



**DIVERSITY AND ABUNDANCE OF MOTHS  
(LEPIDOPTERA: HETEROCERA) IN  
UNIVERSITI MALAYSIA KELANTAN,  
JELI, KELANTAN**

by

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A thesis submitted in fulfilment of the requirements for the degree of  
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## DECLARATION

I declare that this thesis entitled “Diversity and Abundance of Moths (Lepidoptera: Heterocera) in Universiti Malaysia Kelantan, Jeli, 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.

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**Diversity And Abundance Of Moths (Lepidoptera: Heterocera) In  
Universiti Malaysia Kelantan, Jeli, Kelantan**

**ABSTRACT**

Universiti Malaysia Kelantan, Jeli Kelantan, is a government university that was established during the presentation of the Ninth Malaysia Plan in 2006. A moths study was conducted at Universiti Malaysia Kelantan at UMK Court, from 1 to 8 March 2024 aimed at determining the Diversity and Abundance of Moths (Lepidoptera: Heterocera) in Universiti Malaysia Kelantan, Jeli, Kelantan. A total of 165 individuals of moths consisting of 25 species from 6 families were recorded in 8 sampling days using light traps. This species consists of the family Erebidae (14 species), the Uraniidae family (2 species), the family Notodontidae (1 species), the family Sphingidae (5 species), the family Cossidae (2 species), and the family Lasiocampidae (1 species). The family Erebidae is the most dominant family in this area compared to other families. *Lymantria Lepcha* from the Erebidae family and *Lyssa zampa* from the Uraniidae family are the most recorded species. Overall, the value of Shannon-Wiener index (H') is 4.63. This shows that Universiti Malaysia Kelantan, Jeli Kelantan records a stable environmental condition and has a moderately large variety of butterfly species with a uniform distribution. Moths play an important role in determining the ecosystem at Universiti Malaysia Kelantan. Therefore, future research recommendations should include long-term monitoring to assess the effects of environmental change and conservation efforts to reduce light pollution and preserve moths habitat.

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## **Kepelbagaian dan Kelimpahan Rama-Rama (Lepidoptera: Heterocera) In Universiti Malaysia Kelantan, Jeli, Kelantan**

### **ABSTRAK**

Universiti Malaysia Kelantan, Jeli Kelantan, ialah sebuah universiti kerajaan yang telah ditubuhkan semasa pembentangan Rancangan Malaysia Kesembilan pada tahun 2006. Satu kajian rama-rama telah dijalankan di Universiti Malaysia Kelantan di Gelanggang UMK, dari 1 hingga 8 Mac 2024 bertujuan untuk menentukan kepelbagaian dan kelimpahan Rama-Rama (Lepidoptera: Heterocera) di Universiti Malaysia Kelantan, Jeli, Kelantan. Sebanyak 165 individu rama-rama yang terdiri daripada 25 spesies daripada 6 famili telah dicatatkan dalam 8 hari persampelan dengan menggunakan perangkap cahaya. Spesies ini terdiri daripada famili Erebidae (14 spesies), famili Uraniidae (2 spesies), famili Notodontidae (1 spesies), famili Sphingidae (5 spesies), famili Cossidae (2 spesies), dan famili Lasiocampidae (1 spesies). Famili Erebidae merupakan famili yang paling dominan di kawasan ini berbanding famili lain. *Lymantria Lepcha* daripada famili Erebidae dan *Lyssa zampa* daripada famili Uraniidae merupakan spesies yang paling banyak dicatatkan. Secara keseluruhannya, nilai indeks Shannon-Wiener ( $H'$ ) ialah 4.63. Hal ini menunjukkan bahawa Universiti Malaysia Kelantan, Jeli Kelantan mencatatkan keadaan alam sekitar yang stabil dan mempunyai kepelbagaian sederhana besar spesies rama-rama dengan taburan yang seragam. Rama-rama memainkan peranan penting dalam menentukan ekosistem di Universiti Malaysia Kelantan. Oleh hal yang demikian, cadangan penyelidikan perlu dilakukan pada masa depan termasuk pemantauan jangka panjang untuk menilai kesan perubahan alam sekitar dan usaha pemuliharaan untuk mengurangkan pencemaran cahaya dan memelihara habitat rama-rama.

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## LIST OF ABBREVIATIONS

MyBIS	- Malaysian Biodiversity Information System
UV	- Ultraviolet
UMK	- Universiti Malaysia Kelantan
IUCN	- International Union for Conservation of Nature
p.m.	- Post meridiem
600W	- 600 watt

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## LIST OF SYMBOLS

E	- East
N	- North
H'	- Shannon-Wiener Index
°	- Degree
C	- Celsius
F	- Fahrenheit

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# CHAPTER 1

## INTRODUCTION

### 1.1 Background of Study

The group of creatures related to butterflies are the moths (Insecta: Lepidoptera), which have two sets of broad wings covered in tiny scales. Typically, they are held flat in a sitting position and have vibrant colors. The word "moths" comes from the Scandinavian word "mott," which means "maggot," maybe alluding to moth caterpillars. In addition, there are over 165,000 species of moths worldwide, both micro- and macro-moths, many of which have not yet been described. It is generally accepted that flowering plants were a major evolutionary partner for both adult and larval lepidopteran species (butterflies and moths). In terms of evolution, the micro-lepidoptera in moths are often more rudimentary than the macro-lepidoptera (Perveen & Khan, 2018).

The study of diversity and abundance of moths (Lepidoptera: Heterocera) needs to be studied in a broader perspective and to be updated in dealing with the complex nature of diversity and abundance. All insects belonging to the order Lepidoptera that are not butterflies are referred to as moths. (Hangay et al., 2008). However, because Lepidoptera are highly sensitive to changes in their environment, elements like temperature, humidity, wind, and rainfall have a significant impact on both the abundance and rate of growth of this community.

When there is an environmental disruption, lepidoptera abundance will decline. Lepidoptera are a model organism that many researchers use to evaluate the effects of pollution and human disturbance as well as management techniques on the forest ecosystem (Chowdhury et al., 2023). Because of this, lepidoptera are increasingly acknowledged as a bioindicator of the health of ecosystems. Most moth species are nocturnal,

while some are diurnal and crepuscular.

## 1.2 Problem Statement

Study on the diversity and abundance of moths in Universiti Malaysia Kelantan, Jeli, Kelantan is still lacking and inadequate. To date, there is not much data about moths diversity in the selected study sites. Hence, this study is timely as it will give an insight into the diversity and abundance of moth species in Universiti Malaysia Kelantan, Jeli, Kelantan.

## 1.3 Objective

- i. To determine species diversity and abundance of moths in Universiti Malaysia Kelantan, Jeli, Kelantan.

## 1.4 Scope of Study

This study will be carried out to evaluate the species diversity and abundance of moths in Universiti Malaysia Kelantan, Jeli, Kelantan. Light traps will be used as a method to sample nocturnal moths for the duration of 8 days and field sampling will be done in March 2024. Shannon-Weiner Index and rarefaction curve will be performed to determine the diversity and abundance of moths. Species accumulation curve will be plotted to ensure the completeness of sampling.

