecological studies were conducted by highlighting the tropical forests as the main subject purposely to have a better understanding of the role played by forest in term of floristic biodiversity, sustainable development and climate change. The tropical forest provides many goods and ecosystem services such as species conservation, prevention of soil erosion, and preservation of habitat for plants and animals (Li et al., 2003; Wang, 2003; Armenteras et al., 2009). According to National Biodiversity Index (Choi & Jung, 2015) Malaysia is ranked on 12th megadiversity countries in the world. The tropical rainforest constitutes the core of biodiversity in Malaysia while flora in Peninsular Malaysia are better served compared to the other tropical countries (Kiew, Chung, Saw & Rafidah, 2007).

According to the Whittaker (1969), the multicellular and autotrophic eukaryotes that existed on the Earth which conducted photosynthesis are classified under kingdom Plantae. The plants were classified into four phyla based on the three criteria. Phyla Bryophyta, Pteridophyta, Gymnosperms, and Angiosperms are designated based on the plant body (structure and development), vascular system and seed formation. The plant body is classified whether has well-differentiated structures or not. Next, the presence of a vascular system in the plants for the

transportation of substances such as water and minerals. Third criteria are the formation of seed, whether the plant could bear for flowers and seeds or not.

The most diverse phylum is the Angiosperms or more known as a flowering plant. Angiosperms are defined as the vascular seed plants which are the ovule (egg) are fertilized and develops into a seed in an enclosed hollow ovary in a flower. Generally, there is the male or female reproductive part and sometimes have both. Secondary tissues in woody are rich but rarely have any in a herbaceous form. Basically, flowering plants have three types of a growing cycle which are annuals, biennials, and perennials. Annuals plant is the plants that complete a life cycle within one season while the plant that completes the life cycle in two years called as biennials. The third type of growing cycle is perennials which plant lives more than two years and usually over many years.

In addition, Angiosperms are categorized into two classes which are monocotyledons and dicotyledons depending on the number of cotyledons present in the seeds. Next, the difference between the root, leaf veins, stems and the flower as shown in Figure 1.1. The single-leaf seed group is classified under monocots and two seed-leaf group is under dicots class. The structure of the pollen in monocots is single and the dicots have three furrows. The stem vascular bundle in monocots are scattered but in dicots, the stem vascular bundles in the ring. Taproot exists in monocots while dicots' root develops from radicle as fibrous root. However, dicots presence of secondary growth and not for monocots.

In other perspectives, wildflowers are expertly defined by Lindgren & Schaaf (2005) as flowering herbaceous plants that grow with little assistance and best suited for low maintenance areas, wetlands and in sites requiring drought-

tolerant plants. Thus, the concept of wildflowers can be simply explained as the flowering plants that grow naturally without any cultivation from the humans instead intentionally planted. Wildflowers have a variety of seasonal characteristics (color, texture, height) and can grow on a variety of substrates with low nutrient soil compared with cultivated crops. The flower is the important part in the reproduction of flowering plants. Thus, each part of the flowers is shown in Figure 1.2 with their function in Table 1.1.

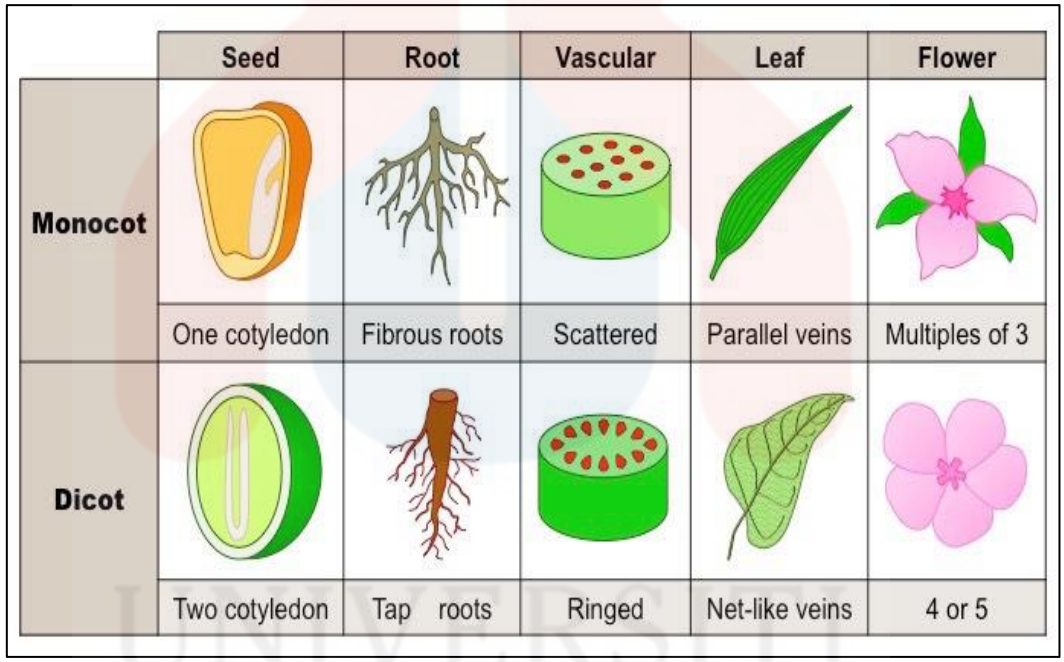


Figure 1.1 The comparisons between monocots and dicots (Source: Cornell, 2016)

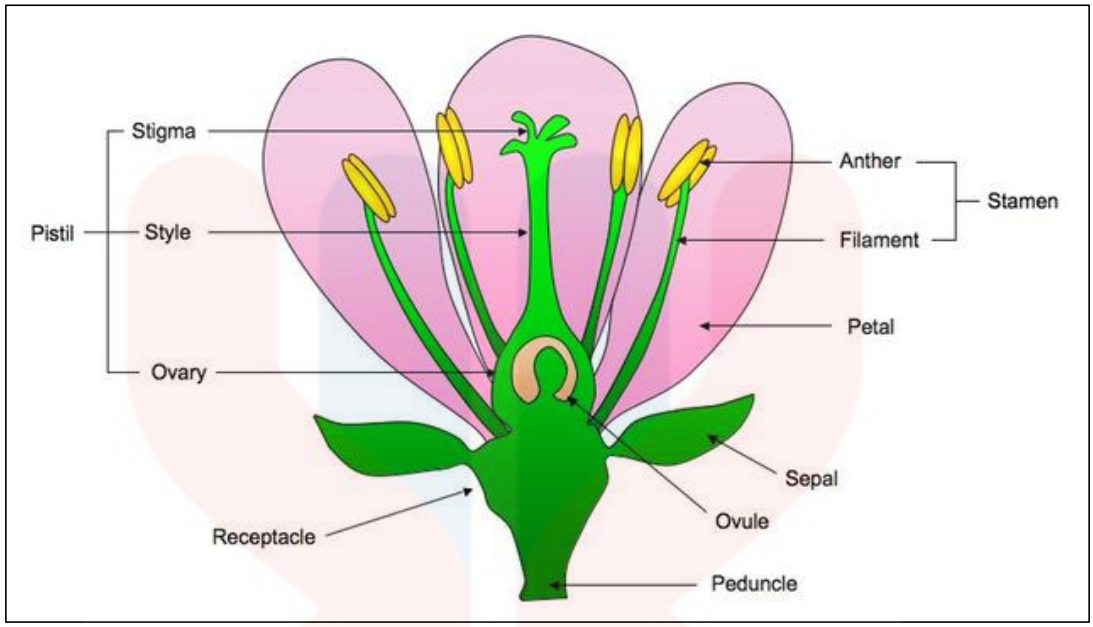


Figure 1.2 The part of the flower (Source: Mattew, 2015)

Table 1.1 The function each part of the flower

Part	Function
Anther	Produces pollen, which contains the sperm cells
Filament	Supports the anther
Ovary	Contains the ovule(s) which develop into seeds when fertilized
Ovule	Contains the egg cells, which will be fertilized by sperm from pollen, and which will become seeds
Peduncle	Act as stalk to supports an inflorescence
Petal	The parts of a flower that is often brightly colored to attract the insects
Pistil	The female reproductive part
Receptacle	The flower stalk where the parts of the flower are attached
Sepal	Protects the developing flower while in the bud
Stamen	The male reproductive part
Stigma	The sticky part of the pistil where pollen lands

(Source: Patrice, 2017)

1.2 Problem Statement

Globally, there are 52% of the total forests are in tropical regions and they are known to be the most important areas in terms of biodiversity (Djuikuou et al., 2010). The diversity of flora around the world is widely studied but less specifically to the wildflowers compared to the trees' study. However, the flora in Peninsular Malaysia is well discovered as there are several publications such as Flora of Malaysia Illustrated (Jones & German, 1993) and Flora of the Malay Peninsula by Ridley in five volumes which each volume is published per year since 1922. For example, Flora of the Malay Peninsula volume I was published in 1922, volume II (1923) and ended to the volume V (1925).

Nonetheless, the discovery of wildflowers in Malaysia is still low compared to other countries. The publication of wildflowers such as Wild Flowers by Henderson (1954), Begonias of Peninsular Malaysia (Kiew et al., 2005) and Discovering the Wonders of Malaysia Orchid by Go and Raffi (2017) shows that many new species are being discovered and from the trends can be predicted presumably there will be more increases of flora within the years that will contribute to Malaysia's biodiversity.

Hence, this study is conducted as there is no published data about the wildflowers diversity and their composition in a specific location, especially in Kelantan. Similar to Universiti Malaysia Kelantan, Jeli Campus (UMKKJ) there is no record of their abundance. In addition, most of the people do not realize or have any idea that the existence of wildflowers also has a significance similar to other flora.

1.3 Objectives

The study is carried out to achieve these objectives:

1. To determine the diversity and composition of wildflowers around Universiti Malaysia Kelantan, Jeli Campus, Kelantan.
2. To prepare the checklist of wildflowers that found in Universiti Malaysia Kelantan, Jeli Campus, Kelantan.

1.4 Scope of Study

The plants under phylum Angiosperms is the largest and common type of flora in Malaysia and comprising thousands of wildflowers. Thus, this study only focus on wild herbaceous Angiosperms in Jeli Campus of Universiti Malaysia Kelantan and the scope is only on wildflowers with range 5-100cm tall which are mainly the herbs and shrubs. This study focuses on wild terrestrial wildflowers and exclude from the Poaceae and Cyperaceae families and also the landscape flowers that have been cultivated by humans.

1.5 Significance of Study

Global biodiversity is declining rapidly due to habitat destruction, over-exploitation, pollution and species introduction caused by humans in the name of development and modernization (Pragasan & Parthasarathy, 2010). As a result, most of the natural forest occur in fragments and in degraded forms causing a lot of spatial and temporal variation in species richness, composition, and productivity at local and regional levels (Anbarashan & Parthasarathy, 2013). Human disturbances often lead to altered environmental conditions, which influence the process that can both augment and erode species diversity in a forest community (Sapkota et al., 2010). Similar to UMKKJ, the area is still on the developing progress. A developing campus is likely to be built with a few of building that will give impact on the natural environment.

