



# **ABUNDANCE OF *APIS MELLIFERA* IN UNIVERSITY MALAYSIA KELANTAN, JELI CAMPUS**

by

**IVY ANDREA UNUS**

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

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**FACULTY OF EARTH SCIENCE  
UNIVERSITI MALAYSIA KELANTAN**

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2023

## DECLARATION

I declare that this thesis entitled “Abundance of *Apis Mellifera* in University Malaysia Kelantan, Jeli Campus” 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 :   
Name : Ivy Andrea Unus  
Date : 30/06/2024

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## **Abundance Of *Apis Mellifera* in University Malaysia Kelantan, Jeli Campus**

### **ABSTRACT**

The study titled "Abundance of *Apis mellifera* in University Malaysia Kelantan, Jeli Campus" looks into the population dynamics and distribution of *Apis mellifera*, also known as Western honey bees, on campus. The study aims to evaluate the factors that influence their abundance, such as floral resources, habitat suitability, and anthropogenic impacts. Data collection included systematic surveys and observation techniques to record bee abundance and behavior across various habitats on campus. Statistical analyses were used to investigate the relationships between bee abundance and environmental variables. The findings highlight *Apis mellifera*'s significant presence in a variety of campus habitats, as well as the importance of campus landscapes in supporting urban pollinator populations. The study provides important insights into local bee ecology and makes recommendations for campus management practices that promote biodiversity conservation and pollinator-friendly environments.

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## **Kemelimpahan *Apis mellifera* di Universiti Malaysia Kelantan, kampus Jeli**

### **ABSTRAK**

Kajian yang bertajuk "Kemelimpahan *Apis mellifera* di Universiti Malaysia Kelantan, Kampus Jeli" mengkaji dinamik populasi dan taburan *Apis mellifera*, juga dikenali sebagai lebah madu Barat, di kampus tersebut. Kajian bertujuan untuk menilai faktor-faktor yang mempengaruhi kemelimpahan mereka, seperti sumber flora, kesesuaian habitat, dan impak antropogenik. Pengumpulan data melibatkan survei sistematik dan teknik pemerhatian untuk mencatat kemelimpahan dan tingkah laku lebah di pelbagai habitat di kampus. Analisis statistik digunakan untuk menyelidik hubungan antara kemelimpahan lebah dan pembolehubah alam sekitar. Penemuan kajian menyorot kehadiran signifikan *Apis mellifera* dalam pelbagai habitat kampus, serta pentingnya landskap kampus dalam menyokong populasi penyerbuk bandar. Kajian ini memberikan wawasan penting mengenai ekologi lebah tempatan dan memberi cadangan untuk amalan pengurusan kampus yang menggalakkan pemeliharaan biodiversiti.

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## CHAPTER 1

### INTRODUCTION

#### 1.1 Background of study

Honeybees, an insect at the intersection of pollination and honey production, are one of the most important pollinator species and the most widely used insects. Since the 1960s, the number of managed honeybee colonies in Europe has generally decreased, at least in Central Europe. (Guilia, 2022).

*Apis mellifera* is a fascinating insect and one of the world's most studied bee species. *Apis mellifera* is found in a variety of habitats in Malaysia and is an important pollinator for many of the country's agricultural crops. The University of Malaya Kelantan, Jeli campus, located in Malaysia's northeastern region, is a transition zone between the Indo-Pacific and Palearctic regions, making it a hotspot for *Apis mellifera* diversity in the country.

There are at least 28 subspecies of *Apis Mellifera*. Given the importance of honeybees in pollinating monocultures, which are critical for human food security and variety, as well as other ecological services provided by honeybees, there is a critical need for a better understanding of changes in genetic variability of (semi) natural populations and how these may be related to domestication and artificial selection.

Furthermore, the Jeli campus may provide opportunities for fieldwork and data collection, which can improve the study's quality. Researchers can collaborate with local communities to

form a partnership for the protection and conservation of *Apis mellifera* populations, taking advantage of the campus's location as a gateway to various ecosystems.

### **1.2 Problem Statement**

The University Malaysia Kelantan, Jeli campus is located in Malaysia's northeast, surrounded by diverse ecosystems such as rainforests, swamps, and hills, and serves as a transition zone between the Indo-Pacific and Palearctic regions. Studies on the occurrence of *Apis mellifera* is scarce. The goal of this study is to look into the abundance of *Apis mellifera* in the area surrounding the UMK Jeli campus in Kelantan, Malaysia, and to determine the factors affecting their occurrence. The research will shed light on the *Apis mellifera* populations in UMK Jeli Campus it will help to conserve the population and protect the biodiversity.

### **1.3 Objectives**

- i. To determine the abundance of *Apis mellifera* populations near the Jeli campus in Universiti Malaysia Kelantan.
- ii. To determine factors influencing the abundance of the *Apis mellifera* in Universiti Malaysia Kelantan Jeli Campus.

### **1.4 Scopes of Study**

This study will focus in the assessment of *Apis mellifera* abundance in the selected study areas within Universiti Malaysia Kelantan (UMK) Jeli Campus. This will involve using

standard methods such as point surveys, transect walks, record and analyse data on the population size, distribution, and habitat preferences of *Apis mellifera* in the study area.