## 1.5 Significance of Study

The study provides baseline data of moth in Universiti Malaysia Kelantan which could be utilized comparatively by other researchers. It also provides an inventory list and vouchers specimens of the moth species composition. This study

contributes to the insect collection of Natural Resources Museum, Universiti Malaysia Kelantan, Jeli, Kelantan. In addition, the Malaysian Biodiversity Information System (MyBIS) is used to identify the moths species that have been obtained.



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## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Morphology of Moths

Moths are classified according to their unique morphological characteristics and consist of three distinct body segments, the head, thorax, and abdomen.

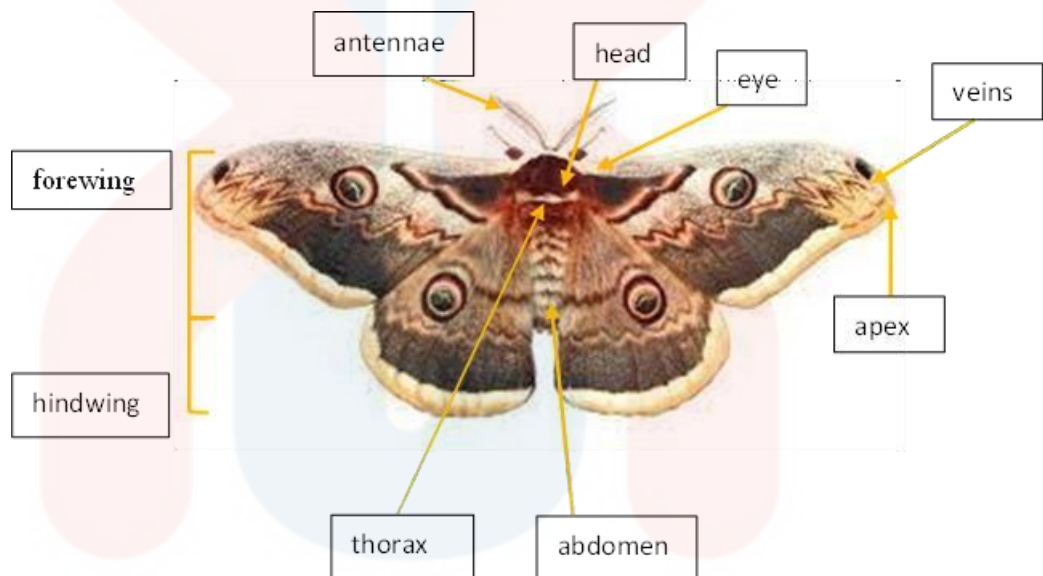


Figure 2.1: Structure of Moths

##### 2.1.1 Head

According to Evans W.H. (2014), like the heads of other animals, the moth's primary sensing and feeding organs are in its head. The head has two antennae, two compound eyes, two palpi, and a proboscis, among other distinguishing characteristics. Ocelli are present in lepidoptera and might be visible or not. They also have chaetosemata, which are sensory organs with primarily unknown functions. The brain, the sucking pump, and the muscular bundles that are connected to them are the three main components of the head. Larvae possess mandibles that are just segmented, unlike adults. Lamellar, or hair-like, scales cover the head. These scales

are classified as smooth-scaled when they are located near to the head, or rough-scaled when they are found in tufts on the face or vertex. The sensory organs and architecture of the skull differ greatly from one another. These features' existence or absence, as well as their form and shape, are important taxonomic cues that help classify species into families.

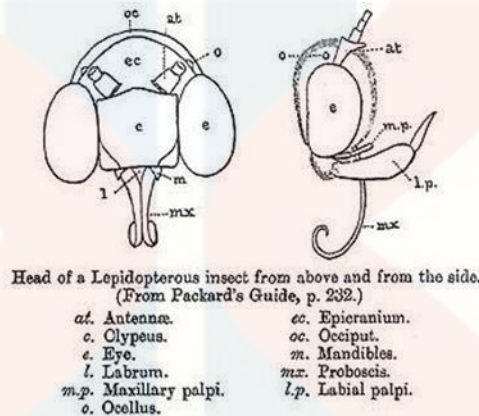


Figure 2.2: Head of a Lepidoptera insect from above and from the side.

The shape of the antennae varies greatly between species and even between the sexes. Prominent paired appendages with several segments, antennae extend forward between an animal's eyes. According to John L. Capinena (2008), moth antennae can be hooked, clubbed, thickened, filiform (like thread), unipectinate (like comb), or bipectinate (like feathers). An example of a species having bipectinate antennae is *Bombyx mandarina*. A few moth families, including Castniidae, have knobbed antennae that resemble moths antennae.

The main organs of olfaction, or smell, in Lepidoptera are the antennae. As many as 1,370,000 olfactory scales, hairs, or pits cover the antenna surface of a monarch. Male moths typically have featherier antennae than female moths in order to detect the female pheromones from a distance. Because they do not required to locate men, the antennae of females are simpler.

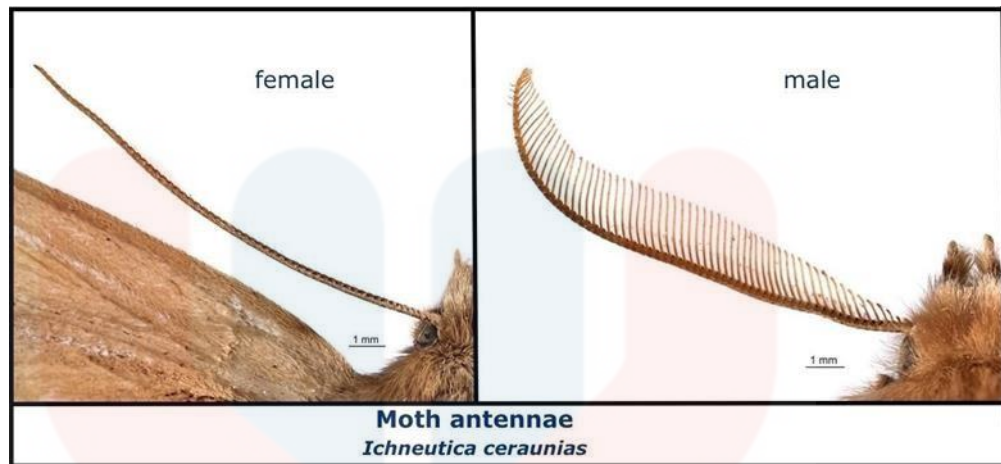


Figure 2.3: Structure of clubbed antennae between female and male moths  
(Butterfly – Preston Park, 2023).

Lepidoptera have two enormous, immovable compound eyes that are composed of several facets or lenses, each of which is attached to a lens-like cylinder and a nerve that sends information to the brain. Up to 17,000 different light receptors, or ommatidia, may be identified in each eye (G, 2023). Together, these receptors provide a large mosaic image of the surrounding area. The eyes may have minute hairs covering them even though they are ordinarily smooth. All Lepidoptera species have only two simple eyes, or ocelli, one on each side of the head close to the edge of the compound eye, except for a few moth species. Most insects, on the other hand, have three basic eyes.