Thus, this study is very important as wildflowers gives a lot of contributions towards an ecosystem in term of pollination, food source and climate regulation. It is also contributed to socioeconomic as wildflowers existence can also influence human well being. Generally, the study of flora around the world widely focuses on the forest and trees until most of the people do not realize the abundance of the wildflowers on the Earth. Therefore, the finding of the study is to figure up the diversity of wildflowers so that we know the condition of the study area and the wildflowers' abundance with the next conservation action if needed. This study is conducted around Universiti Malaysia Kelantan and hopefully could give a clear picture for the students and lecturers to understand the value of the wildflowers and appreciate it. Hence, the herbarium and the checklist provided could be the reference for the next study that has interconnected toward this study.

CHAPTER 2

LITERATURE REVIEW

2.1 The Diversity of Angiosperms in Malaysia

There are about 250,000 to 300,000 species of plants in the world and Malaysia has about 15,000 species (Latiff, 1994). The earliest botanical studies in Malaysia that have been listed by Ridley (1922-1926) shows that there are over 6,743 Angiosperms from Peninsular Malaysia which are 5,009 species from dicots consisted of 132 families and 1,734 species from monocots consisted of 31 families. Then, Henderson (1954) has conservatively estimated that there are 8,000-9,000 species of flowering plants in Malaysia. Next, a publication A Catalogue of the Vascular Plants of Malaya by Turner (1995) stated that the dicots diverse into 5,529 species with 165 families. Similar goes for monocots, there are 45 families found with 2,010 species.

For Borneo, Masamune (1945) enumerated about 7,167 species which are 4,997 species are from dicots and the rest are monocots from a total of 162 families. The similar trends show in Peninsular Malaysia, the families in dicots are more diverse compared to monocots. The flora in Borneo is more difficult to enumerate as the latest data from Soepadmo and Wong (1995) estimated the species is about 9,000 to 15,000 species without classifying its taxonomy.

Within the year, Kiew, Chung, Saw and Soepadmo (2010) have listed 5,718 species of dicots and 2,087 species of monocots in Peninsular Malaysia. Then, Saw and Chung (2015) stated that the flora is diverse over 8,300 species and supported with a comprehensive checklist from Kamarudin and Turner (2004) with additional data from Kiew (2010-2017).

2.2 The Largest Families of Angiosperms

Ten of the largest families of Angiosperms in the world and in Peninsular Malaysia are tabulated in Table 2.1 and Table 2.2 respectively. The largest families are classified based on the number of species and there are six families in Peninsular Malaysia that have been listed also in the list of largest families around the world.

The ranking for both diversity around the world and in Peninsular Malaysia shows that Orchidaceae is at the first rank with 17,000 species around the world. There are about 669 species evolved in Peninsular Malaysia. It is highly evolved and widely distributed monocotyledonous family with a large number of terrestrial, saprophytic and epiphytic species. According to Kong, Goh, Chia and Chia (2003), it comprises more than 30,000 species but Gutierrez (2010) estimated that there are 20,000 species with more than 850 genera.

Second largest Angiosperms family around the world is Compositae or more known as Asteraceae with 13,000 species while the second largest Angiosperms families in Peninsular Malaysia is Rubiaceae with 468 species but it recorded at the fifth rank in the world with 6,000 species. The third largest Angiosperms families in Peninsular Malaysia is Euphorbiaceae with 343 species, and it also recorded in the sixth rank of largest Angiosperms in the world with 5,000 species.

Table 2.1 Ten largest Angiosperms families around the world

No.	Families	No. of Genus	No. of Species
1.	Orchidaceae	735	17,000
2.	Asteraceae	900	13,000
3.	Fabaceae	600	12,000
4.	Gramineae	620	10,000
5.	Rubiaceae	500	6,000
6.	Euphorbiaceae	300	5,000
7.	Liliaceae	250	3,700
8.	Lamiaceae	180	3,500
9.	Cruciferae	375	3,200
10.	Melastomataceae	240	3,000

(Source: Global Information Hub on Integrated Medicine, 2013)

Table 2.2 Ten largest Angiosperms families in Peninsular Malaysia

No.	Families	No. of Genus	No. of Species
1.	Orchidaceae	104	699
2.	Rubiaceae	67	468
3.	Euphorbiaceae	71	343
4.	Fabaceae	66	266
5.	Gramineae	83	205
6.	Annonaceae	30	184
7.	Palmae	181	181
8.	Melastomataceae	25	174
9.	Lauraceae	16	174
10.	Acanthaceae	36	168

(Source: Global Information Hub on Integrated Medicine, 2013)

2.3 The Contribution of Wildflowers

2.3.1 The Contribution towards Ecosystem

Insect pollination is one of the crucial processes in the ecological to enhance the ecosystem production by transferring the pollen to a stigma, ovule, flower, or plant for the fertilization process. Mostly the flowering plants undergo dramatic ontogenetic color changes that serve as signals to their insect pollinators (Weiss & Lamont, 1997). Animal-mediated pollination provides a key ecosystem service to the maintenance of wildflowers as most angiosperms are pollen-limited and rely on animals for sexual reproduction (Potts et al., 2010; Albrecht, Schmid, Hautier, & Müller, 2012). The most diverse insect pollinator is the species of Hymenoptera, followed by Diptera, Lepidoptera and Coleoptera (Larson, Kevan & Inouye, 2001; Choi & Jung, 2015). This is because Hymenoptera mostly the bees spend most of their lives in collecting pollen (Aizen & Harder, 2009).

Wildflowers also contribute to the ecosystem as they provide food source towards insects, mollusks, herbivore animals and also the birds (Speiser, 2001). Next, rabbits, insects, birds or bug eat the plants and disperse or spread the seed naturally and the growth of wildflowers have continued the ecosystem cycle. Wildflowers also act as a habitat and being the important nectar sources, especially for butterflies (Aviron, Herzog, Klaus, Schüpbach & Jeanneret, 2011). Other than pollination, wildflowers also support ecosystems by helping in air and water quality control (Niu, Rodriguez & McKenney, 2012). Plants undergo the photosynthesis process and indirectly filtered the air from dust. Similar to the water, wildflowers filtered water as it passes by on the leaf and ensures that many of the pollutants are removed before reached the land and consumed by the primary consumers.

2.3.2 The Contribution towards Socioeconomic

According to Younis, Riaz, Saleem and Hameed (2009) colorful flowering plants not only contribute to the aesthetic quality of a street and appealing to the eyes, reduce the impacts of concrete along with greens but also have a positive influence on physiological well-being (Todorova, Asakawa & Aikoh, 2004). In addition, wildflowers can improve the quality of life and give greater insight into the nature of man and his interaction with the natural environment (Shoemaker, Jones & Cannon, 1991). The use of native or wildflowers especially for landscaping purpose requires less external input and support more biodiversity (Bormann, Balmori, Geballe & Vernegaard, 1993; Diekelmann & Schuster, 2002). In addition, the use of wildflowers in green spaces is very important as they contribute to the reduced cost of establishing and maintaining these areas (Emery, 1986).

2.4 Ethnobotany of Various Families of Angiosperms

Most of the wildflowers are used in the traditional system especially by the old folks. This method of medicine used as a remedy for a number of ailments as they contain with high of phytochemicals. The different phytochemical present in different parts such as in leaf, root, and seed with different quantity. Different species have different usage although they are in the same genus or family.

As Orchidaceae is the largest families diverse, there are a lot of species that high with benefits, especially to human. For example, infusion or decoction of the whole plant of *Calanthe discolor* and *Calanthe liukiuensis* are believed to treat the hair-related problems. A species from Fabaceae family, *Cassia alata* may help the people who are suffered from Dermatophytosis (ringworms), a fungal infection of the skin (Yoshikawa et al., 1998).

Next, *Elephantopus scaber* from Asteraceae family is used as a traditional medicine in many countries of Southeast Asia, Latin America, and Africa. The methanolic extracts from this species is reported to exhibit anti-tumor activity (De Silva, Herath, Jennings, Mahendrant & Wannigama, 1982). Each part of the species is traditionally used as the roots used to arrest vomiting by chewed, treat leucorrhoea and anemia in women and children by boil. The leaves are consumed to treat venereal disease, menstrual disorders in women, relief a cough within the certain method. De Silva et al. (1982) also agreed that decoction from the whole plant is used as a drink to treat hepatitis, bronchitis and to relieve pain in the chest.

Curcuma longa from Zingiberaceae family is mostly used in India and various parts of Southeast Asia both as a spice, and yellow coloring agent in cooking. The rhizome serves as a carminative and anti-spasmodic in diarrhea and as a folk remedy for other ailments such as disorders of the urinary tract, headaches and stiffness of the joints (Elliott & Brimacombe, 1987).

Different with *Costus speciosus* from Costaceae, the sap from the crushed stem is taken to treat diarrhea, earache and eye trouble, but the fresh rhizome is taken with betel to treat coughs and respiratory ailments like asthma (Katewa, Chaudhary & Jain, 2004). An infusion or a decoction of the leaves is used to treat fever and for the effective remedy, it also used in baths. Similar to a species from Solanaceae family, *Datura metel* is used as a remedy for asthma and respiratory tract, treat colds, nervous disorders and used to wash swollen feet. In addition, *D. metel* has also been reported to possess analgesic activity (Mohagheghzadeh, Faridi, Shams-Ardakani & Ghasemi, 2006).

Last but not least is the *Centella asiatica,* the creeping herb that very common in Malaysia from Apiaceae family. It is used to treat bronchitis, asthma, gastric, catarrh, dysentery, leucorrhoea, kidney trouble, urethritis and dropsy (Mitra, Orbell & Muralitharan, 2007). An infusion of the herb is consumed as a tonic as well as a cooling drink. It is also used in liver complaints and for treating the passing of blood in the urine. It is also used to treat dizziness and for internal administration for the treatment of hemorrhoids. The leaves themselves are used for poulticing sores, for the treatment of an inflammatory skin condition (Dattner, 2003) or applied over the whole body to treat fever, leprosy, and rheumatism. The hot juice from the roots is used to clean wounds and interestingly, the leaves can be eaten raw as a salad (Mitra et al., 2007).

2.5 Threat to Wildflowers around the World

There is a lot of threat that affected the abundance of wildflowers. But the factors obviously comes from anthropogenic activity. First and foremost, the factors come up from the tourism sector. There are a lot of places that centred on wildflowers around the world as shown in Table 2.3. Uncontrolled tourists that visited the protected area such as National Park have resulted in the bad effect when the careless tourist trample the wildflowers intentionally or unintentionally even though using the established trails during hiking or biking (Ballantyne, Gudes, & Pickering, 2014). Then the attitude and behaviors of tourists that freely plucking the flowers without any of sense of guilt also give an impact toward the abundance of wildflowers.

Table 2.3 The tourism that centered the wildflowers around the world

Species focus on the tourism	Example of location	Country
Alluaudia procera	Berenty Reserve	Madagascar
Banksia sp.	Stirling Range National Park	Western Australia
Dendrosenecio kilimanjari	Mount Kilamanjaro	Tanzania
Drosera spatulata var. *bakoensis*	Bako National Park	Sarawak, Malaysia
Leucodendron sp.	Fernkloof	South Africa
Nepenthes spp.	Mount Kinabalu	Sabah, Malaysia
Pachpodium namaaquanum	Garies, Namaqualand	South Africa
Stenocereus thurberi	Organ Pipe National Monument	United State America
Warszewiczella discolor	Bosque De Paz Biological Reserve	Costa Rica

(Source: Newsome, Moore, and Dowling, 2012)

In Great Smoky Mountain National Park that is located in the United State, the threat comes majorly from air pollution. A long-term research conducted in the park shows that ground-level ozone pollution is injuring at least 30 species of native plants (Anderson, 2005). In addition, the smog that is produced from the reaction of nitrogen oxides with sunlight and natural hydrocarbons (Chappelka, Neufeld, & McLaughlin, 2006) had worsened the situation and badly affect the *Rudbeckia hirta* or more known as black-eyed susan, tall milkweed, and coneflower. Moreover, the nitrogen oxides sources are from the vehicles and factories around the area.