### **1.5 Significance of Study**

This study will give a better understanding towards the abundance of *Apis mellifera* in UMK Jeli Campus, Kelantan. Bees serves an important role in the ecosystem pollinators. They offer high-quality honey, royal jelly, pollen, and other products like beeswax, propolis, and honey bee venom (UN Environment Programme, 2022). They are historically significant, benefit human health, and aid in the preservation of ecosystem health. Bees, on the other hand, are currently in decline due to factors such as pesticide use and urbanisation, which is having a negative impact on many of the Earth's ecosystems. Thus, the findings of this study can be used to develop conservation and management strategies that address *Apis mellifera*'s unique needs within the ecosystem, ensuring its long-term survival and success.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Morphology of *Apis Mellifera*

*Apis mellifera* is typically red or brown in colour, with black bands and orange yellow rings on the abdomen. Their thorax has more hair and their abdomen has less. They have a pollen basket on the back of their legs as well. Honeybee legs are mostly dark brown or black.

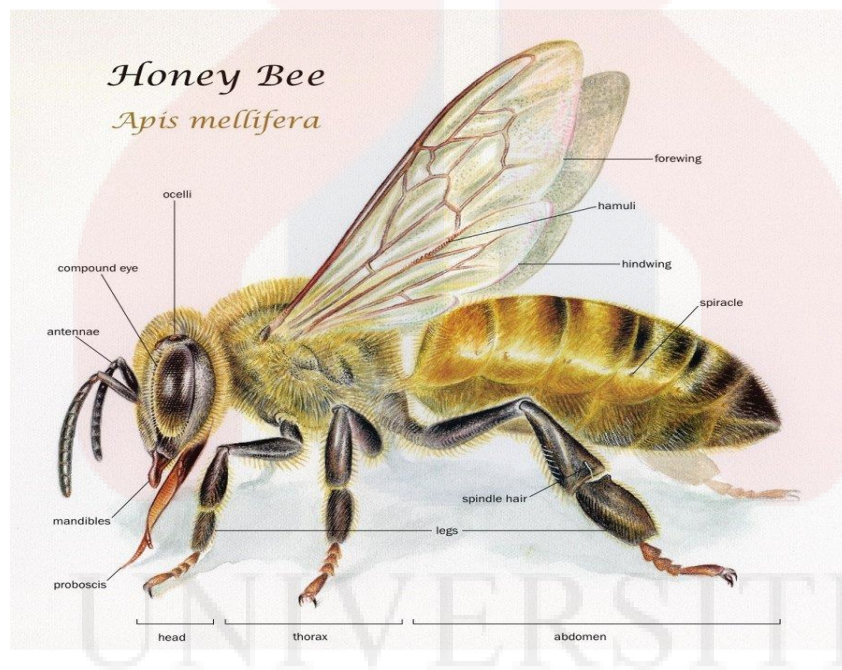


Figure 2.1.1: Structure of *Apis mellifera* (Online Sciences Notes, 2017 )

Females are classified as either sterile workers (adults 10-15 mm long) or fertile queens (18-20 mm). Male drones can grow to be 15-17 mm long. Despite their smaller size, workers have longer wings than drones. The stingers of both female castes are made of modified ovipositor structures. The sting is barbed and tears away from the body when used on workers. In both cases, the stinger receives venom from glands in the abdomen. Males have much larger eyes than females, which helps them detect flying queens during mating flights. (George, 2023)

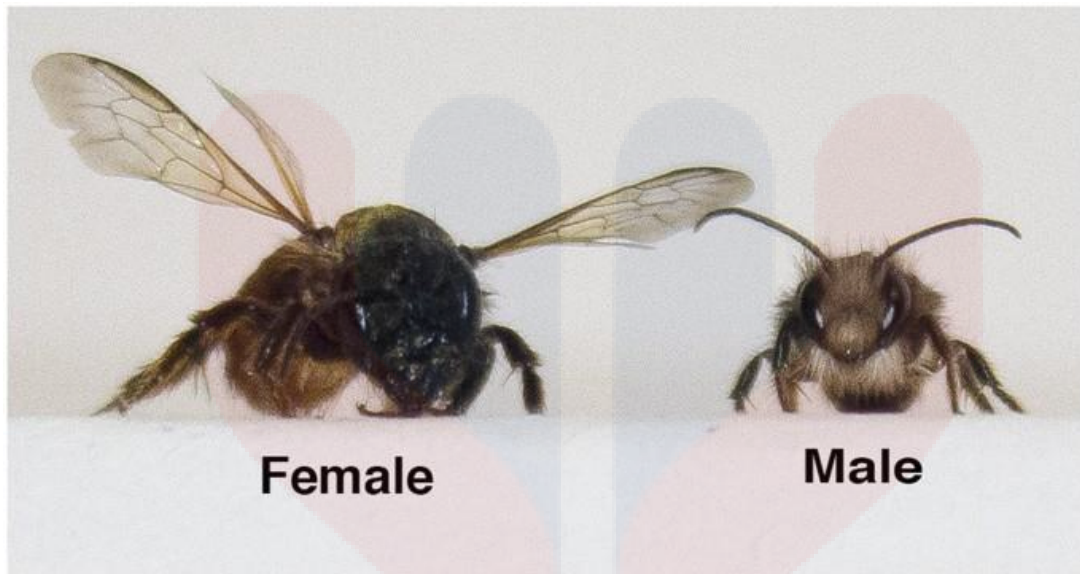


Figure 2.1.2: Female and male *Apis mellifera* (Scientific Reports, 2016)