Lepidoptera vision is mostly attributed to ultraviolet (UV) light that use to detect the color and pattern of moth wings. Their wing patterns under UV light differ greatly from those under normal light. The UV pattern acts as a visual cue to assist distinguish between species, which facilitates mating. As a result, research has been done on Lepidopteran UV-illuminated wing patterns, particularly on moths. This is because the larvae tear up the plant material they eat using their mandibles. Although

the labium, or lower jaw, is weak, it may have an organ called a spinneret that is used to make silk. Each of the broad lateral lobes that make up the head has an ellipse that can contain up to six simple eyes (Thomas R. et al., 2020).

### 2.1.2 Thorax

The prothorax, metathorax, and mesothorax are the three invisibly divided segments that make up the thorax, which develop from larval segments 2, 3, and 4. The thorax support the legs and wings, the organs used by insects for locomotion. The prothorax supports the front legs, the mesothorax support the front wings and a pair of middle legs, and the metathorax support the hindlegs and hindwings (Foster & Walker, 2019).

The two pairs of membrane wings on adult Lepidoptera are typically entirely coated in microscopic scales. A wing is made up of an upper and lower membrane joined by tiny fibres and reinforced by a network of thickening hollow ribs, popularly but incorrectly referred to as "veins" because they can also include blood vessels, nerve fibres, and tracheae. Tiny scales with hairs or jagged ends that are fastened to the membranes by hooks covering them. The thoracic muscles contract and expand quickly, moving the wings.

The mesothorax and metathorax segments give birth to the wings, which are similar in size in the basal groups. The mesothorax wings of more derived groups have larger vein structures on the costal edge and stronger musculature at their bases. Wings serve the dual purposes of flight and self-defense in addition to their additional roles in camouflage and thermoregulation (barb, 2014). Certain families of Lepidoptera, like the Psychidae and Lymantriidae, have wings that are either reduced in size or completely missing (usually in the female but not male).

### 2.1.3 Scales

According to Perveen & Khan (2017), scales are classified into three groups such as blade, piliform, lamellar, and other variable shapes. Its function is to cover the head, thorax, abdomen and genitals. Supported by Dmitry Grodnitsky & Kozlov (1991) stated that, the scales Lepidoptera (the insect order encompassing moths and butterflies) are integral to their structure, coloration, and various functions. Scales are small, modified hairs that cover the wings and bodies of moths and butterflies. These scales are formed from a protein called chitin, arranged in overlapping layers. (Dinwiddie et al., 2014).

Scales overlap like roof tiles, providing insulation, aiding in flight, and protecting the delicate wings underneath. Scales are attached to the exoskeleton of the insect and can easily detach, often leaving a powdery residue when touched or rubbed off. This powdery residue is composed of the scales themselves (Etymonline, 2018). The color of scales is due to various factors, including pigments present in the scales themselves and the structural arrangement of the scales, which can cause light interference and create iridescence. According to Doekele Stavenga et al., (2020), scales contain pigments such as melanins (blacks and browns), carotenoids (yellows and oranges), and flavonoids (reds and blues). The combination of these pigments results in the vast array of colors seen on moths and butterflies.

The function of scale include camouflage. Scales play a crucial role in camouflage, allowing moths and butterflies to blend in with their surroundings, avoiding predators or aiding in hunting prey. Next, the function of the scale is to help moths thermoregulate. The arrangement of scales can help regulate the temperature of the insect's body by trapping or releasing heat. They can absorb solar radiation or reflect it away. In addition, it also helps in communication and mate selection. This is

because, according to Williamson (2023), Vibrant and intricate patterns on wings, created by scales, are often used in mating rituals and species recognition. These patterns can help individuals identify potential mates and assess their fitness for reproduction.



Figure 2.4: Copper Underwing Moth camouflaged on tree bark.

#### 2.1.4 Abdomen

Abdomen consists of eight segments and terminal genitalia. The abdomen is usually soft and at the tip of the abdomen the female moth will often have a hairy lobe. The females of some butterflies have an odor-emitting organ located at the tip of the abdomen. While males have a pair of clamps associated with the genitalia combed at the tip of the abdomen that can both be seen with the naked eye (Perveen & Khan, 2017).

The abdomen of moths is a vital body segment that houses several important organs, including the genitalia and cloaca. The genitalia of moths and butterflies show significant differences between males and females, often crucial for species identification and classification (Museum, 2000). In many moth species, male genitalia can be quite complex and are often used in taxonomy to distinguish between species.

They can have various structures, including claspers used during mating. Female genitalia are less studied but are also important for species differentiation. They often have specialized structures for receiving and storing sperm (Rogers et al., 2015).

The cloaca is a chamber at the end of the digestive, urinary, and reproductive tracts in many animals, including moths. It serves as a common opening for the release of feces, urine, and gametes (reproductive cells) in some species. In certain Lepidoptera, the cloaca might be involved in the deposition of eggs or sperm during mating. The abdomen in moths and Lepidoptera, like in many insects, plays a crucial role in reproduction and waste elimination. The abdomen of lepidopteran insects has a cloaca at the end. This include the anus and ovipore alone, or it could be partial. (New Zealand Journal of Zoology, 2023).

## 2.2 Life Cycle of Moth

According to Joan (2022), moths typically begin their life cycle as eggs. Female moths lay their eggs on suitable host plants, often selecting specific plants that can provide adequate nourishment for the emerging caterpillars. Depending on the species, females may lay one egg or many eggs at a time. Most animals affix their eggs to the host plants that the caterpillar will consume. The size, shape, and color of the eggs vary among different moth species. The duration of the egg stage varies depending on environmental conditions, but it generally lasts from a few days to a few weeks. Less than 100 to more than 1000 eggs can be produced per female. (Arbogast et al., 1980). Moth (2016) stated that temperature below  $-8^{\circ}\text{C}$  ( $18^{\circ}\text{F}$ ) can killed moths larvae.

Upon hatching from the egg, the moth enters the larval stage, known as the caterpillar phase. During this stage, the caterpillar's main goal is to feed and grow rapidly. Caterpillars have voracious appetites and consume large amounts of plant material, often the leaves of the host plant on which they were laid (Orkin, 2021). As

they grow, caterpillars periodically shed their outer skin in a process called molting, allowing them to accommodate their increasing body size. The duration of the larval stage can vary significantly, lasting from weeks to months, depending on the moth species and environmental conditions.

When the caterpillar has completed its growth phase, it undergoes a process called pupation, during which it transforms into a pupa, also known as a chrysalis. Inside the protective casing of the pupa, the caterpillar undergoes a remarkable metamorphosis, during which its tissues are broken down and reorganized into the adult moth's structures. This process involves the development of the wings, legs, antennae, and other adult features. According to Croft (2022), the duration of the pupal stage also varies among different moth species and can last from a few days to several months, depending on environmental conditions such as temperature and humidity.

After completing the transformation within the pupal casing, the adult moth emerges. The adult moth is sexually mature and ready to engage in the process of reproduction. Adult moths have specialized mouthparts that are often adapted for feeding on liquids, such as nectar from flowers. Their primary goal at this stage is to find a mate and reproduce, thereby completing the life cycle. Adult moths often have distinct behaviors and characteristics that enable them to find suitable partners, locate appropriate food sources, and ensure the survival of the next generation. The lifespan of adult moths can vary significantly depending on the species, ranging from a few days to several weeks or even months. It is also crucial that the moth's preferred food source is present. Webbing clothing moths usually have a life cycle that lasts between 65 and 90 days. Certain kinds of moths can live up to thirty days, while the immature stages alone can take up to three months to complete (Orkin, 2021).