In Western Australia, there are more than 40% of native plants are susceptible to the Phytophthora dieback infection and half of the infected are endangered species (Dell, Vear, & Carter, 2004). There are several species of *Phytophthora*, but *P. cinnamomi* is the most widespread and destructive. It was spread through the movement of soil and mud, especially by vehicles and footwear and also via root-to-root contact between plants (Kueh, 2012). The infection usually attacks the root system and cause the death to plants as they cannot take up the water

and nutrients they need. The plants that have been affected do not show any sign and often appear to be dying from drought. Until now, a research is still in the study to find the cure for this infection.

2.6 The Sampling Method

Sampling is a critical part of any ecological study. The basic premise of sampling is that a small portion of a population is studied in order to understand the whole population. Ecologists rely on samples because the lack the time, money, personnel or equipment to study the entire population. Thus, there are three basic sampling method that commonly used by the researchers which are stratified, systematic and random sampling (Southwood & Henderson, 2009). Stratified sampling is used to take into account different areas (or strata) which are identified within the main body of a habitat. These strata are sampled separately from the main part of the habitat. Second, the systematic sampling is when the samples are taken at fixed intervals, usually along a line by applying the line or belt transect method.

Third is the random sampling. This type of sampling is usually carried out when the study area is fairly uniform, very large, and there is limited time available. When using random sampling techniques, a large numbers of samples/records are taken from different positions within the habitat. According to Krebs (1989) simple random sampling is the easiest, most common sampling design with each possible sample unit must have an equal chance of being selected to obtain a random sample. Moreover, all the formulas of statistics are based on random sampling, and probability theory is the foundation of statistics. According to Bonham (1989) there are four monitoring protocol should be followed before using the quadrats. First of all is determine the distribution of plants inside the study area which is generally in

clumps or scattered pattern, select the appropriate quadrat size, choose the quadrat shapes either square, rectangle or circle and the last one is determination the sample size. The choice of dimensions and shape of the quadrat are depending on the type of study and can be established with various shape. According to the guideline by Launchbaugh (2009) 0.5-1m^2 quadrats would be suitable for short grassland and herb species. Southwood and Henderson (2009) also stated that this size is the most common in the ecological study for herb and small shrub. The taller flora and shrubby herbs habitats require 2m^2 quadrats, and the quadrats of 20m^2 or larger more suits for woodland habitats or forest.

CHAPTER 3

MATERIALS AND METHODS

3.1 Study Area

Universiti Malaysia Kelantan (UMK) is a public university in Kelantan, Malaysia and was established on 31 March 2006. UMK operates in three campuses and one of it is Jeli Campus. This study was conducted in Universiti Malaysia Kelantan, Jeli Campus (UMKKJ) at the longitude of 5.7445° N and latitude 101.8642° E as shown in Figure 3.1. It is located in the District of Jeli which are the border to Perak. UMKKJ can be reached from Gerik, Perak within 192 km. However, the location can be reached within 92 km from Kota Bharu, the capital of Kelantan and 117 km from Gua Musang.

The concept of Jeli Campus is "In Forest Park Campus" because it is located in the suburban area surrounded by hills and greenery. This study area is believed rich with the growth of wildflowers as Malaysia has a continually hot and wet climate (Henderson, 1954). Therefore, the diversity study is focused on the area inside the and excluded the Agropark area. The residential area in Kolej Kediaman IBS and Taman Pinggiran UMKKJ also discovered along the students and lecturers' house and excluded from the orchard and rubber plantation area.

Figure 3.1 The study area by satellite view (Source: Imagery© Google Malaysia, 2019)

3.2 Materials

The material that used was mainly the pipe that made up from Polyvinyl chloride or more known as the PVC Pipe. The $1m^2$ size of the quadrat formed using the pipe and tied by using the nylon string. The Global Positioning System (GPS) used purposely to determine the geographical location of the specific point in the study area. A camera was used for capturing the specimen's picture and the details recorded in the field notebook by using the pencil. For the herbarium preparation's materials, ethanol with 70% concentration was used for the plant preservation and stored in the zip locked plastic bag. Then, the pressing process required the newspapers and wooden pressers. For the drying process, the oven with a temperature 50°C was used. Last materials used was the 28 x 42cm herbarium sheets for the dried specimen mounting.

3.3 Methods

3.3.1 Sampling Method

The method used was the random quadrat sampling. The random sample is a method where every potential sample plot within the area sample has an exactly equal chance of being chosen for sampling. This technique requires the square quadrat with the size 1m × 1m as the wildflowers often grow in a scattered pattern. This technique is important to determine the specific wildflowers in the specific location at a certain time. The quadrat is randomly thrown (Figure 3.2) at a different area (Figure 3.3) with a different number of repetition in each area depending on the width of the areas. According to Sokal and Rohlf (1981), they wrote:

"a biased but sensitive scale might yield inaccurate but precise weight. By chance, an insensitive scale might result in an accurate reading, which would, however, be imprecise, since a repeated measurement would be unlikely to yield an equally accurate weight"

Figure 3.2 Random quadrat sampling technique

(Photo taken on 21st July 2018 at Taman Pinggiran UMK)

3.3.2 Observing Method

The second method used was the general observation where an observation was made to obtain the additional data. The general observation method covers the area in UMKKJ that cannot be reached by the quadrat. This method was conducted because the quadrat delimits the area in which wildflowers can be counted and also limitation from the plant's height. Observing method was conducted with aid of experts for the first time to make sure there were no plants were overlooked.

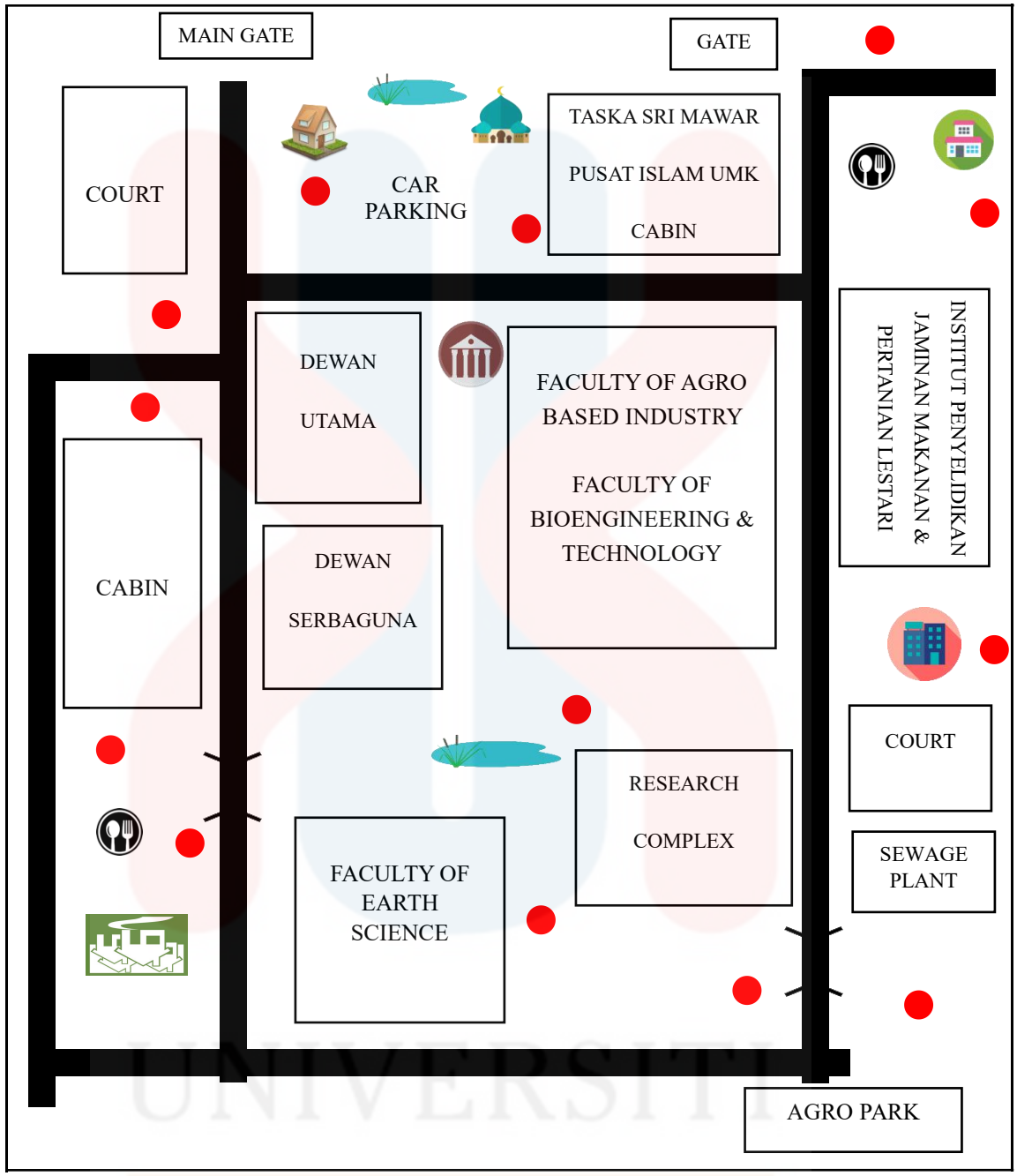


Figure 3.3 Non-scaled map of the quadrat spot in UMKKJ

3.4 Data collection

Based on the sampling method technique used, the full details of each plant species found such as local name and type of habitat were recorded along with the GPS coordinate. Then, the specimens were plucked and tagged with collector's number and the date of collection. The main characteristics such as colour, size, shape, smell of the flower, the presence of hairs and the height of the plant also noted in the field book as suggested by Sunil, Katari and Khan (2015). Each part that shows the identity of the plant were collected too instead of the specimen's photograph only in order to ease the species identification process. The specimen with new species found outside the quadrat also be collected when using general observation methods.

All the collected specimens were preserved with ethanol 70% concentration and prepared for the herbarium. The specimens were placed between the newspapers and tied with the wooden pressers and undergo the drying process in the oven with 50°C about three to five days depending on its thickness. Next, the dried specimens were mounted on the 28 x 42 cm herbarium sheet.

The identification process was carried out by applied and compared the existing taxonomic binomial from several taxonomic books such as Flora of Peninsular Malaysia Series II by Kiew (2010-2017), Common Wayside Plants of Jambi Province, Sumatra, Indonesia by Rembold, Tjitrosoedirdjo and Kreft (2017) and A Checklist of the Total Vascular Plant Flora of Singapore: Native, Naturalized and Cultivated Species by Chong, Tan and Corlett (2009). The process then continued by assessing the Integrated Taxonomic Information System (ITIS), a database that documented taxonomic information of flora and fauna from both aquatic and terrestrial habitats. The species scientific name were compared also with

Catalogue of Life, a checklist and index of the world's species. The conservation status of the species was checked by assessing the online database of the International Union for Conservation of Nature (IUCN) Red List. Lastly, the specimens also compared with existing specimens with the assistance of experts and the complete herbariums with taxonomic information was stored at Natural Resources Museum, UMKKJ for reference in the future.