## 2.2 Distribution of *Apis mellifera*

Bees and flowering plants have become increasingly dependent on one another over the past 130 million years. There are currently 20,000-30,000 bee species, with approximately 16,000 of them scientifically described. Honey bee ancestors first appeared 40 million years ago, with a modern type of open nesting species first appearing in South East Asia around 10 million years ago. Later, species that nested inside cavities appeared, eventually spreading across tropical and temperate Asia, as well as into Europe. As the Middle East became desertified, these European bees became separated from Asian species and evolved into the species known today as *Apis mellifera*, which has an indigenous distribution stretching from the Arctic Circle to South Africa, with the eastern limits of the Ural Mountains in the north and the central deserts of Afghanistan in the south. *Apis cerana* and several other *Apis* species that nest in cavities are descended from Asian cavity-nesting bees. The various open nesting species that exist today evolved from the open nesting species. As a result, Asia has many

*Apis* species, whereas Europe and Africa only have one. The world's industrialised beekeeping sector, on the other hand, is based on a single species, *Apis mellifera*. (Bees for development, 2016)

### **2.3 *Apis mellifera* life cycle**

The lifecycle of an Italian honey bee is divided into four distinct stages: egg, larva, pupa, and adult, and it is determined by the bee's role within the colony. A queen bee has a life expectancy of 2-3 years, while worker bees can live for six weeks to six months (depending on the season), and drones live for two months on average after mating. (Anderson, 2023)

The egg stage of a honey bee's life begins after a queen mates with a male (drone) from another hive and deposits the fertilised eggs into cells within the hive. The queen bee spends the majority of her life in the hive laying eggs; however, the young queen will make one to three mating flights five to eight days after hatching. The larva stage occurs immediately after the egg stage, after the egg has developed into the larva, a white, worm-like form. The pupa stage occurs on the ninth day of the life cycle after the larva has been capped over and is the final stage before a fully developed bee emerges from the cell. The larva is sealed inside the cell during the pupa stage, but the length of time they stay in their capped cell is determined by their role in the hive. When the bee chews through the cap on their cell and emerges, its wings will still be hardening. Before it can join the colony, this young bee will need to be fed by other workers for a few days. After three weeks from egg to emergence, the bee will perform a variety of tasks depending on its role. To summarise, a beehive contains three types of honey bees.

Each queen, drone, and worker bee serves a specific purpose within the colony. (Schmus, 2022).




	QUEEN 	WORKER 	DRONE 
<b>EGG</b>	Up to Day 3	Up to Day 3	Up to Day 3
<b>LARVA</b>	Up to Day 8½	Up to Day 8	Up to Day 9½
<b>CELL CAPPED</b>	Day 7½	Day 9	Day 10
<b>PUPA</b>	Day 8 Until Emergence	Day 10	Day 10 Until Emergence
<b>DAYS UNTIL EMERGENCE</b>	16 Days	21 Days	24 Days
<b>START OF FERTILITY</b>	Day 23 and Up	N/A	About 38 Days
<b>BODY LENGTH</b>	18-22mm (0.71-0.87in)	12-15mm (0.47-0.59 in)	15-17mm (0.59-0.67 in)
<b>WEIGHT ON EMERGING</b>	Nearly 200 mg (3.1g)	Nearly 100 mg (1.5 gr)	Nearly 200mg (3.1g)

Figure 2.3.1: Honeybee (*Apis mellifera*) lifecycle (Best bees, 2022)

## 2.4 *Apis mellifera* as pollinators

### 2.4.1 Importance of pollination

Ecosystems provide free services such as insect pollination. Insects pollinate hundreds of plant species by visiting them in search of nectar and/or pollen. Indeed, while foraging, nectar- and pollen-feeding insects may accidentally transmit pollen grains to flower stigmas, increasing fertilisation. Although insects, particularly bees, pollinate the vast majority of animal-pollinated plants, nectar-feeding vertebrates like several mammal and bird species can promote cross-pollination. (Theodore, 2008).

Because pollination and plant-pollinator interactions are critical for flowering plant reproductive success and fruit production, this ecosystem service promotes plant biodiversity and is inextricably linked to all of the supporting, regulating, and provisioning services provided by terrestrial vegetation.

According to (Ollerton, 2017), Plant-pollinators interactions are one of the most important drivers of biodiversity on the planet. Without pollinators, pollen and seeds cannot be transported, and flowering plants cannot reproduce. Pollination ensures not only the survival and spread of flowering species, but also the survival of other ecosystem components that rely on floral resources, such as herbivores and seed eaters. (Simon, 2006). Flowers, in addition to leaves, provide important microhabitats for a variety of invertebrates and support a fauna. Many micro- and macro-invertebrates inhabit and visit flowers for pollination and floral herbivory, or because flowers serve as resting/nesting sites or aggregation sites for mating or predators. (Carl, 2012).