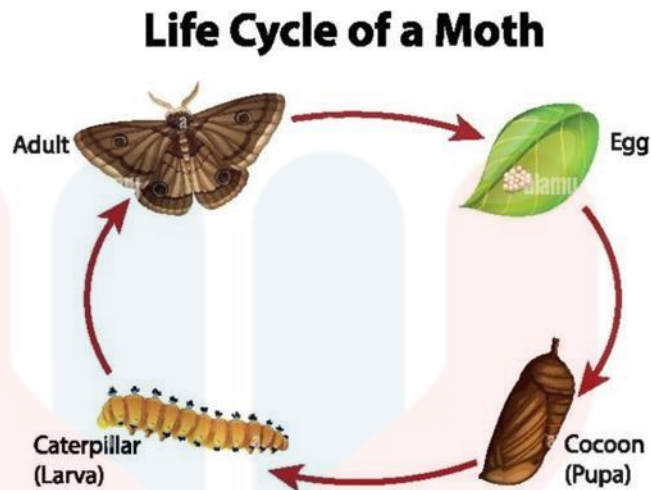


Figure 2.5: Life cycle of moth (life, 2019).

### 2.3 Classification of Lepidoptera

One of the world's most varied insect groups, the Lepidoptera, includes moths and butterflies (Holloway et al., 2001). The word "Lepidoptera" comes from the Greek "scaly winged," which describes the distinctive layer of tiny dust grains that resemble scales on the wings. Because of that, butterflies and moths are closely related to each other because they have almost the same characteristics. Moths are classified as paraphyletic groupings within the Lepidoptera, whereas butterflies and skippers are considered monophyletic groups (Isman, 2005). Moths are classified as paraphyletic groupings within the Lepidoptera, whereas butterflies and skippers are considered monophyletic groups (Isman, 2005). There are two suborders of moths: Macrolepidoptera, which includes large moths, and Microlepidoptera, which includes small moths. Over 32 families of moths have been identified worldwide, with varying colours, sizes, and wings.

The group of smaller moths, which includes microlepidoptera, often exhibits incredible diversity in terms of species numbers and ecological niches. Some microlepidoptera species might indeed have greater species richness compared to

certain groups of macrolepidoptera. Regarding their evolutionary position, some studies, like the one referenced (Kawahara et al., 2019), have suggested that certain smaller moths could retain more primitive or ancestral characteristics compared to larger butterflies and moths. This might imply that they exhibit traits or behaviors that have been conserved over evolutionary time, potentially reflecting characteristics of their ancestors.

As for the variety of plant parts utilized by Lepidoptera species, this order showcases an extraordinary range of ecological adaptations. Different species within the Lepidoptera order have evolved to exploit various parts of plants for feeding, mating, or shelter. This includes twigs, fallen material, leaves, buds, roots, fruits, seeds, trunk, bark, branches, and flowers. The diversity of host plants and plant parts utilized by Lepidoptera species reflects their ecological adaptability and the co-evolutionary relationships between these insects and the plants they interact with (van et al., 2021).

Some Lepidoptera larvae exhibit carnivorous behavior by preying on other insects. For example, certain species of the (Oecophoridae) and (Pyralidae) are known to feed on egg masses of spiders or another Lepidoptera. Additionally, larvae from families such as (Noctuidae) and (Batrachedridae) may target scale insects or ant larvae as part of their diet. For the Epipyropidae family, it is known for its ectoparasitic lifestyle.

Their larvae attach externally to plant bodies and leaf funnels, feeding on hemolymph (insect blood) as a source of nutrition. Different from the Tineidae family. They exhibit specialized feeding habits in which the larvae feed on materials of animal origin, particularly fur and keratin. This behavior is commonly observed in clothes moths, which attack materials such as fur, wool, feather, and other animal-based products (Foote, 1977). Moths are divided into many families that have different

morphological characteristics. The following families include most moth species Noctuidae, Geometridae, and Saturniidae (Smithsonian Institution, 2023).

The Noctuidae family is the largest of the moths, with about 25,000 known species in the world. Cutworms, fruit caterpillars and underwing moths are found in this Family. Noctuidae species exhibit diverse characteristics in terms of size, color and habitat preferences. Most of these moths are nocturnal, and their caterpillars, often called cutworms or armyworms, can be significant agricultural pests. Meanwhile, Geometridae with some 15,000 described species, this family is the second largest of moths in the world. Larvae are usually called inchworms because of their walking patterns. They are also known as inch worms or spanworms, forming another broad family. They are characterized by a distinctive looping caterpillar movement. Geometridae species exhibit diverse color patterns and body shapes. Their larvae often have unusual camouflage adaptations, resembling twigs or leaves.

This family includes various species that occupy various habitats around the world. The family Saturniidae, on the other hand, is often known for its members' large size and beautiful, often brightly colored wings, including some of the largest and most spectacular moths. This family includes the largest of moths and incorporates some 1,000 worldwide species. The Luna Moth of the Eastern United States is an example of this Family. Saturniidae moths are commonly known as silk moths. Their caterpillars, or silkworms, spin silk cocoons. They are known for their economic importance in silk production, especially the domesticated silkworm, *Bombyx mori*.

#### 2.4 Importance of Lepidoptera for Ecosystems

Lepidoptera, which includes butterflies and moths, play several important roles in the ecosystem. This process is important for the survival of many plant species and the production of fruits and seeds. Moths are pollinators because they feed on nectar from flowers. It directly transfers pollen from one flower to another and helps in plant

reproduction. Lepidoptera are often said to be indicators of environmental health. The presence or absence of species of moths can indicate the health of the ecosystem. This is because, they are sensitive to climate change, pollution, habitat loss and other environmental factors making them valuable indicators of overall ecosystem health. Therefore, by monitoring their population, it can provide insight into the state of the environment (Krenn, 2010).

According to Strand (2008), lepidoptera are important because they contribute to the nutrient cycle. The feeding habits of caterpillars contribute to nutrient cycling in the ecosystem. This happens when they eat plant material, they break down organic matter that helps in decomposition. This is because their waste contains nutrients that enrich the soil and benefit plant growth. The contribution of lepidoptera to the ecosystem is to provide various aspects of biodiversity and ecological balance. Moths especially are an important part of the ecosystem. They do pollination and are part of the food chain.

## 2.5 Factor affecting lepidopterans diversity.

Numerous variables can impact the diversity and distribution of the insect order Lepidoptera, which includes moths and butterflies. Comprehending these variables is crucial for ecological management and conservation endeavors. The loss and fragmentation of habitats are among the primary factors influencing the diversity of Lepidoptera. Because there are less appropriate breeding and foraging locations available because of human activities like deforestation, urbanization, and agricultural growth, the variety of Lepidoptera can be greatly impacted. (Nadeau, Urban & Bridle 2017).

Next, is climate change. Temperature variations, patterns of precipitation, and extreme weather can all have an impact on lepidopteran behavior and life cycle, as

well as host plant distribution and abundance. Lepidoptera's survival and ability to reproduce may be impacted by a mismatch that arises between its emergence and the host plants because of climate change. Also, the application of insecticides. According to Tilman et al., (2011), lepidoptera can suffer direct harm from the widespread use of pesticides in urban and agricultural regions, as this can reduce their food supplies and interfere with their life cycle. Lepidoptera can also be indirectly impacted by pesticides by the removal of their host plants or by ingestion of tainted nectar or foliage.