3.5 Data Analysis

3.5.1 Diversity Index

Species diversity is an expression or index of some relation between a number of species and number of individual (Spellerberg, 1991). Shannon Diversity Index is the common index used in the ecological study (Spellerberg & Fedor, 2003) as shown in Equation (3.1).

$$H = -\sum_{i=1}^{S} (Pi) \ln (Pi) \qquad (3.1)$$

Where:

H'= Shannon Diversity Index

P_i = The number of individuals of a species over the total number of individual overall

S = Total number of species

ln = Natural logarithm

3.5.2 Evenness Index

Evenness index provides information on area composition and shown in Equation (3.2). This calculation shows the frequent (in number) does each species found in an area. The value of Shannon Evenness Index falls between 0 and 1.

$$E = \frac{H'}{\ln(S)} \tag{3.2}$$

Where:

E = Evenness

H'= Shannon's Diversity Index

S = Total number of species

ln = Natural logarithm

3.5.3 Richness Index

Species richness is one of the simplest parameters. Species richness is a count of the total number of species by quadrat/ area (Oba, Vetaas & Stenseth, 2001). In this study, species richness is calculated using Margalef's Index (Magurran, 1988) to calculate the different species that dominate the study area. The formula for richness is shown in the Equation (3.3).

$$Dmg = \frac{S-1}{\ln(N)} \tag{3.3}$$

Where:

S = total number of species

N = total number of individuals in the sample

ln = natural logarithm

3.5.4 Abundance Parameter

Two parameters that used to calculate the abundance were frequency (*f*) and density (d) as shown in Equation (3.4) – (3.5).

$$f = \frac{\text{Area of a species}}{\text{Total area sampled}} \tag{3.4}$$

$$d = \frac{\text{Number of a species}}{\text{Total area sampled}} \tag{3.5}$$

3.5.5 Importance Value Index (IV*i*)

The value of co-dominance species is calculated using IV*i* as shown in Equation (3.8) by using relative frequency (R*f*) and relative density (Rd) as shown in Equation (3.6) – (3.7). R*f* and Rd have expressed the value as a percentage.

$$Rf = \frac{\text{The frequency of a species}}{\text{Total frequency of all species}} \text{ x } 100 \tag{3.6}$$

$$Rd = \frac{\text{The density of a species}}{\text{Total density of all species}} \text{ x } 100 \tag{3.7}$$

$$IVI = \frac{Rf + Rd}{2} \tag{3.8}$$

CHAPTER 4

RESULT AND DISCUSSION

4.1 Floristic Composition

A study conducted in Universiti Malaysia Kelantan, Jeli Campus (UMKKJ) discovered a total of 103 species of wildflowers from 31 families and 88 genera. This data includes the results from both of the method used. Similarly, 21 species of wildflowers in UMKKJ was found by Kamal-Uddin et al. (2009) regarding the study on the floristic composition of weeds in West Peninsular Malaysia. The number of genus and species wildflowers found in UMKKJ according to the family were shown in Table 4.1. These data shown that two families (Asteraceae and Fabaceae) were dominantly present in the study area based on the both number of genera and species. Asteraceae and Fabaceae recorded the number of genera 16 and 17 respectively. However, the number of species by Fabaceae recorded the highest which was 21 species compared to species from Asteraceae (17). Apart from Malaysia, the floristic survey in Brazil stated that both Asteraceae and Fabaceae represents the families with a greater number of species (Maciel et al., 2008). Others study by Kambhar, Jadhav, and Chougala (2017) in India and Ghanim, Hassan, Galal, and Badr (2010) in Saudi Arabia found that Asteraceae was the largest family found. Thus, from the present data and supported by the previous related studies, Asteraceae and Fabaceae were the largest families discovered around the world especially in Asia country (Malaysia, India and Saudi Arabia).

Table 4.1 The number of genus and species according family from both method

Families	No of Genus	No of Species
Acanthaceae	2	2
Amaranthaceae	2	2
Apiaceae	1	1
Asteraceae	16	17
Cleomaceae	2	2
Commelinaceae	2	2
Convolvulaceae	4	3
Cucurbitaceae	5	5
Dilleniaceae	1	2
Eurphorbiaceae	2	2
Fabaceae	17	21
Lamiaceae	2	2
Linderniaceae	1	3
Loganiaceae	1	1
Lythraceae	1	1
Malvaceae	4	5
Melastomataceae	2	2
Moraceae	2	2
Onagraceae	1	1
Oxalidaceae	1	2
Pedaliaceae	1	1
Phyllanthaceae	1	2
Piperaceae	1	1
Plantaginaceae	1	1
Polygalaceae	2	2
Portulaceae	1	1
Primulaceae	1	1
Rubiaceae	6	9
Solanaceae	2	2
Urticaceae	1	1
Verbenaceae	2	4
TOTAL	**88**	**103**

4.1.1 General Observation

The general observation was conducted as additional data to the species found around UMKKJ. There were 73 species consisted of 27 families with 65 genera discovered by this method. The five largest families were determined based on the highest number of genus and species found (Table 4.2).

The largest family found was Fabaceae with 14 genera including of 16 species. There were two species were contributed by two dominant genus which were *Desmodium* (*D. heterocarpon* and *D. heterophyllum*) and *Clitorea* (*C. laurifolia* and *C. ternatea*). Next family was Asteraceae that contributed to 10 genera complies of 11 species with dominant genus *Sphagneticola*. This genus contributed to two species which were *S. calendulacea* and *S. trilobata.* The rank then followed by Cucurbitaceae (five genera with five species), Malvaceae (four genera with five species), and the last one was Rubiaceae (two genera with four species).

Table 4.2 The top five largest family discovered by general observation in UMKKJ

Family	**Genus**	**Species**
Asteraceae	*Acmella*	*Acmella paniculata*
	Chromolaena	*Chromolaena odorata*
	Crassocephalum	*Crassocephalum crepidioides*
	Eleutheranthera	*Eleutheranthera ruderalis*
	Erigeron	*Erigeron sumatrensis*
	Mikania	*Mikania micrantha*
	Pectis	*Pectis prostrata*
	Sphagneticola	*Sphagneticola calendulacea*
	Sphagneticola	*Sphagneticola trilobata*
	Synedrella	*Synedrella nodiflora*
	Tridax	*Tridax procumbens*

Table 4.2 (Continued)

Cucurbitaceae	*Alsomitra*	*Alsomitra macrocarpa*
	Hodgsonia	*Hodgsonia macrocarpa*
	Trichosanthes	*Trichosanthes* sp.
	Genus A	Species A
	Genus B	Species B
Fabaceae	*Aeschynomene*	*Aeschynomene indica*
	Arachis	*Arachis pintoi*
	Bauhinia	*Bauhinia* sp.
	Centrosema	*Centrosema pubescens*
	Clitoria	*Clitoria laurifolia*
	Clitoria	*Clitoria ternatea*
	Crotalaria	*Crotalaria pallida*
	Desmodium	*Desmodium heterocarpon*
	Desmodium	*Desmodium heterophyllum*
	Leucena	*Leucena leucocephala*
	Macroptilium	*Macroptilium lathyroides*
	Mimosa	*Mimosa diplotricha*
	Pueraria	*Pueraria phaseoloides*
	Senna	*Senna alata*
	Uraria	*Uraria crinita*
	Zornia	*Zornia diphylla*
Malvaceae	*Abelmoschus*	*Abelmoschus moschatus*
	Melochia	*Melochia corchorifolia*
	Sida	*Sida acuta*
	Sida	*Sida rhombifolia*
	Urena	*Urena lobata*
Rubiaceae	*Involucrella*	*Involucrella coronaria*
	Spermacoce	*Spermacoce articularis*
	Spermacoce	*Spermacoce alata*
	Spermacoce	*Spermacoce remota*

4.1.2 Random Quadrat Sampling

From the research, a total of 1901 individuals of wildflowers belonging to 13 families, 28 genera and 30 species were recorded in Universiti Malaysia Kelantan, Jeli Campus (UMKKJ) by using random quadrat sampling method. Table 4.3 shown the genus and species discovered according to each family. It was clearly shown that families with a high number of genus have resulted as the largest family. Asteraceae was on the top rank with six genera and closely followed by Fabaceae and Rubiaceae which both of families consisted of five genera.

In addition, the number of wildflowers by families were counted based on the individual count. Therefore, the top five largest families based on individual number were presented in Figure 4.1. Asteraceae was the family that predominant with total 793 individuals, and followed by Fabaceae (455) which was recorded at the second rank while Rubiaceae (242) as the third largest families. The rest of families with the number of individuals were Linderniaceae (143), Acanthaceae (74), Cleomaceae (59), Polygalaceae (53), Euphorbiaceae (35), Phyllanthaceae (25), Melastomataceae (4), Lythraceae (7), and both Convolvulaceae and Verbenaceae contributed with two individuals.

Furthermore, the percentage of wildflowers by family was shown in Figure 4.2. It was obviously shown that 42% of wildflowers was dominantly discovered by Asteraceae and followed with Fabaceae (24%). The least percentage shown by four families with the portion less than 1% were Convolvulaceae, Lythraceae, Melastomataeae and Verbenaceae.

Table 4.3 List of genus and species according family discovered by quadrat sampling method

Families	**Genus**	**Species**
Acanthaceae	*Asystasia*	*Asystasia gangetica*
Asteraceae	*Adenostemma*	*Adenostemma viscosum*
	Ageratum	*Ageratum conyzoides*
	Centratherum	*Centratherum punctatum*
	Cyanthillium	*Cyanthillium cinereum*
	Eclipta	*Eclipta prostrata*
	Emilia	*Emilia sonchifolia*
Cleomaceae	*Cleome*	*Cleome rutidosperma*
Convolvulaceae	*Ipomoea*	*Ipomoea triloba*
Euphorbiaceae	*Croton*	*Croton hirtus*
	Euphorbia	*Euphorbia hirta*
Fabaceae	*Alysicarpus*	*Alysicarpus vaginalis*
	Calopogonium	*Calopogonium mucunoides*
	Desmodium	*Desmodium triflorum*
	Mimosa	*Mimosa pudica*
	Stylosanthes	*Stylosanthes humilis*
Linderniaceae	*Lindernia*	*Lindernia ciliata*
	Lindernia	*Lindernia crustacea*
	Lindernia	*Lindernia diffusa*
Lythraceae	*Cuphea*	*Cuphea carthagenensis*
Melastomataceae	*Melastoma*	*Melastoma malabathricum*
Phyllanthaceae	*Phyllanthus*	*Phyllanthus urinaria*
Polygalaceae	*Salomonia*	*Salomonia cantoniensis*
	Polygala	*Polygala paniculata*
Rubiaceae	*Exallage*	*Exallage auricularia*
	Mitracarpus	*Mitracarpus hirtus*
	Oldenlandia	*Oldenlandia corymbosa*
	Richardia	*Richardia brasiliensis*
	Spermacoce	*Spermacoce prostrata*
Verbenaceae	*Stachytarpheta*	*Stachytarpheta jamaicensis*