#### **2.4.2 Polination process of *Apis mellifera***

When a bee collects nectar and pollen from a flower, pollen from the stamen, the plant's male reproductive organ, adheres to her body hairs. When she visits the next flower, some of the pollen rubs off on the stigma, or tip of the pistil, the flower's female reproductive organ. This allows for fertilization and the development of a fruit containing seeds. Because plants rely on bees and other insects for reproduction, they have evolved over time to become more appealing to them. Plants with open or flat tubular flowers that contain a lot of pollen and nectar attract bees. The scent of a flower, as well as its bright colours, can be particularly appealing

to bees. Flowers visited more frequently by bees produce larger and more uniform fruit than those visited less frequently. Pollination has the greatest positive impact on tree fruit. (Canada Agriculture and Food Museum, 2023)

## 2.5 Diseases related to *Apis mellifera*

### 2.5.1 Varroa mites

The Varroa mite (*Varroa destructor* and *Varroa jacobsoni*) is a parasite that feeds on honey bee adults and brood. It weakens and kills honey bee colonies and may spread honey bee viruses. In June 2022, Varroa was discovered in New South Wales. Adult female varroa are reddish-brown in colour, shaped like a scallop shell, and are visible to the naked eye. Adult males are smaller and have a yellowish-white coloration. The eggs are 0.5 mm long, milky in colour, and initially rounded. Females of *Varroa jacobsoni*, a closely related exotic species, are about 1.0 mm long and 1.5 mm wide, making them smaller than females of *V. destructor*. (Department of Energy, Environment and Climate Action, 2021)



Figure 2.5.1: Varroa mites found in bees

### 2.5.2 Brood diseases: American foulbrood (AFB) and European foulbrood (EFB)

AFB and EFB are highly contagious bacteria-based diseases. Adult honey bees, robbers, contaminated equipment, and the use of contaminated honey and pollen are all possible entry points for these bacteria into a healthy colony. Nurse bees transmitted both diseases throughout the colony by feeding infected food to larvae two days old or younger. Sick, dying, or dead larvae change color from gleaming white to yellow, brown, or even black. Nurse bees will notice shotgun brood patterns after diseased larvae are removed. To make matters more difficult, both diseases emit foul odours of decay as the brood dies. Both diseases, if left unchecked, can completely destroy not only a single colony, but an entire apiary in a short period of time

*Paenibacillus* larvae, a spore-producing bacterium, causes AFB. Spores consumed by larvae germinate and multiply rapidly in the honey bee's midgut, allowing bacteria to infiltrate the body cavity and kill the host. European foulbrood, caused by the non-spore producing bacterium *Melissococcus plutonium*, is not nearly as deadly as AFB if treated properly. EFB transmission, on the other hand, is similar to AFB in that it affects adult bees, equipment, and food sources, with severe colony losses possible if left untreated. The good news is that there are numerous visible indicators that can distinguish EFB from AFB. EFB is more common in early spring, when colonies are stressed by cool, wet weather, nectar shortages, and high varroa counts, among other common stressors. (Cook, 2023).



Figure 2.5.2: ABF disease in bees



Figure 2.5.3: EBF disease in bees

## CHAPTER 3

### MATERIALS AND METHOD

#### 3.1 Study Area

The research will be carried out at the Universiti Malaysia Kelantan, Jeli Campus. It is situated at latitude  $5.74599^{\circ}$  and longitude  $101.86597^{\circ}$ . The university was founded in 2006, during the presentation of the Ninth Malaysia Plan. It is Malaysia's 19th public university (UA). UMK Kampus Jeli is a fully operational UMK campus that opened in January 2012. The UMK Kampus Jeli campus is located in the Gemang forest, surrounded by small and picturesque hills. The Jeli campus is strategically located on the East-West highway that connects the East and West, between the towns of Tanah Merah and Jeli.