Other than that, it is a species that has spread. Lepidoptera can fluctuate in range and abundance because of the introduction of non-native plant species or pests that can affect the availability of host plants for them. Lepidoptera larvae are a source of prey for invasive species, which can affect their populations by directly competing with natural host plants (Burghardt et al., 2010). In addition, the habitat's variety, and quality. Diversity among Lepidoptera is increased by the existence of a wide range of plant species, including trees, blooming plants, and natural host plants. Maintaining a A diversified Lepidoptera community requires habitats that are healthy, well-maintained, and provide an appropriate microclimate, food sources, and refuge.

Moreover, agriculture and land usage changes. The disruption of Lepidoptera populations and consequent decline in their diversity might result from the conversion of natural habitats to agricultural land or urban areas (Botham et al., 2015). The availability of host plants and nectar supplies for Lepidoptera can be decreased by monoculture farming methods, which might impact the insects' capacity to survive and reproduce. Finally, according to Kelly Brenner (2018), there are parasites and natural predators. Lepidoptera populations can be managed by interactions with natural predators and parasitic species. The variety and quantity of Lepidoptera can be strongly

impacted by modifications to the dynamics of the predator-prey relationship or by the introduction of new predators. Thus, to effectively apply conservation methods, habitat management techniques, and policy interventions aimed at preserving and enhancing the diversity of Lepidoptera in diverse ecosystems, it is imperative to understand these elements and their relationships (Symondson et al., 2002).

## 2.6 Attraction to light

Moths are positive phototactic which means that they really like light. (Simon Leather 2005), Moths will be guided by natural light sources such as the moon and stars for navigation. However, when artificial light is present, as will be done in this research, for example light traps moths will become uncertain. According to Jonason et al., (2014), they will rotate until they are close to the light. This is likely due to instinctive and evolutionary behavior developed over time when natural light sources are the primary navigational aids. Moths think a lot of food or insects will be in the light. Light traps are the most widely used and most efficient method to survey nocturnal insects, especially moths.

Although light traps provide the best method for collecting data, there are many factors that affect the abundance and catch in light traps. It is affected by month, day, season, and sampling period. Abiotic factors include temperature, rain, moonlight, and cloud cover (Holyoak et al., 1997). Trap nights should be done on moonless nights that occur at the beginning or at the end of the descending cycle. Light traps should be carried out at night because the moths' activity is maximum at that time (Robinson & Tuck, 1993; William, 1939, 1940; Chey, 1994).

## CHAPTER 3

### MATERIAL AND METHOD

#### 3.1 Study Area

Universiti Malaysia Kelantan (UMK), Jeli, Kelantan (N 5° 44' 45.5244 E 101° 51' 56.9736) is a government university. This university was established during the presentation of the Ninth Malaysia Plan in 2006. Sampling of moths was conducted at UMK in March 2024. Sampling was conducted at UMK Court, Universiti Malaysia Kelantan, Jeli, Kelantan. Various flora and fauna found around UMK Court (N 5° 44' 39.2784 E 101° 51' 46) makes it an area where many species of moths are found.



Figure 3.1: Maps of Universiti Malaysia Kelantan, Jeli, Kelantan.

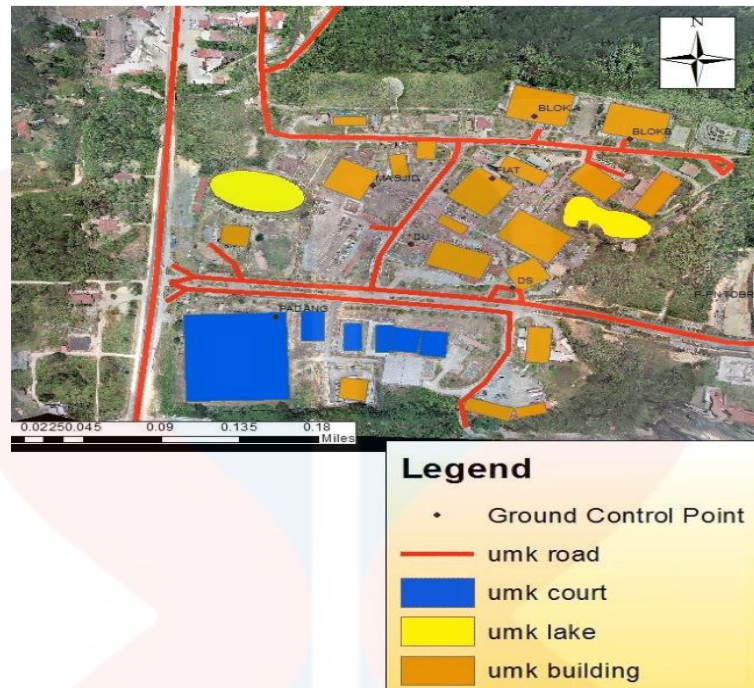


Figure 3.2: Maps of UMK Court, Universiti Malaysia Kelantan, Jeli, Kelantan.

### 3.2 Material

Table 3.1 indicates the materials and apparatus that have been used during the sampling of moths species and preparation items that have been used to mount, preserve and identify moths.

Material	Description
Portable Light Trap	Made from dusbin (12-gallon volume) covered with polyplast impra board. 600W rechargeable portable bulb is hung on the bin cover.
Ethanol	Moths was killed
Entomology set	Basic equipment used when identifying moths
Spreading board	Mounting moths
Labelling paper	Information or data about moths

Table 3.1: shows the material and apparatus.

### 3.3 Method

#### 3.3.1 Data collection

A portable light trap has been used to sample moths at Universiti Malaysia Kelantan, Jeli, Kelantan. This is the most common method used to sample Lepidoptera and capture various species of moths. This portable light trap was chosen because it is easy to move from one location to another. This light trap has been installed at UMK court, Universiti Malaysia Kelantan, Jeli, Kelantan for eight days.

These light traps are set up between 8:00 p.m. and 11:00 p.m. local time and collected the following day. This light trap uses a 600W rechargeable portable bulb. The design of the light trap is a dustbin (12-gallon volume), has a large funnel using polyplast impre board as a stable stand for the bulb that is easy to open and clean and is equipped with a rain cover. A container filled with ethanol is placed under it. Moths will be attracted to the bulb and then fly towards the light and fall into the container under the funnel. Polyplast impre board should not be too close to the bulb because it can melt the plastic which will produce a smell that causes moths not to fly towards the light trap.



Figure 3.3: Portable light trap.

### 3.3.2 Specimen preservation

Specimen preservation was carried out at the UMK laboratory, Jeli, Kelantan. Each specimen of moths has been preserved by sorting, spreading, pinning, and labeling. Samples of moths collected from field sampling will be labeled with data on collection date and locality. All specimens will be taken to the laboratory for identification purposes. Specimens will be spread on a spreading board with small labels on the moths containing information such as date, location and species for species identification purposes.



Figure 3.4: Sorting of Moths were done in laboratory.



Figure 3.5: Dissecting of moth was done in laboratory.