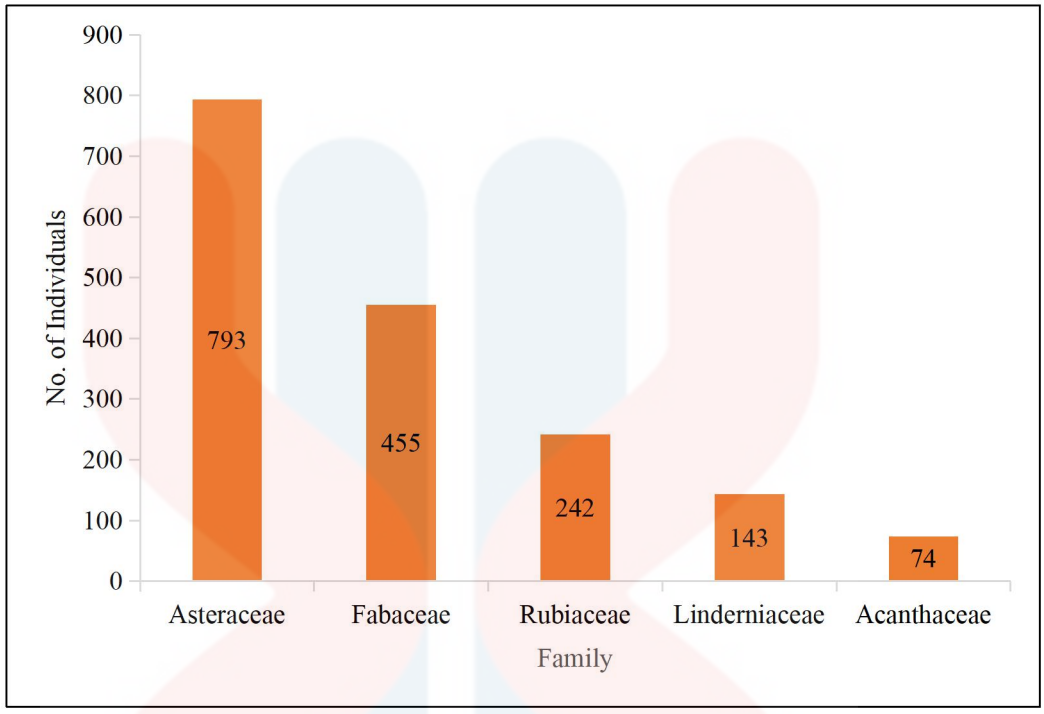


Figure 4.1 The top five largest families of wildflowers based on individual count by quadrat sampling method

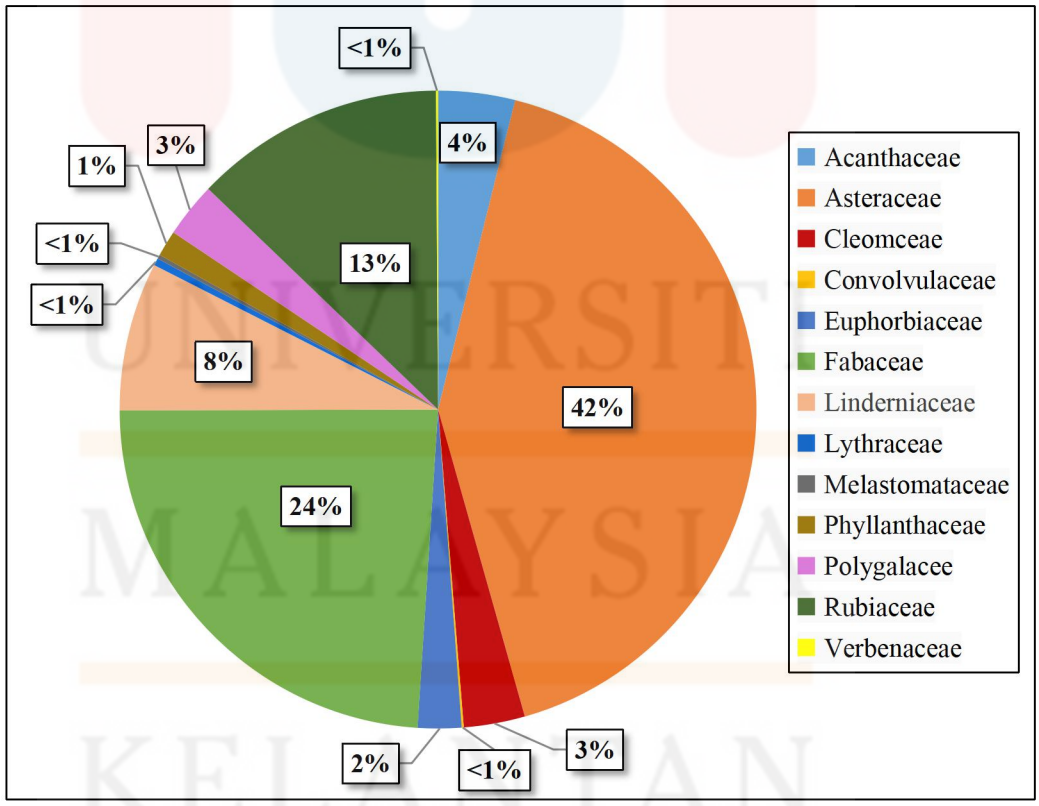


Figure 4.2 Percentage of families based on individual counts by quadrats sampling method

4.2 Species Diversity, Evenness and Richness Indices

The overall data that have been recorded toward the biodiversity of wildflowers around Universiti Malaysia Kelantan, Jeli Campus (UMKKJ) by using the random quadrat sampling was presented as shown below:

Table 4.4 The value for overall biodiversity indices of wildflowers around UMKKJ

Index	Overall Value
Shannon Diversity Index (H')	2.554
H_{max}	3.401
Shannon Evenness Index (E)	0.751
Margalef Richness Index (D_{mg})	3.841

In reference to Table 4.4, the Shannon Diversity Index (H') shown the value of 2.554 which indicate the moderately diverse of wildflowers since the value to reach the maximum diversity (H_{max}) value was 3.401. The Shannon Evenness Index (E) shows the value 0.751 indicate moderate to highly evenness in species distribution of wildflowers in UMKKJ. Next, the Margalef Richness Index (D_{mg}) shown the value 3.841 indicated that the study area was rich with species of wildflowers.

4.2.1 Shannon Diversity Index and Evenness Index

The Shannon Diversity Index was used as the quantitative measure for species diversity in a community with accounted of relative abundance (evenness). The species diversity was calculated by referring to the total 1901 individual of wildflowers found in UMKKJ by random quadrat sampling method. A greater number of species and a more even distribution will increase the diversity index (H'). The overall H' obtained from the data of wildflowers in UMKKJ was 2.554 while the H_{max} value was 3.401. Table 4.5 shown the species with the evenness index > 0.030. Thus, the obtained data was proven that high diversity was influenced by the high value of evenness. The value of the rests species were presented in Appendix B.

Table 4.5 Species of wildflowers with evenness index > 0.030 and diversity value for each species

Species	Evenness (E)	Diversity (H')
Wildflowers	**0.751**	**2.554**
Adenostemma viscosum	0.049	0.167
Ageratum conyzoides	0.108	0.367
Alysicarpus vaginalis	0.042	0.144
Asystasia gangetica	0.037	0.126
Calopogonium mucunoides	0.049	0.168
Cleome rutidosperma	0.032	0.108
Desmodium triflorum	0.062	0.212
Lindernia crustacea	0.042	0.143
Mimosa pudica	0.040	0.136
Oldenlandia corymbosa	0.044	0.151

The diversity index probably influenced by the interference with the invasive species. As the data recorded, the highly diverse species of wildflowers around UMKKJ was *Ageratum conyzoides*. It was reported by Ekeleme et al. (2005) that this species was categorized as the weed and had become the host of many crop diseases. Generally, an invasive species interference with others plants via allelopathy which they inhibit the bioactive metabolites into the surrounding environment and the growth of nearby vegetation is negatively affected (Batish, Singh, & Kohli, 2008).

Next, the species evenness or the similarity in species relative abundance in a community captures another aspect of diversity as a standardized index of relative species abundance (Krebs, 1999). In this study, the calculation of evenness is based on the Shannon Evenness Index. Reference to Table 4.5, *Ageratum conyzoides* shows the high number of evenness (0.108) and followed by *Adenostemma viscocum* and *Calopogonium mucunoides* with similar value (0.049). The data from the study resulted in the overall value of evenness was 0.751. According to Schleuter (2010), the value 1 for the species evenness shows the complete evenness. The higher the value of evenness index, the more even the species in their distribution within a given area (Magurran, 1988). Thus, wildflowers in UMKKJ was moderately even in distribution.

4.2.2 Richness Index

Species richness was calculated to show how much the different species covered the study area based on Margalef Index. It is the simplest measure of diversity and does not consider differences in species relative abundance. Table 4.6 shown the species with the richness value > 12.000 while the the value for rest species was presented in Appendix B. The highest value for richness contributed by two species; *Stachytarpheta jamaicensis* and *Ipomoea triloba* with value 41.838. Furthermore, both species were discovered to two individuals only. Next species with high richness value was *Lindernia diffusa* with 26.397. This species was found with three individual inside a single quadrat. A study by Gotelli and Colwell (2001) was best supported by present result that low number of individuals leading to the high number of richness. However, although the high value of richness obtained by these species, but it did not influenced much to the diversity index. Thus, total richness index obtained from the study of wildflowers in UMKKJ was 3.841 indicated that UMKKJ is rich with the species of wildflowers.

The high richness of study area with wildflowers probably because of the existence of weeds. There were a few of wildflowers in UMKKJ categorized under weeds. For example, *Emilia sonchifolia* and *Euphorbia hirta* were listed as the common weed by Turner (1995). As mentioned by Baker (1965), the weed has no special environmental requirements for germination and has vigorous vegetative reproduction while shows rapid seedling growth.

Table 4.6 Species of wildflowers with richness value > 12.000 and diversity value by each species

Species	Richness Index (D_{mg})	Diversity (H')
Wildflowers	**3.841**	**2.554**
Centratherum punctatum	18.019	0.016
Cuphea carthagenensis	14.903	0.021
Emilia sonchifolia	16.185	0.018
Euphorbia hirta	14.903	0.021
Ipomoea triloba	41.838	0.007
Lindernia diffusa	26.397	0.010
Melastoma malabathricum	20.919	0.013
Polygala paniculata	12.595	0.028
Stachytarpheta jamaicensis	41.838	0.007
Stylosanthes humilis	18.019	0.016

4.3 Abundance Parameter

The abundance parameters used in this study were the frequency and density. Species frequency (*f)* is the proportion of species of wildflowers present in a number of quadrat within the study area. Besides, species density (*d*) is the measurement number of an individual by species within the study area. The result shown by representatives species in Table 4.7 shows the highest frequency and density were both presented by *Ageratum conyzoides* from Asteraceae with 41.667 and 10.773 respectively. This indicated that this species was dominantly found with a uniform distribution over UMKKJ. The value *f* and *d* for the rest species were presented on Appendix C.