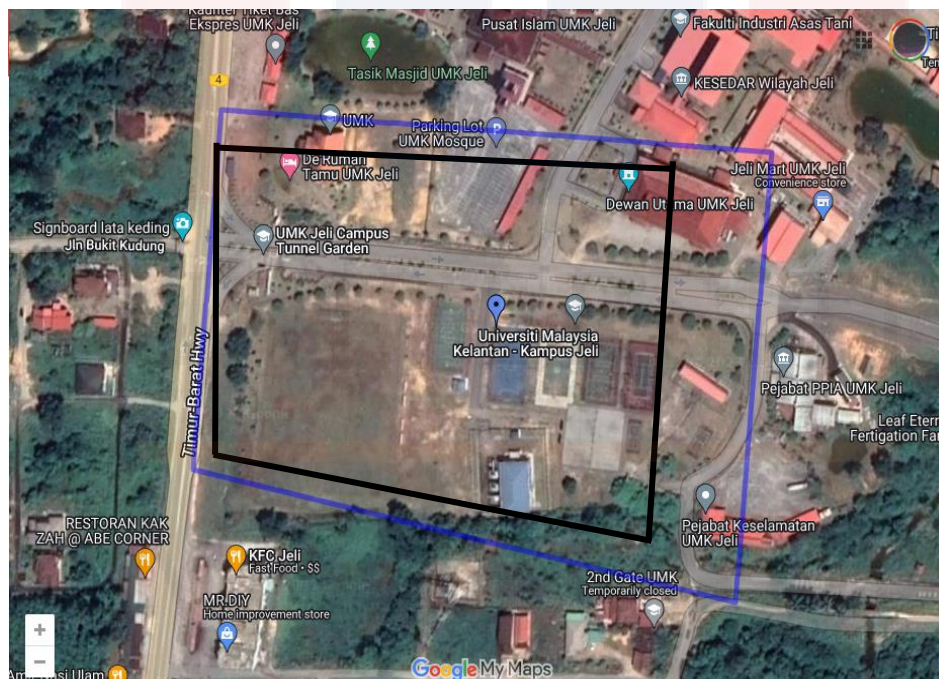


Figure 3.1.1: Map of Universiti Malaysia Kelantan, Jeli Campus

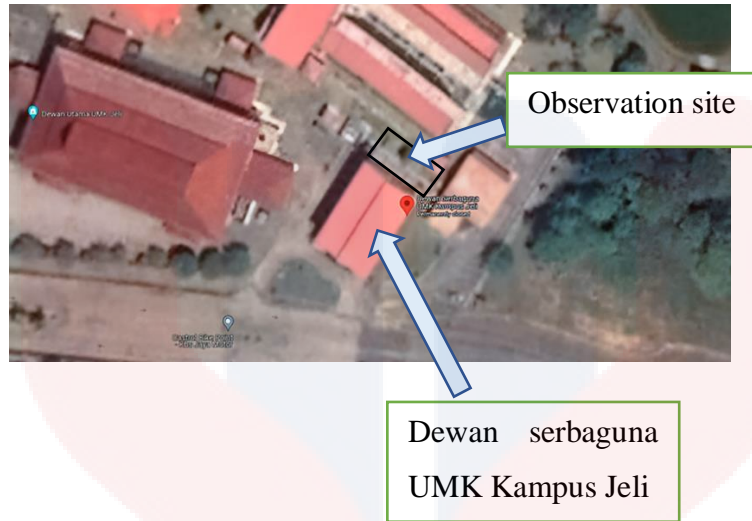


Figure 3.1.2: Map of observation site



Figure 3.1.3: Tree plot in the observation area

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### 3.2 Materials and description

Materials	Description
Paper/book	To record necessary information while observation
Pen and pencil	To write down information
Gadget/Smartphone	<ul style="list-style-type: none"> <li>To record any necessary videos/pictures in the observation area</li> <li>To check time, weather and temperature</li> </ul>
Bee suit (Optional)	Protection from sting injuries

### 3.3 Observation Method

Observations were conducted for eight days at the observation area, specifically at the pathways near the Dewan Serbaguna (multipurpose hall) on the UMK Jeli Campus, from April 6th to April 13th, 2024. An observation method was developed to systematically assess the abundance and behavior of *Apis mellifera* (European honeybees) at the University Malaysia Kelantan's Jeli Campus. The method entails locating key areas on campus known to attract honeybees, such as flowering gardens and green spaces. Observations were made at different times of day to capture variations in honeybee activity, with data collected on weather conditions, floral resources available, and the number of honeybees seen. Collected data on weather conditions, floral resources available, and the number of honeybees observed. Each observation session lasts at least 15 minutes, and researchers use notebooks or electronic

devices to record honeybee activity, which can be supplemented with cameras or smartphones for visual documentation. After collecting observations, the data is analyzed to identify patterns in honeybee abundance and behavior across different locations and times, while accounting for variables such as floral availability, weather conditions, and human activities.



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### **3.4 DATA ANALYSIS**

#### **3.4.1 Scatter plot correlation between abundance and temperature**

Daily data on temperature and bee abundance were collected over a set time period. To visualize the relationship, a scatter plot was created with temperature on the X-axis and *Apis mellifera* abundance on the Y-axis.

#### **3.4.2 Trend line and regression**

A trend line and regression analysis are statistical tools used to identify and forecast the relationship between variables. A trend line shows the general direction of data points in a scatter plot, making it easier to detect patterns over time.

#### **3.4.3 Boxplot**

A boxplot is a standardized way of displaying the distribution of data based on a five-number summary. It is crucial in order to identify the central tendency, dispersion, and skewness of data, as well as detecting outliers. It helps to visualize the distribution and variability of bee populations across different sampling sites, highlights any significant anomalies that may indicate environmental factors or sampling inconsistencies.

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#### **3.4.4 Rate of sightings**

The rate of sightings is an important metric in ecological studies, especially when assessing the abundance and activity patterns of species such as *Apis mellifera* (honey bees). This measure provides a standardized method for quantifying how frequently a species is observed over a given time period, allowing researchers to draw meaningful conclusions about the population's dynamics.

#### **3.4.5 Frequency of occurrence**

The frequency of occurrence is a useful metric for understanding how frequently specific levels of abundance are observed over a given time period. It is a simple metric that measures the proportion of samples (often expressed as a percentage) in which a specific item is present.

## CHAPTER 4

### RESULT AND DISCUSSION

#### 4.1 OVERALL ABUNDANCE

Table 4.1.1 shows the overall abundance of *Apis mellifera* (honeybees) documented in Universiti Malaysia Kelantan's Jeli Campus over an eight days observation period, with varying temperature recorded each day. The table includes temperature and number of bees observed at five different sampling points per day. Temperatures ranged from 26°C to 30°C, with higher bee abundance observed on hotter days, such as Day 2 and Day 8, both of which were 30°C. Higher temperatures (30°C on days 2 and 8) appear to correspond with higher overall bee activity, whereas lower temperatures (26°C on day 7) show variable activity levels.

The data at the Universiti Malaysia Kelantan, Jeli Campus, suggests that temperature may have a significant impact on bees' foraging behavior and activity levels. The data shows a significant level of consistency in the number of bees at specific temperatures, particularly at 27°C, which was the most commonly recorded temperature.