Figure 3.6: Labelling Note of The Moth Specimen.



Figure 3.7: The Moths Were Spread on Spreading Board in Laboratory.

### 3.3.3 Moths identification

The specimens have been categorized into families and then further sorted based on the specimens species identification Publication referred to were Barlow (1982) and Holloway (1983, 1985, 1988, 1989, 1993, 1996, 1997, 1998, and 1999). The number of individual specimens for every species were also counted.



Figure 3.8: Moths Labeling of Family and Species Name.

### 3.3.4 Data analysis

#### a) Shannon-Wiener Index

In the Shannon-Wiener Index,  $p$  is the proportion ( $n/N$ ) of individuals of one particular species found ( $n$ ) divided by the total number of individuals found ( $N$ ),  $\ln$  is the natural log,  $\Sigma$  is the sum of the calculations, and  $s$  is the number of species.

$$H' = - \sum [ (n_i / N) \ln (n_i / N) ]$$

Where the range is between  $H'_{\max}$ ,  $H'_{\max} = \ln s$

$H'$  = Shannon-Wiener Index

$N$  = Total individual in a population

$n_i$  = Total individual for  $n_i$  species

$s$  = Number of species

#### b) Species Accumulation Curves

The data collected from the sampling were analyzed using the species accumulation curve. The species accumulation curve is a visual representation that illustrates the relationship between the number of species discovered and sampling effort. As sampling effort increases, more species are typically discovered. This curve is constructed by plotting the number of observed species against the cumulative sampling effort. The sampling effort could be represented by various metrics, such as the number of samples collected, the area surveyed, or the time spent collecting data.

### c) Rarefaction Curve

Rarefaction is a technique to assess species richness from the results of sampling. It enables the determination of species richness for a specific number of individual samples based on the development of rarefaction curves. This curve represents a plot of the number of species as a function of sample size using PAST 4.03 software.

## CHAPTER 4

### RESULTS AND DISCUSSION

#### 4.1 Overall Abundance and Species Richness

In this study, a total of 165 individuals of moths, representing 25 species and 6 families were collected in UMK, Jeli, Kelantan using light traps. Moth which consists of 6 families namely Erebiidae, Uraniidae, Notodontidae, Sphingidae, Cossidae, and Lasiocampidae were collected at UMK Court, Universiti Malaysia Kelantan, Jeli, Kelantan. The Malaysian Biodiversity Information System (MyBIS) website has been used to identify species, scientific names and families. In addition, IUCN Red List website <http://www.iucnredlist.org/> has also been used as a reference to find out the conservation status of moth's species collected. However, there is no record of moth species at this study site recorded in IUCN Red List status.

This species accumulation curve is used to estimate species richness to show the adequacy of the fauna survey in representing the fauna and to show the rate of new species found in the community at UMK Court, Universiti Malaysia Kelantan, Jeli Kelantan. The more individuals sampled, the total number of species recorded in the sample increased and the species accumulation curve was generated, and the figure showed a stable line at the end of the day indicating that there was sufficient sampling at the study site and no new species collected at the study site (Figure 4.1). The species accumulation curve (Figure 4.1) shows that the species richness estimated at the study site is asymptotic, which indicates that the 8-day fauna survey in Universiti Malaysia Kelantan, Jeli Kelantan is sufficient to determine the species richness with 25 total species collected.

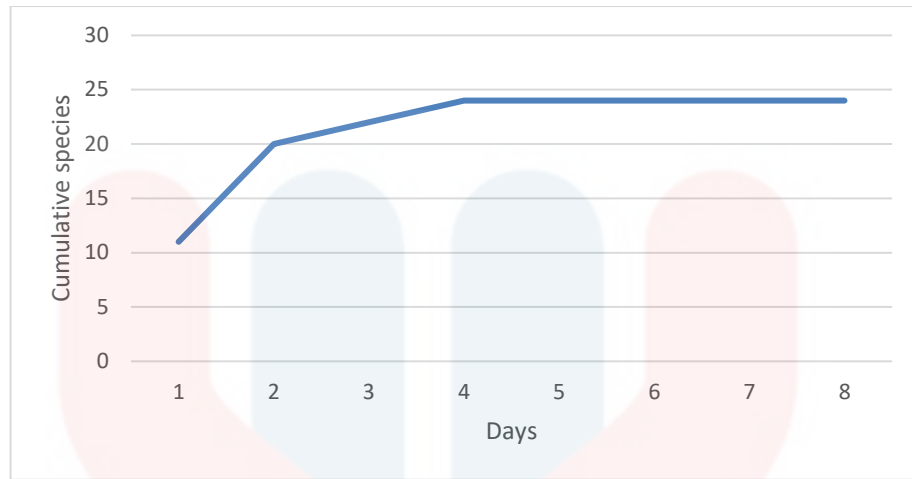


Figure 4.1: Species Accumulation Curve for Moth Species Collected in Universiti Malaysia Kelantan, Jeli, Kelantan.

Rarefaction curves are used to assess and compare species richness or species diversity and abundance. Figure 4.2 has reached an asymptote where as sampling effort increases, the rate of discovery of new species decreases, and the curve eventually flattens. This indicates that the majority of species or occurrences present in the sampled population have been observed.

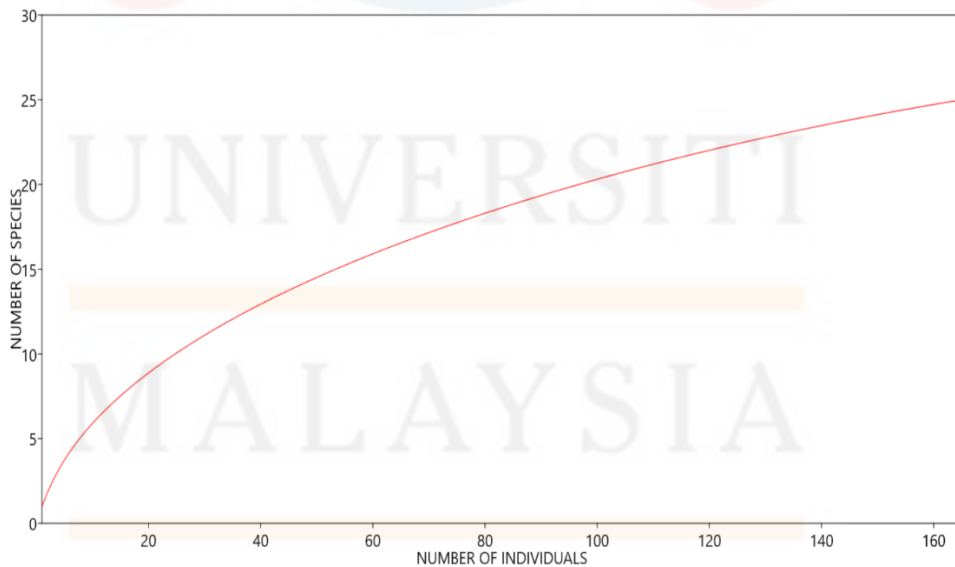


Figure 4.2: Rarefaction Curves for Moths Species.