Table 4.7 Representative species of wildflowers with frequency and density value

Species	**Frequency (*f*)**	**Density (*d*)**
Asystasia gangetica	13.333	1.233
Adenostemma viscosum	8.333	0.200
Ageratum conyzoides	41.667	10.733
Cyanthillium cinereum	8.333	0.200
Alysicarpus vaginalis	20.000	1.500
Calopogonium mucunoides	23.333	1.883
Desmodium triflorum	25.000	2.750
Mimosa pudica	48.333	1.367
Lindernia ciliata	10.000	0.850
Lindernia crustacea	15.000	1.483
Phyllanthus urinaria	11.667	0.417
Polygala paniculata	10.000	0.167
Salomonia cantoniensis	8.333	0.717
Oldenlandia corymbosa	13.333	1.600
Richardia brasiliensis	8.333	0.900
Spermacoce prostrata	13.333	0.883

Previous study mention that *Ageratum conyzoides* was one of the species that mostly found in any of ecological studies *(*Kambhar, Jadhav, & Chougala, 2017). In fact, *A. conyzoides* (Figure 4.3) is the annual plants with great advantages. According to Crawley (1997), they reproduce early, so they have the potential for very high intrinsic rate of increase and they can survive adverse condition as dormant seeds in the soil. Moreover, *A. conyzoides* has the potential to produce many seeds (94,772 seeds) and to shed seeds over extended times (5 to 8 months). In addition, one plant of *A. conyzoides* will germinated half of the seed produced (Holm, Plucknett, Pancho, & Herberger, 1997). Batish et al. (2009) found that the white-flowered produce more flowers and attract more insect pollinators than violet ones.

Figure 4.3 Photo of *Ageratum conyzoides*
(Photo taken on 23rd July 2018 at Taman Pinggiran UMK)

4.4 Important Value Index

Importance Value Index (IV*i*) of a species shown the overall picture of the ecological importance of the species in a community in UMKKJ. Two parameters used were species relative frequency (R*f*) and species relative density (R*d*). The value of R*f* gave the idea about the percentage of dispersion by a species in the study area while R*d* has shown the percentage of a covered area by particular species among the total species. Table 4.8 shows the ten species with the highest IV*i* by descending order. The highest IV*i* contributed by *Ageratum conyzoides* indicated that this species was the highly disperse among the study area. However, the species on second rank (*Mimosa pudica*) and third rank (*Desmodium triflorum*) show a large difference value apart from the first species (*A.conyzoides*). The difference value between *A.conyzoides* and *M. pudica* were very large with more than 10%. In addition, the difference between other species were very low and in a range of 0 to 1.4 % only as attached on Appendix C.

Table 4.8 Ten species with highest IV*i* by descending order

Species	**R*f***	**R*d***	**IV*i***
Ageratum conyzoides	12.500	33.877	23.188
Mimosa pudica	14.500	4.314	9.407
Desmodium triflorum	7.500	8.680	8.090
Calopogonium mucunoides	7.000	5.994	6.472
Alysicarpus vaginalis	6.000	4.734	5.367
Lindernia crustacea	4.500	4.682	4.591
Oldenlandia corymbosa	4.000	5.050	4.525
Adenostemma viscosum	2.500	5.892	4.196
Asystasia gangetica	4.000	3.893	3.946
Spermacoce prostrata	4.000	2.788	3.394

4.5 Species-Area Curve

Species-area curve expresses the relationship between areas of different sizes and the number of species found in the study area (Connor & McCoy, 1979). The curve generated was used to determine the least number of quadrat of minimal size which will give an adequate sample of a community.

The curve (Figure 4.4) shown the relationship between the total number of species found when the number of quadrats increases regarding the study on the diversity of wildflowers in UMKKJ by using random quadrat sampling. The sampled assume to be sufficient when the curve begins to plateau. Based on the figure, the number of total species keeps increasing on the first 30m^2. However, the curve started to constant on 31m^2 until the 60m^2. Thus, the sampling was stopped as the data was perfectly adequate since there were no new species adding since the sampling at 31m^2.

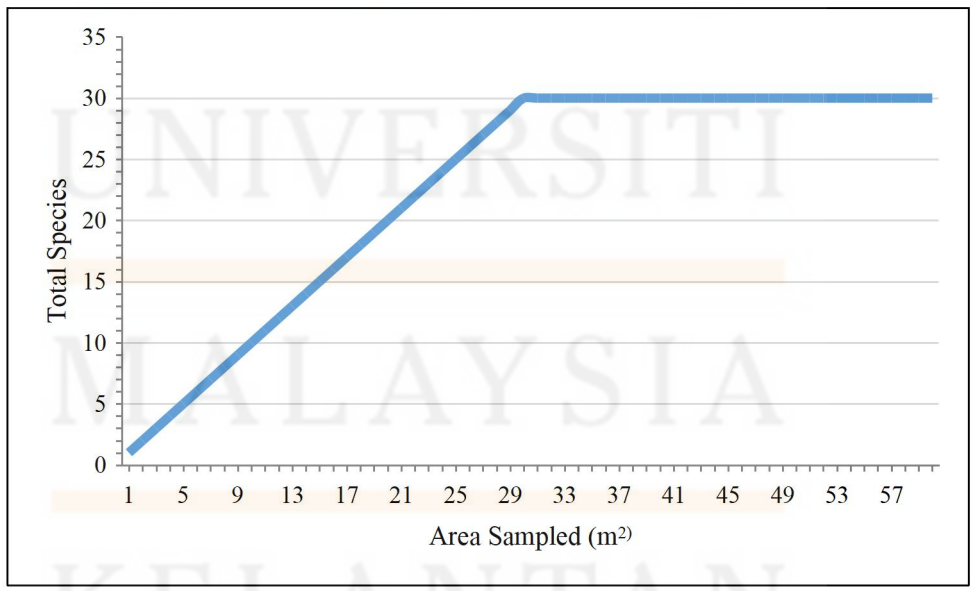


Figure 4.4 Species area-curve of wildflowers by random quadrat sampling

4.6 Conservation Status

Conservation status of the wildflowers species discovered in UMKKJ was checked under the International Union for Conservation of Nature (IUCN) Red List. The status could be the most comprehensive inventory of the global conservation status of plant species. The status was checked to set criteria to evaluate the extinction risk of a species by years. The status of IUCN was classified based on nine categories; Extinct (EX), Extinct in the Wild (EW), Critically Endangered (CE), Endangered (EN), Vulnerable (V), Near Threatened (NT), Least Concern (LC), Data Deficient (DD) and Not Evaluated (NE). In this study, there were 12 species wildflowers listed under Least Concern (LC) status (Table 4.9) while the rest were not in the IUCN record. The species that were not listed by any of status of IUCN can be assumed either IUCN did not have adequate data for the status evaluation or the species are too common around the world.

Table 4.9 Wildflowers' **s**pecies with Least Concern (LC) status on IUCN

Family	**Species**
Apiaceae	*Centella asiatica*
Asteraceae	*Acmella paniculata*
	Eclipta prostrata
Commelinaceae	*Commelina benghalensis*
Fabaceae	*Aeschynomene indica*
	Desmodium triflorum
	Mimosa pudica
Linderniaceae	*Lindernia ciliata*
	Lindernia diffusa
Moraceae	*Artocarpus elasticus*
Onagraceae	*Ludwigia hyssopifolia*
Rubiaceae	*Oldenlandia corymbosa*

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In conclusion, this study gave new information on diversity and composition of wildflowers around Universiti Malaysia Kelantan, Jeli Campus, Kelantan (UMKKJ) with a total of 103 species were discovered. The largest families discovered by this study was Fabaceae as this family contributed to the highest number of species. However, the diversity of wildflowers had resulting *Ageratum conyzoides* from Asteraceae as the most abundant and the most widespread species. *Ageratum conyzoides* was found with 644 individuals inside the quadrat. This species was generally known as the common weed. An attention should be considered to this species as *A. conyzoides* was the invasive species that gave implication to others wildflowers' growth.

For the study on diversity of wildflowers in UMKKJ, the sampling with $60m^2$ provides sufficient data as the species-area curve shown the total number of species reach the plateau on $30m^2$. Furthermore, the conservation status shown from 12 wildflowers indicated these species have the adequate data for the IUCN record. In addition, this study proves that the abundance of the wildflowers have others significant instead of weeds only, but also has potential with medicinal value based on the previous study and best support the natural ecosystem in term of continuous food chain on insects and cover crops.

5.2 Recommendation

From this study, several species of wildflowers were discovered as the weeds. The diversity of weeds gave ecologically impact toward the native species and crops. As Jeli Campus has several vegetable farms that is handled by the student, an action should be conducted to control the weeds especially the invasive species. The weeds will give impacts towards the crops in term of competition for nutrients and sunlight and also the spread of disease.

Other than that, the study shows the moderate diversity index of wildflowers in UMKKJ. As a recommendation, the finding for this study can be improved by longer the periods of sampling as the wildflowers have their own seasons for blooming. The annual and biennial wildflowers usually bloom on their season only. Thus, the more interesting and magnificent photo can be captured for collection. In addition, the study for wildflowers should not be conducted in dried season. This is because some of the wildflowers poor in the growth of hot weather. Moreover, in the tropics, changes in the quantity and distribution of rainfall along with temperature and the length of the dry season gradually alter the vegetation formation (Murphy & Lugo, 1986).

Last but not least, this study has high potential to continue further. This is because this study only covers the area inside the campus and excluded from AgroPark area. The next study perhaps could be weighted both on wildflowers and trees in UMKKJ. Thus, it is believed that there will be a new and interesting species discovered within the long period for sampling to cover up all the area.

REFERENCES

Aizen, M. A. & Harder, L. D. (2009). The global stock of domesticated honey bees is growing slower than agricultural demand for pollination. *Current Biology.* 19(11), 915-918.

Albrecht, M., Schmid, B., Hautier, Y. & Müller, C. B. (2012). Diverse pollinator communities enhance plant reproductive success. Proc. R. Soc. B, 279(1748), 4845-4852

Anderson, D. (2005). National Park Service. *Great Smokey Mountain*. Retrieved from https://www.nps.gov/grsm/learn/nature/threats-to-wildflowers.html

Armenteras, D., N. Rodríguez & J. Retana. (2009). Are conservation strategies effective in avoiding the deforestation of the Colombian Guyana Shield?. *Biological Conservation.* 42: 1411-1419.

Anbarashan, M. & Parthasarathy, N. (2013). Tree diversity of tropical dry evergreen forests dominated by single or mixed species on the Coromandel coast of India. *Tropical Ecology.* 54(2), 179-190.

Aviron, S., Herzog, F., Klaus, I., Schüpbach, B., & Jeanneret, P. (2011). Effects of wildflower strip quality, quantity, and connectivity on butterfly diversity in a Swiss arable landscape. *Restoration Ecology.* 19(4), 500-508.

Baker, H. G. (1965). Characteristics and modes of origin of weeds. 147-72.

Batish, D. R., Kaur, S., Singh, H. P., & Kohli, R. K. (2009). Nature of interference potential of leaf debris of Ageratum conyzoides. *Plant growth regulation.* 57(2), 137.

Ballantyne, M., Gudes, O. & Pickering, C. M. (2014). Recreational trails are an important cause of fragmentation in endangered urban forests: a case-study from Australia. *Landscape and urban planning.* 130, 112-124.

Bonham, C.D. (1989). Measurements of terrestrial vegetation. John Wiley, New York, USA.

Bormann, F., Balmori, D. Geballe, G. & Vernegaard, L. (1993). Redesigning the American lawn. *A search for environmental harmony*.