Among the five monitored sites, sampling point 4 consistently had higher bee counts, with 18 individuals observed, implying that these locations may provide better conditions for bees. The abundance of *Ixora coccinea*, also known as West Indian jasmine, at sampling point 4 could have contributed significantly to the consistently higher bee counts observed. An abundance of nectar, attractive flowers, a long blooming period, suitable habitat conditions, increased pollination opportunities, and shelter all contribute to a thriving environment for bee populations. Bees are attracted to *Ixora coccinea's* bright red, orange, or yellow flowers. This visual allure may draw more bees to the area, resulting in higher counts.

On the other hand, Site 3 recorded the lowest abundance, with only 5 individuals recorded. The change in this observation could be attributed to differences in local environmental variables, such as the presence of floral resources, the structure of the habitat, and potential variations in microclimate.

Bee abundance varies daily, implying that factors other than temperature, such as floral resources and human activity, influence bee presence. The data show that higher temperatures are associated with increased bee activity, but more research with more environmental variables and longer sampling periods is needed to fully understand the factors influencing bee populations in the area.

Table 4.1.1 Overall *Apis mellifera* abundance documented in Universiti Malaysia Kelantan, Jeli Campus

Day	Temperature	Abundance				
		1	2	3	4	5
1	27°C	0	3	0	3	1
2	30°C	3	4	2	4	1
3	29°C	2	1	0	2	2
4	27°C	0	1	1	1	0
5	27°C	0	1	0	3	1
6	27°C	2	0	1	0	2
7	26°C	2	1	0	2	3
8	30°C	1	0	1	3	2
<b>TOTAL</b>		10	11	5	18	12

4.2 GRAPH VISUALIZATION FOR ABUNDANCE OF APIS MELLIFERA

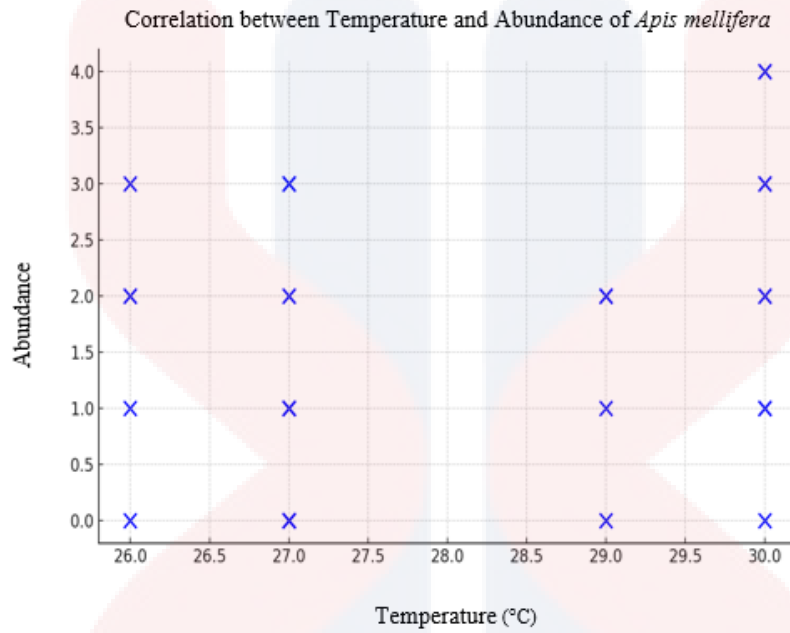


Table 4.2.1: scatterplot of overall correlation between *Apis mellifera* abundance and temperature

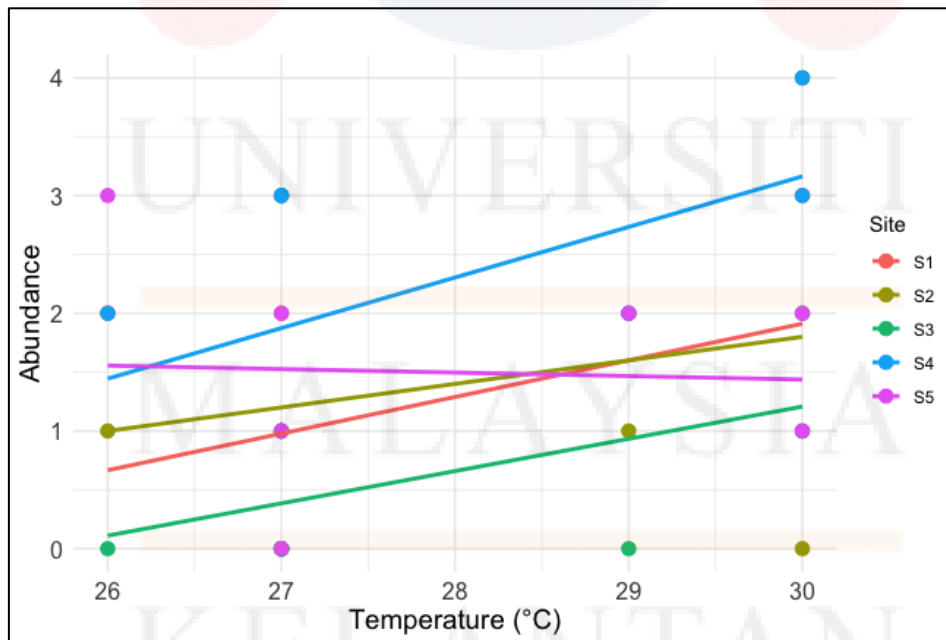


Table 4.2.2: Scatterplot of *Apis mellifera* abundance versus temperature by sites.