Species abundance is the number of individuals observed for each different one species found in the community. Abundance is calculated based on the number of individual samples in each species. Based on figure 4.3, family Erebidae shows the highest number individuals of moths specimens with 14 species recorded total of 95 individuals consisting of *Lymantria Lepcha* (54 individuals), *Lymantria dispar* (17 individuals), *Tinolius eburneigutta* (7 individuals), *Euproctis fimbriata* (4 individuals), *Arctornis spp*, *Eudocima phalonia*, and *Nyctemera amica*, each recorded 2 individuals. *Asota egens confinis*, *Asota speciosa*, *Cyclodes cf. omma*, *Cretonotos transiens*, *Asota caricae*, *Erebus ephesperis* and *Mocis* each recorded as much as one individual or singleton species. Meanwhile, the lowest number of individuals of moths specimens are from the family Lasuicampidae which recorded as many as 2 individuals from the *Trabala vishnou* species.

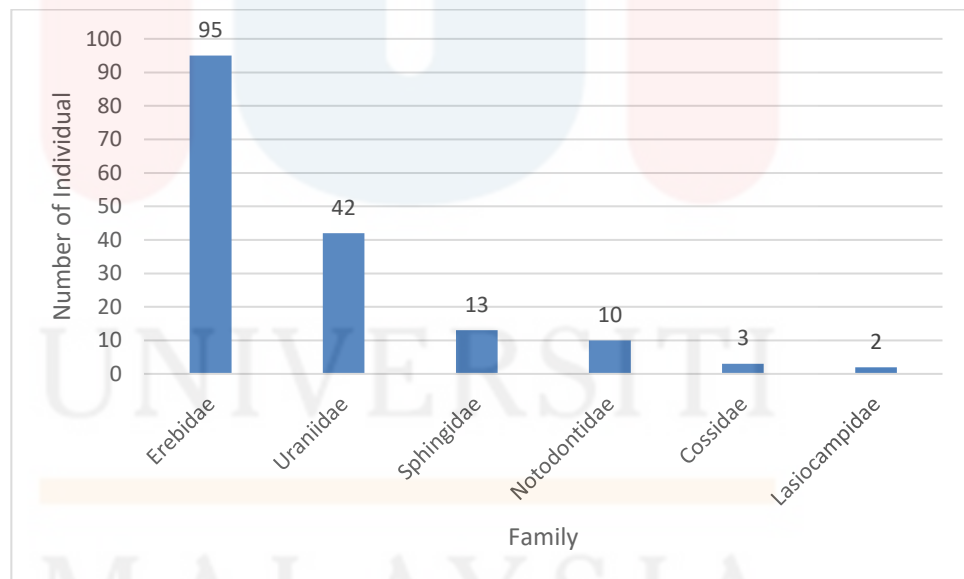


Figure 4.3: Number of Individuals of Each Family of Moths.

## 4.2 Species Diversity

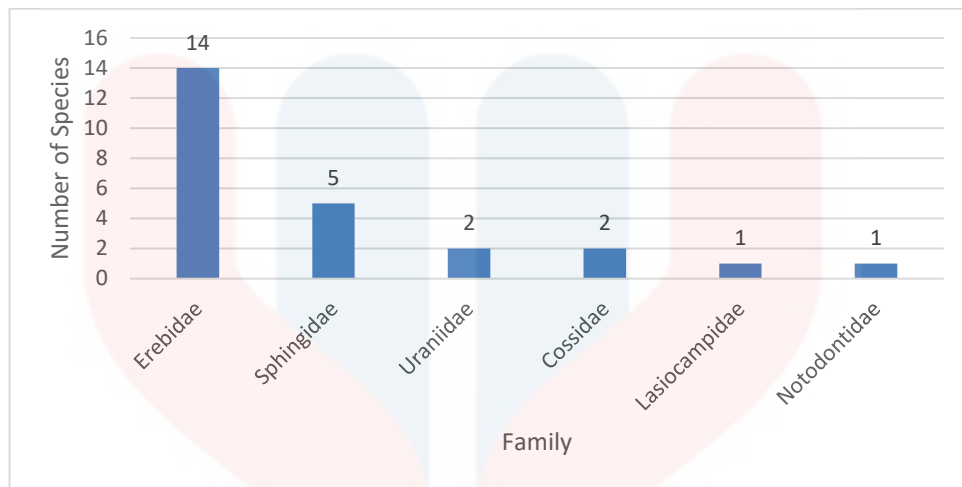


Figure 4.4: Number of Species of Each Family of Moth Collected in Universiti Malaysia Kelantan, Jeli Kelantan.

Based on figure 4.4, the family Erebidae recorded the highest, with 14 species consisting of *Nyctemera amica*, *Tinolius eburneigutta*, *Cretonotos transiens*, *Lymantria lepcha*, *Asota caricae*, *Erebus ephesperis*, *Euproctis fimbriata*, *Mocis*, *Cyclodes cf. omma*, *Lymantria dispar*, *Eudocima phalonia*, *Asota speciosa*, *Asota egens confinis* and *Arctornis spp.*. While the family of Lasiocampidae and Notodontidae recorded the lowest, with 1 species consisting of *Trabala vishnou* and *Tarsolepis sommeri*.

Table 4.3: Shannon-Wiener Index

Symbol	Total
H'	4.63

Another widely used indicator of biodiversity is the Shannon-Wiener Index (H'), sometimes referred to as the Shannon-Wiener Index. It considers both species evenness, or the distribution of individuals among species, and species richness, or the number of species. The range of the Shannon-Weiner Index is 0 to 5. The Shannon-Weiner index for the diversity index in this study is  $H' = 4.63$ , which is

regarded as a stable environmental situation. Higher values suggest more species and more evenly distributed areas, but there is no top limit.  $H'$  has a value of 4.63. This is regarded as a rather high value, indicating that the moths community is highly diverse. Higher  $H'$  values are indicative of both richness (many species) and evenness (more even distribution of individuals within those species). This suggests a robust and thriving environment. A high number like this indicates that conservation efforts are working, but habitat management and ongoing monitoring are necessary to keep biodiversity high.

#### 4.3 Discussion



Figure 4.5: The most abundance species: *Lymantria lepcha* from family Erebidae and *Lyssa zampa* from family Uraniidae.

The most abundance species is *Lymantria lepcha* from the Erebidae family. Its characteristics are that it is unspotted apart from the discal markings and a pink suffusion towards the base of the hindwing. Host plants for *Lymantria lepcha* are Shorea (Dipterocarpaceae) and Sonneratia (Sonneratiaceae) trees. This species recorded as many as 54 individuals out of 95 individuals from the Erebidae family. Apart from *Lymantria lepcha*, the most abundance species is *Lyssa zampa* from Uraniidae family. This species recorded as many as 32 individuals out of 42 individuals from the Uraniidae family. *Lyssa zampa* has a paler gray-brown zone (more pronounced in females) immediately distal to the white stripe on the upper

side, and there is a darker stripe on the back of the distal wing. Both sexes have wider bands on the apical and dorsal corners of the hindwing.

On the underside there is a more or less even scattering of dark lines distal to the white band, slightly more emphasized on the hindwing. In *menoetius* this zone is not striped on the forewing, and the hindwing stripes resemble the upper ones. Host plant for *Lyssa zampa* are *Endospermum* (Euphorbiaceae) and *Eugenia* (Myrtaceae) species. This species has been found to be active both during the day and at night. This species is also known for its mass emergence and migration. Because of that ecology and the habit that they are often attracted by urban bright lights, this species can attract human attention.