Chappelka, A., Neufeld, H. & McLaughlin, S. (2006). Ozone Pollution Damage to Growth and Physiology of Native Trees and Wildflowers in Great Smoky Mountains National Park.

Choi, S.W., & Jung, C. (2015). Diversity of Insect Pollinators in Different Agricultural Crops and Wild Flowering Plants in Korea: Literature Review. *Journal of Apiculture.* 30(3), 191-201.

Chong, K. Y., Tan, H. T., & Corlett, R. T. (2009). A checklist of the total vascular plant flora of Singapore: native, naturalised and cultivated species.

Cornell, B. (2016). Monocots versus Dicots, Retrieved 14 June 2018 from http://ib.bioninja.com.au/higher-level/topic-9-plant-biology/untitled 3/monocots-versus-dicots.html

Connor, E.F., McCoy, E.D. (1979). The statistics and biology of the species-area relationship. *The American Naturalist.* 113: 791–83.

Dattner, A. M. (2003). From medical herbalism to phytotherapy in dermatology: back to the future. *Dermatologic therapy. 16*(2), 106-113.

De Silva, L., Herath, W., Jennings, R., Mahendrant, M. & Wannigama, G. (1982). A new sesquiterpene lactone from Elephantopus scaber. *Phytochemistry.* 21(5), 1173-1175.

Dell, B., Vear, K. & Carter, R. (2004). *Arresting Phytophthora Dieback: The biological bulldozer*: WWF Australia and Dieback Consultative Council.

Diekelmann, J. & Schuster, R. M. (2002). *Natural Landscaping: Designing with native plant communities.* Univ of Wisconsin Press.

Djuikouo, M. N. K., Doucet, J. L., Nguembou, C. K., Lewis, S. L., & Sonké, B. (2010). Diversity and aboveground biomass in three tropical forest types in the Dja Biosphere Reserve, Cameroon. *African Journal of Ecology.* 48(4), 1053-1063.

Ekeleme, F., Forcella, F., Archer, D. W., Akobundu, I. O., & Chikoye, D. (2005). Seedling emergence model for tropic ageratum (*Ageratum conyzoides*). *Weed science*. 53(1), 55-61.

El-Ghanim, W. M., Hassan, L. M., Galal, T. M., & Badr, A. (2010). Floristic composition and vegetation analysis in Hail region north of central Saudi Arabia. *Saudi Journal of Biological Sciences.* 17(2), 119-128.

Elliott, S. & Brimacombe, J. (1987). The medicinal plants of Gunung Leuser National Park, Indonesia. *Journal of Ethnopharmacology.* 19(3), 285-317.

Emery, M. J. (1986). *Promoting nature in cities and towns.* Croom Helm.

Global Information Hub on Integrated Medicine (2013). Biodiversity of Flora in Malaysia. Herbal Medicine Research Center. Institute for Medical Research.

Go, R. & Raffi, A. (2017). *Discovering the Wonders of Malaysian Orchids*. Universiti Putra Malaysia Press, Serdang, Malaysia.

Gotelli, N. J., & Colwell, R. K. (2001). Quantifying biodiversity: procedures and pitfalls in the measurement and comparison of species richness. *Ecology letters.* 4(4), 379-391.

Gutierrez, R. M. P. (2010). Orchids: A review of uses in traditional medicine, its phytochemistry and pharmacology. *Journal of Medicinal Plants Research.* 4(8), 592-638.

Henderson, M. R. (1954). Malayan wildflowers. Malayan Nature Society.

Holdridge, L. R. (1967). Life zone ecology. (rev. ed.)).Tropical Science Center, San Jose, Costa Rica.

Holm, L. G., Plucknett, D. L., Pancho, J. V., & Herberger, J. P. (1977). The world's worst weeds: Distribution and biology. East-West Center Book. Univ. Honolulu. Press Hawaii.

Imagery© 2019 CNES/Airbus, Map data© 2019 Google. Retrieved 5 January 2019, https://www.google.com/maps/@5.7460612,101.861777,946m/data=!3m1!1e3

Integrated Taxonomic Information System(ITIS). Retrieved 10 October 2018, from http://www.itis.gov

IUCN Red List of Threatened Species. Version 2018-2 Retrieved 5 November 2018, from https://www.iucnredlist.org

Jones, D. T. & German, P. (1993). *Flora of Malaysia illustrated*: Oxford University Press.

Kamal-Uddin, M., Juraimi, A. S., Begum, M., Ismail, M. R., Rahim, A. A., & Othman, R. (2009). Floristic composition of weed community in turf grass area of west peninsular Malaysia. *International Journal of Agriculture and Biology.* 11(1),13-20.

Kamarudin, M. & Turner, I. (2004). Quarterly notes: New taxa and records of Malaysian vascular plants. *Folia malaysiana. 5*(1), 65-68.

Kambhar, S. V., Jadhav, P. M., & Chougala, S. S. (2017). Weed Diversity in North-East Part of Belgavi District, Karnataka (India).143(6), 585-590. Indian Forester.

Katewa, S. Chaudhary, B. & Jain, A. (2004). Folk herbal medicines from tribal area of Rajasthan, India. *Journal of ethnopharmacology.* 92(1), 41-46.

Kiew, Chung, R., Saw, L. & Rafidah, A. (2007). *The flora of Peninsular Malaysia project.* Paper presented at the Conference on Forestry & Forest Products Research.

Kiew. (2010-2017). *Flora of Peninsular Malaysia:* (R. C. Ruth Kiew, LG Saw, E Soepadmo, Peter C Boyce Ed. Vol. 1-6). Malaysia: Forest Research Institute of Malaysia.

Kiew, Mustafa, Z., Gibbs, W., Kok-Sun, Y., Ibrahim, A. & Jiew-Hoe, T. (2005). *Begonias of Peninsular Malaysia*. Singapore: Natural History Publications (Borneo) / Singapore Botanic Gardens National Parks Board.

Krebs, C. J. (1999). Ecological Methodology. (Benjamin Cummings/Addison-Wesley Educational Publishers Inc. Menlo Park, CA.).

Krebs, C. J. (1989). Ecological methodology (No. QH541. 15. S72. K74 1999.). New York.

Kong, J., Goh, N., Chia, L. & Chia, T. (2003). Recent advances in traditional plant drugs and orchids. *Acta pharmacologica Sinica.* 24(1), 7-21.

Kueh, K. H. (2012). *Susceptibility of native plant species to Phytophthora cinnamomi and the spread of Phytophthora dieback in South Australia.*

Larson, B., Kevan, P. & Inouye, D. W. (2001). Flies and flowers: taxonomic diversity of anthophiles and pollinators. *The Canadian Entomologist.* 133(4), 439-465

Launchbaugh,K. (2009). Principles of Vegetation Measurement & Assessment and Ecological Monitoring & Analysis, Retrieved 5 November 2018 from https://www.webpages.uidaho.edu/veg_measure/help.htm

Latiff, A. (1994). *Kepelbagaian tumbuhan: status sumber alam Malaysia*: Penerbit Universiti Kebangsaan Malaysia.

Li, Y. D., Zhou, G. Y., Zeng, Q. B. Wu, Z. M., & Luo, T. S. (2003). The values for ecological service function of tropical natural forest in Hainan Island, China (in Chinese). 16, 146-152. Forest Research .

Lindgren, D. T. & Schaaf, D. (2005). Survival and growth of wildflowers with buffalo grass or blue grama grass. *HortScience.* 40(6), 1787-1789.

Maciel, C.D.G., J.P. Poletine, C.J.R. Aquino, D.M. Ferreira and R.M.D. Maio. (2008). Floristic composition of the weed Community in Paspalum Planta Daninha Viçosa-MG. 26: 57–64.

Magurran, A. E. (2004). An index of diversity. *Measuring biological diversity.* 100-133.

Magurran, A. E. (1988). Why diversity? *Ecological diversity and its measurement* (pp. 1-5): Springer, Dordrecht.

Mattew, S. (2015). Flower diagram Retrieved 6 May 2018 from https://www.thinglink.com/user/562808909065093120

Masamune, G. (1945). *Enumeration Pteridophytarum Bornearum*: Imperial University.

Mitra, R., Orbell, J. & Muralitharan, M. S. (2007). Agriculture: Medicinal Plants of Malaysia. *Asia-Pacific Biotech News.* 11(02), 105-110.

Mohagheghzadeh, A., Faridi, P., Shams-Ardakani, M. & Ghasemi, Y. (2006). Medicinal smokes. *Journal of Ethnopharmacology.*108(2), 161-184.

Murphy, P. G., & Lugo, A. E. (1986). Ecology of tropical dry forest. Annual review of ecology and systematics, 17(1), 67-88.

Newsome, D., Moore, S.A., & Dowling, R.K. (2002). Natural area tourism: ecology, impacts and management. Clevedon, UK: Channel View Publications.

Niu, G., Rodriguez, D. S. & McKenney, C. (2012). Response of selected wildflower species to saline water irrigation. *HortScience.* 47(9), 1351-1355.

Oba, G., Vetaas, O. R., & Stenseth, N. C. (2001). Relationships between biomass and plant species richness in arid-zone grazing lands. *Journal of Applied Ecology.* 38(4), 836-845.

Potts, S. G., Biesmeijer, J. C., Kremen, C., Neumann, P., Schweiger, O. & Kunin, W. E. (2010). Global pollinator declines: trends, impacts and drivers. *Trends in ecology & evolution.* 25(6), 345-353.

Patrice, C. (2017). The function of each part of flowers, Retrieved 10 April 2018 from https://sciencing.com/parts-flowers-do-8173112.html

Pragasan, L. A., & Parthasarathy, N. (2010). Landscape-level tree diversity assessment in tropical forests of southern Eastern Ghats, India. *Flora-Morphology, Distribution, Functional Ecology of Plants.* 205(11), 728-737.

Rembold, K., Tjitrosoedirdjo, S. S., & Kreft, H. (2017). Common wayside plants of Jambi Province (Sumatra, Indonesia).

Ridley, H. N. (1922-1926). *Flora Of The Malay Peninsula* (Vol. 1-5): L. Reeve & Co. London.

Roskov, Y., Kunze, T., Paglinawan, L., Orrell, T., Nicolson, D., Culham, A., ... & Hernandez, F. (2013). Species 2000 & ITIS Catalogue of Life, 2013 Annual Checklist.

Sapkota, I. P., Tigabu, M., & Odén, P. C. (2010). Changes in tree species diversity and dominance across a disturbance gradient in Nepalese Sal (Shorea robusta Gaertn. f.) forests. *Journal of Forestry Research.* 21(1), 25-32.

Saw, L. & Chung, R. (2015). The flora of Malaysia projects. *Rodriguésia.* 66(4), 947-960.

Schleuter, D., Daufresne, M., Massol, F., & Argillier, C. (2010). A user's guide to functional diversity indices. *Ecological Monographs.* 80(3), 469-484.

Shoemaker, E., Jones, P. & Cannon, A. (1991). Trees outside forests, Agro-community and Urban Forestry. 17, 145-174. New York.

Soepadmo, E. & Wong, K. (1995). A brief history of botanical collecting and documentation in Borneo. P. XXXI-XLI). Forest Research Institute Malaysia, Kuala Lumpur, Sabah Forestry Department, Sandakan & Sarawak Forestry Department, Kuching.

Sokal, R. & Rohlf, F. (1981). Biometry: Freeman San Francisco.