The scatter plot above depicts the eight-day relationship between temperature and *Apis mellifera* abundance on the Universiti Malaysia Kelantan campus in Jeli, Malaysia. The temperatures recorded ranged from 26°C to 30°C, resulting in a relatively narrow range of environmental conditions for observing the bee population. At 26°C, the abundance of *Apis mellifera* varied from 0 to 3. At 27°C, the abundance varied greatly, from 0 to 3. At 29°C, the abundance was relatively low, ranging between 0 and 2. At 30°C, the abundance was highly variable, ranging from 0 to 4.

At the highest recorded temperature of 30°C, the noticeable variation in abundance suggests that factors other than temperature may be influencing the bee population. The majority of data points cluster around temperatures of 27°C and 30°C, indicating that these temperatures are more commonly observed or conducive to *Apis mellifera* activity on campus.

While temperature appears to have some influence on bee abundance, it is clear that a variety of other factors contribute to the observed variability. Further research incorporating additional environmental and ecological variables would provide a more complete understanding of the dynamics affecting *Apis mellifera* populations.

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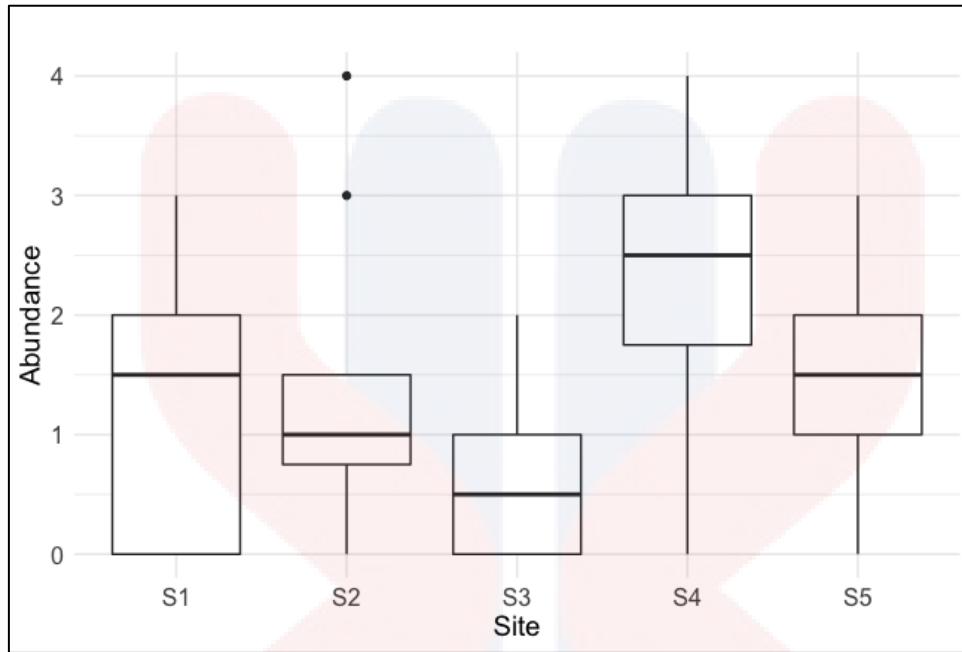


Table 4.2.2: Boxplot of *Apis mellifera* abundance by site

The boxplot depicts the abundance of *Apis mellifera* (honey bees) at various locations (S1, S2, S3, S4, S5) at Universiti Malaysia Kelantan's Jeli Campus. Overall, the boxplot shows that median abundance differs between sites, with Site S4 having the highest and Site S3 having the lowest median values. The spread of abundance values is greatest at Sites S1 and S4, indicating greater variability, whereas Site S3 has the least variability. Outliers are only found at Site S2, indicating that abundance values occasionally exceed those at other sites. This visualization effectively highlights differences in median values, variability, and outliers in *Apis mellifera* abundance across campus sites.

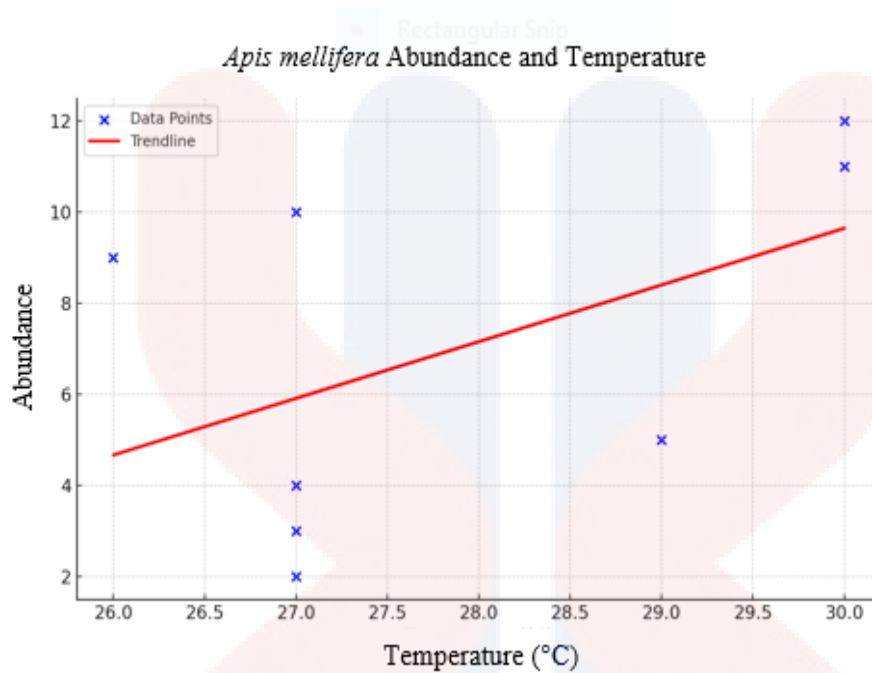


Table 4.2.3: Trend line and regression of the correlation between *Apis mellifera* abundance and temperature