The least species of moths found are *Cretonotos transiens*, *Asota caricae*, *Erebus ephesperis*, *Asota speciosa*, *Asota egens confinis*, *Mocis*, *Cyclodes cf. omma* from the family Erebidae, *Callanbulyx amanda* from the family Sphingidae, and *Zeuzera indica* from the family Cossidae. Each record one individual or is called a singleton species. Singleton species show a rare occurrence due to specific habitat requirements and limited availability of host plants. Unsuitable environmental conditions for some populations cause a species to be less in the sampling environment because moths are very sensitive to environmental temperature changes.

*Lymantria lepcha* and *Lyssa zampa* are the most abundant, showing that they are well supported by the local flora. Singleton species, on the other hand, suggest multiple ecological niches and host plant dependencies that may limit their abundance in the surveyed area. This diversity indicates a complex ecosystem with varying host plant availability that affects moths populations.

## CHAPTER 5

### CONCLUSION AND RECOMMENDATIONS

#### 5.1 Conclusion

This study aimed to analyze the abundance, species richness, and diversity of moths at Universiti Malaysia Kelantan, Jeli Kelantan. The results confirmed the successful attainment of the study's objectives. The findings revealed that the most abundant species were *Lymantria lepcha* from the family Erebidae and *Lyssa zampa* from the family Uraniidae. The diversity indices calculated, Shannon-Wiener Index ( $H' = 4.63$ ), indicate a stable environmental condition for moth diversity. The study highlights the importance of specific host plants, such as *Shorea* and *Sonneratia* for *Lymantria lepcha*, in supporting moth populations.

#### 5.2 Recommendations

To comprehend more general ecological patterns and the effects of various environmental conditions, future research should compare the moth diversity and abundance found in this study with other similar habitats. It is important to monitor moth populations over an extended period in order to evaluate variations in variety and abundance. This will allow researchers to better understand how human activity and climate change affect moth communities.

The restoration and conservation of natural habitats are vital to the survival of many moth species and should be pursued. Moth biodiversity will be supported by safeguarding host plants and other important environmental elements. Since moths are often attracted to artificial lights, strategies to manage light pollution in urban and semi-urban areas should be implemented. This can include using lights

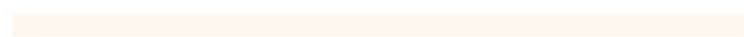
that are less attractive to moths or reducing unnecessary lighting during peak activity periods for moths. By following these suggestions, it will be possible to maintain the variety and health of moths populations, which are vital to the ecology because they are both important for pollinators and components of the food chain.



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## APPENDIX A

Checklist of Moths Species Encountered According to Family in Universiti  
Malaysia Kelantan, Jeli Kelantan.

Family	Scientific name	Abundance
Erebidae	<i>Lymantria Lepcha</i>	54
	<i>Lymantria dispar</i>	17
	<i>Tinolius eburneigutta</i>	7
	<i>Euproctis fimbriata</i>	4
	<i>Eudocima phalonia</i>	2
	<i>Nyctemera amica</i>	2
	<i>Arctornis spp.</i>	2
	<i>Cretonotos transiens</i>	1
	<i>Asota caricae</i>	1
	<i>Erebus ephesperis</i>	1
	<i>Asota speciosa</i>	1
	<i>Asota egens confinis</i>	1
	<i>Mocis</i>	1
	<i>Cyclodes cf. omma</i>	1
	Uraniidae	<i>Lyssa zampa</i>
<i>Urapteroides astheniata</i>		10
Notodontidae	<i>Tarsolepis sommeri</i>	10
Sphingidae	<i>Acosmeryx socrates</i>	4
	<i>Ambulyx pryeri</i>	4
	<i>Theretra Nessus</i>	2
	<i>Ambulyx maculifera</i>	2
	<i>Callanbulyx amanda</i>	1
Cossidae	<i>Xyleutes strix</i>	2
	<i>Zeuzera indica</i>	1
Lasiocampidae	<i>Trabala vishnou</i>	2
<b>TOTAL</b>		<b>165</b>

## APPENDIX B

Number of species, individuals and diversity index of moths collected in Universiti

Malaysia Kelantan, Jeli Kelantan.

Scientific name	Number of Individuals	Diversity Index
<i>Lymantria lepcha</i>	54	0.73
<i>Lymantria dispar</i>	17	0.47
<i>Tinolius eburneigutta</i>	7	0.27
<i>Euproctis fimbriata</i>	4	0.18
<i>Eudocima phalonia</i>	2	0.11
<i>Nyctemera amica</i>	2	0.11
<i>Arctornis spp.</i>	2	0.11
<i>Cretonotos transiens</i>	1	0.06
<i>Asota caricae</i>	1	0.06
<i>Erebus ephesperis</i>	1	0.06
<i>Asota speciosa</i>	1	0.06
<i>Asota egens confinis</i>	1	0.06
<i>Mocis</i>	1	0.06
<i>Cyclodes cf. omma</i>	1	0.06
<i>Lyssa zampa</i>	32	0.64
<i>Urapteroides astheniata</i>	10	0.34
<i>Tarsolepis sommeri</i>	10	0.34
<i>Acosmeryx socrates</i>	4	0.08
<i>Ambulyx pryeri</i>	4	0.08
<i>Theretra nessus</i>	2	0.11
<i>Ambulyx maculifera</i>	2	0.11
<i>Callanbulyx amanda</i>	1	0.06
<i>Xyleutes strix</i>	2	0.11
<i>Zeuzera indica</i>	1	0.06
<i>Trabala vishnou</i>	2	0.11
<b>TOTAL</b>	<b>165</b>	<b>4.63</b>

MALAYSIA  
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APPENDIX C

Images of selected moths collected from the Universiti Malaysia Kelantan,  
Jeli Kelantan.



Family Erebidae  
*Lymantria lepcha*



Family Uraniidae  
*Lyssa zampa*



Family Notodontidae  
*Tarsolepis sommeri*



Family Cossidae  
*Zeuzera indica*



Family Uraniidae  
*Urapteroides astheniata*



Sphingidae  
*Collanbulyx amanda*



Family Sphingidae  
*Theretra nessus*



Family Erebidae  
*Erebus ephesperis*



Family Erebidae  
*Eudocima phalonia*



Family Erebidae  
*Asota caricae*



Family Erebidae  
*Cyclodes cf. omma*



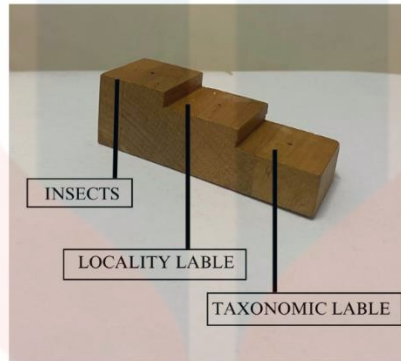
Family Erebidae  
*Tinolius eburneigutta*

MALAYSIA

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## APPENDIX D

Labeling equipment using pinning block.



pinning block and its stage



position of moth on pinning block (upper view)



position of moth on pinning block (side view)