Southwood, T. R. E., & Henderson, P. A. (2009). Ecological methods. John Wiley & Sons.

Speiser, B. (2001). Food and feeding behaviour. *The biology of terrestrial molluscs.* 259-288.

Spellerberg, I. F. (1991). Monitoring ecological change. *Monitoring ecological change*: Cambridge University Press.

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.

Sunil, N., Katari, B. & Khan, I. Y. D. (2015). Methodology for Biodiversity (Flora and Fauna) Study *Biodiversity of Semiarid Landscape. Environmental Science and Engineering* (pp. 13-37): Springer International Publishing.

Todorova, A., Asakawa, S. & Aikoh, T. (2004). Preferences for and attitudes towards street flowers and trees in Sapporo, Japan. *Landscape and urban planning.* 69(4), 403-416.

Turner. (1995). A catalogue of the vascular plants of Malaya. *Gardens' Bulletin (Singapore).* 47(1).

Wang, X. C. (2003). Problems and relevant strategies on natural forest protection in Changbai Mountain forest area (in Chinese). *Journal of Forest Research.* 14: 259-262.

Weiss, M. R. & Lamont, B. B. (1997). Floral color change and insect pollination: a dynamic relationship. *Israel Journal of Plant Sciences.* 45(2-3), 185-199.

Whittaker, R. (1969). New Concepts of Kingdoms of Organisms.

Yoshikawa, M., Murakami, T., Kishi, A., Sakurama, T., Matsuda, H., Nomura, M., . . . Kubo, M. (1998). Novel indole S, O-bisdesmoside, calanthoside, the precursor glycoside of tryptanthrin, indirubin, and isatin from two Calanthe species (Orchidaceae). *Chemical and pharmaceutical bulletin.* 46(5), 886-888.

Younis, A., Riaz, A., Saleem, S. & Hameed, M. (2009). *Potential use of wildflowers in urban landscape.* Paper presented at the II International Conference on Landscape and Urban Horticulture 881.

APPENDIX A

Table of Planning for Final Year Project I and II

Final Year Project I	
25th March - 15th April 2018	Completing Chapter 1 - Introduction
	Completing Chapter 2- Literature Review
	Completing Chapter 3- Material and Method
20th April 2018	Preparation for Proposal Defence
5th July 2018	Submission Report for FYP 1
Final Year Project II	
17th July 2018	Preparation for 1.5 litre ethanol with 70% concentration
18th July - 20th August 2018	Quadrat sampling I and II around Taman Pinggiran UMKKJ with specimens collection
	General observation in Taman Pinggiran UMKKJ
	Quadrat sampling III and IV inside the campus
	General observation around the area inside the campus
	Quadrat sampling V around Kolej Kediaman IBS, UMKKJ with specimen collection
	General observation around Kolej Kediaman IBS, UMKKJ
	Preparation for herbarium
25th November 2018	Completing Chapter 4 - Result and Discussion
30th November 2018	Completing Chapter 5- Conclusion and Recommendation
10th December 2018	Submission of Final Report
18th December 2018	Presentation of FYP II
10th January 2019	Submission of thesis with hardbound

APPENDIX B

Table of overall Evenness Index, Richness Index and Shannon Diversity Index by species

Family	**Species**	**E**	**D_{mg}**	**H'**
Acanthaceae	*Asystasia gangetica*	0.037	6.738	0.126
Asteraceae	*Adenostemma viscosum*	0.049	6.146	0.167
	Ageratum conyzoides	0.108	4.484	0.367
	Centratherum punctatum	0.005	18.019	0.016
	Cyanthillium cinerea	0.009	11.670	0.032
	Eclipta prostrata	0.011	10.989	0.036
	Emilia sonchifolia	0.005	16.185	0.018
Cleomaceae	*Cleome rutidosperma*	0.032	7.112	0.108
Convolvulaceae	*Ipomoea triloba*	0.002	41.838	0.007
Euphorbiaceae	*Croton hirtus*	0.022	8.157	0.074
	Euphorbia hirta	0.006	14.903	0.021
Fabaceae	*Alysicarpus vaginalis*	0.042	6.445	0.144
	Calopogonium mucunoides	0.049	6.134	0.168
	Desmodium triflorum	0.062	5.680	0.212
	Mimosa pudica	0.040	6.581	0.136
	Stylosanthes humilis	0.005	18.019	0.016
Linderniaceae	*Lindernia ciliata*	0.029	7.376	0.097
	Lindernia crustaceae	0.042	6.461	0.143
	Lindernia diffusa	0.003	26.397	0.010
Lythraceae	*Cuphea carthagenesis*	0.006	14.903	0.021
Melastomataceae	*Melastoma malabathricum*	0.004	20.919	0.013
Phyllanthaceae	*Phyllanthus urinaria*	0.017	9.009	0.057

APPENDIX B Continued

Polygalaceae	*Polygala paniculata*	0.008	12.595	0.028
	Salomonia cantoniensis	0.025	7.710	0.086
Rubiaceae	*Exallage aricularia*	0.013	10.033	0.044
	Mitracarpus hirtus	0.015	9.525	0.050
	Oldenlandia corymbosa	0.044	6.354	0.151
	Richardia brasiliensis	0.030	7.270	0.101
	Spermacoce prostrata	0.029	7.304	0.100
Verbenaceae	*Stachytarpheta jamaicensis*	0.002	41.838	0.007
	TOTAL	**0.751**	**3.841**	**2.554**

*E=Evenness Index, Dmg=Richness Index, H'=Shannon Diversity Index

APPENDIX C

Table of overall Frequency, Density, Relative Frequency, Relative Density and Importance Value Index by species

Family	**Species**	***f***	***d***	**R*f***	**R*d***	**IVi**
Acanthaceae	*Asystasia gangetica*	13.333	1.233	4.000	3.893	3.946
Asteraceae	*Adenostemma viscosum*	8.333	1.867	2.500	5.892	4.196
	Ageratum conyzoides	41.667	10.733	12.500	33.877	23.188
	Centratherum punctatum	1.667	0.083	0.500	0.263	0.382
	Cyanthillium cinerea	8.333	0.200	2.500	0.631	1.566
	Eclipta prostrata	6.667	0.233	2.000	0.736	1.368
	Emilia sonchifolia	3.333	0.100	1.000	0.316	0.658
Cleomaceae	*Cleome rutidosperma*	6.667	0.983	2.000	3.104	2.552
Convolvulaceae	*Ipomoea triloba*	1.667	0.033	0.500	0.105	0.303
Euphorbiaceae	*Croton hirtus*	3.333	0.583	1.000	1.841	1.421
	Euphorbia hirta	5.000	0.117	1.500	0.368	0.934
Fabaceae	*Alysicarpus vaginalis*	20.000	1.500	6.000	4.734	5.367
	Calopogonium mucunoides	23.333	1.883	7.000	5.944	6.472
	Desmodium triflorum	25.000	2.750	7.500	8.680	8.090
	Mimosa pudica	48.333	1.367	14.500	4.314	9.407
	Stylosanthes humilis	5.000	0.083	1.500	0.263	0.882
Linderniaceae	*Lindernia ciliata*	10.000	0.850	3.000	2.683	2.841
	Lindernia crustacea	15.000	1.483	4.500	4.682	4.591
	Lindernia diffusa	1.667	0.050	0.500	0.158	0.329
Lythraceae	*Cuphea carthagenensis*	5.000	0.117	1.500	0.368	0.934
Melastomataceae	*Melastoma malabathricum*	3.333	0.067	1.000	0.210	0.605
Phyllanthaceae	*Phyllanthus urinaria*	11.667	0.417	3.500	1.315	2.408

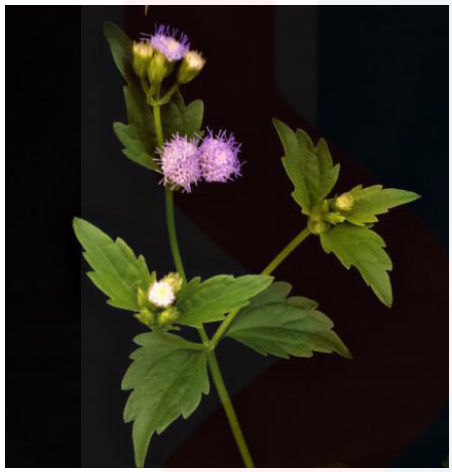
APPENDIX C Continued

Polygalaceae	*Polygala paniculata*	10.000	0.167	3.000	0.526	1.763
	Salomonia cantoniensis	8.333	0.717	2.500	2.262	2.381
Rubiaceae	*Exallage aricularia*	5.000	0.300	1.500	0.947	1.223
	Mitracarpus hirtus	5.000	0.350	1.500	1.105	1.302
	Oldenlandia corymbosa	13.333	1.600	4.000	5.050	4.525
	Richardia brasiliensis	8.333	0.900	2.500	2.841	2.670
	Spermacoce prostrata	13.333	0.883	4.000	2.788	3.394
Verbenaceae	*Stachytarpheta jamaicensis*	1.667	0.033	0.500	0.105	0.303
	TOTAL			**100**	**100**	**100**

**d*=Density, *f*=Frequency, R*f*=Relative Frequency, R*d*=Relative Density, IV*i*= Importance Value Index

APPENDIX D

Checklist of wildflowers found in Universiti Malaysia Kelantan, Jeli Campus (UMKKJ)

	Family : Asteraceae Scientific name : *Adenostemma viscosum* J.R. Forst. & G. Forst An annual or sometimes perennial herb, can grow 30-100 cm tall. Leaf: Lower leaves opposite, upper ones alternate, simple, lanceolate-elliptical to oblong to broadly ovate, base rounded-cuneate, apex acute to obtuse, margins dentate to serrate; petiole of lower leaves up to 9 cm long, upper leaves subsessile; stipules absent. Flower: Flowers all tubular with corolla on the outside with glandular hairs, stamen 5 with white or violet, branches slender, long thickened at the top.
	Family: Solanaceae Scientific name: *Physalis minima* L. Is a perennial herbs with 20 - 50cm high. Leaves are soft and smooth (not furry), with entire or jagged margins, 2.5–12 cm long. Cream to yellowish flowers are followed by edible yellowish fruit encapsulated in papery cover.

	Family : Fabaceae Scientific name : *Clitoria laurifolia* Poir. Growth Form: A woody shrub, can grow up to 0.8 to 1.0m in height. Leaf: Ovate to ovate-oblong in shape and have a pubescent underside. The leaflets have 5 to 7 pairs of lateral veins. The leaf tip is rounded with a cuneate leaf base. Flowers: The flowers are light purple color which are borne on villous racemes which originate from the leaf nodes. Fruits: The fruit is in the form of a legume with a short beak with a longitudinal rib on each side. It turns brown when mature.
	Family: Acanthaceae Scientific name: *Asystasia gangetica* (L.) T. Anderson Trailing to erect, glabrous to lightly hairy, perennial herb to 3.3 feet tall with weak stems, rooting from the nodes. Leaf: Leaves opposite, simple, ovate, petiolate; margins entire to slightly toothed. Flower: Flowers purplish-blue (sometimes yellow or white with dark purple streaks), arranged along one side of a long terminal spike; subtended by 5 linear-lanceolate, green sepals; petals hairy, fused at base to form a funnel-shaped tube with 5 rounded, spreading lobes; 4 fertile stamens.