The trend line indicates that as temperatures rise, honeybee activity or presence increases. This is consistent with known biological patterns, as honeybees become more active in warmer weather, which promotes foraging and other behaviors. However, the data show variation in honeybee abundance even at the same temperature, implying that factors other than temperature may influence their presence

The linear regression analysis shows a positive correlation between temperature and *Apis mellifera* abundance, with higher temperatures leading to increased activity. While the model contains useful information, it should be interpreted with caution due to the factors mentioned above. Further research incorporating more variables and longer data collection periods would improve our understanding of the environmental influences on honeybee behaviour.

### 4.3 RATE OF SIGHTINGS

$$\frac{\text{Total number of individuals observed}}{\text{Total observations period}}$$

Observation period	Number of <i>Apis mellifera</i> sighted
1	7
2	14
3	9
4	3
5	5
6	4
7	8
8	7

$$= \frac{57}{8}$$

= 7.125 individuals per day

The data show a relatively consistent presence of *Apis mellifera* throughout the observation period, with a minimum of three individuals on Day 4 and a maximum of fourteen on Day 2. This suggests that the study area is a stable habitat for honey bees, with resources such as food and nesting sites. The slight variation in the number of bees seen on different days could be influenced by environmental factors like temperature. For example, Day 2 had the highest recorded temperature of 30°C, as well as the highest sighting rate (14 individuals). This is consistent with the known behavior of honey bees, which are more active in warmer weather, as higher temperatures are generally associated with increased foraging activity. To summarize, the rate of sightings provides an important snapshot of *Apis mellifera* presence in the study area, with data indicating a healthy and stable population. Continued monitoring and research will help ensure that these beneficial pollinators thrive in the local ecosystem.

#### 4.4 FREQUENCY OF OCCURRENCE

$$\frac{\text{Number of occurrence of a species abundance}}{\text{Total number of days}} \times 100$$

Abundance	Frequency of occurrence
1 ( day 2, 3, 6, 7, 8 )	$\frac{5}{8} \times 100 = 62.5 \%$
2 ( day 1, 2, 3, 4, 5, 7 )	$\frac{6}{8} \times 100 = 75 \%$
3 ( day 2, 3, 4 )	$\frac{3}{8} \times 100 = 37.5 \%$
4 ( day 1, 2, 5, 6, 8 )	$\frac{5}{8} \times 100 = 62.5 \%$
5 ( day 1, 3, 6, 8 )	$\frac{4}{8} \times 100 = 50 \%$

According to the frequency of occurrence analysis, *Apis mellifera* was most commonly observed in pairs (75%), indicating that small groups were the most frequent sightings. Solitary bees and groups of four were also frequently seen, each with a frequency of 62.5%, indicating that both individual and moderate group sightings were common. Groups of five had a 50% occurrence, indicating a balanced presence of larger groups. In contrast, sightings of exactly three people were uncommon, occurring only 37.5% of the time. Overall, the data indicate a stable and flexible population structure, with *Apis mellifera* regularly observed in a variety of group sizes, indicating a healthy environment that supports different social arrangements for the species.

## CHAPTER 5

### CONCLUSION AND RECOMMENDATION

#### 5.1 CONCLUSION

The abundance of *Apis mellifera*, also known as the western honeybee, at the University Malaysia Kelantan (UMK) Jeli Campus provides an excellent opportunity for ecological research, agricultural enhancement, and community engagement. This study discovered that the campus is a thriving habitat for these important pollinators, indicating a healthy ecosystem and possibly providing valuable insights into environmental health and biodiversity conservation. Finally, the abundance of *Apis mellifera* on the UMK Jeli Campus highlights the importance of biodiversity conservation as well as the interdependence of human activities and the natural environment. We can work to create a more sustainable and harmonious environment for current and future generations by increasing our understanding and appreciation for these vital pollinators.

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## 5.2 RECOMMENDATION

Based on the findings on the abundance of *Apis mellifera* at the University Malaysia Kelantan (UMK), Jeli Campus, several recommendations can be made to improve the understanding, conservation, and use of bee populations on campus. To begin, sampling over a longer period need to be conducted to obtain more extensive and accurate data. Study throughout wet and dry seasons can be done to understand the seasonal dynamics and activity patterns of *Apis mellifera*. Other than that, study the environmental factors that can affect the bee population. By doing this, more effective actions can be taken by considering the existing factors. Furthermore, we can make comparisons between bees in agricultural, urban, and other areas. After studying the habitat or behaviour of bees in these areas, more effective actions can be taken, especially in efforts to conserve and restore the bee population, which is of great importance in the ecosystem and pollination.

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