



**DIVERSITY OF BUTTERFLIES (ORDER:
LEPIDOPTERA) IN LATA HOKKAIDO JELI,
KELANTAN**

by

MUHAMAD NIZAM BIN ISMAIL

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

**FACULTY OF EARTH SCIENCE UNIVERSITI
MALAYSIA KELANTAN**

2024

DECLARATION

I declare that this thesis entitled “Diversity of Butterflies (Order: Lepidoptera) In Lata Hokkaido 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.

Signature : 
Name : MUHAMAD NIZAM BIN ISMAIL
Date : 5 AUGUST 2024

UNIVERSITI
MALAYSIA
KELANTAN

ACKNOWLEDGEMENT

In the name of Allah, the Beneficent, the Merciful. First praise to Allah, the Almighty, on whom ultimately, we depend for sustenance and guidance. First of all, I would like to express my deepest appreciation for the opportunity to complete the project. I would like to express my gratitude towards my parents for the encouragement which helped me in completion of this study. A special gratitude I give to my supervisor, Dr. Irene Christianus, whose contribution in stimulating suggestion and encouragement, always support and help me to complete my project, especially in writing this report. Then, I would like to thanks to Universiti Malaysia Kelantan, Jeli Campus especially to the Faculty of Earth Science for the opportunity given to the final year students to do this project. A million thanks to my examiners, Dr. Norashikin Binti Mohd Fauzi and Dr. Jayaraj Vijaya Kumaran for their guidance and their precious guidelines and also giving a lot of support during my study. Credits also to my friends, Muhamad Fahmi Amin Bin Roslan and Nur Izati Binti Baharom for helping me during the field work of this study also encouraging me to complete my thesis. Special thanks, tribute and appreciation to all those whose names do not appear here who have contributed to the successful completion of this study.

UNIVERSITI
MALAYSIA
KELANTAN

Diversity of Butterflies (Order: Lepidoptera) in Lata Hokkaido Jeli, Kelantan

ABSTRACT

The research focused on the diversity of butterflies (Order: study on Lepidoptera in Lata Hokkaido, Jeli, Kelantan, which is a tropical area, tried to predict the species density, intensity, and distribution in the area. Transect walks were used to sample the butterfly species for the project in systematic field surveys done for a duration of 14 days. A total of 53 butterfly species were recorded, belonging to five families: Nymphalinae, Pierinae, Papilioninae, Lycaeninae and Hesperinae. Family distribution: The most abundant family of butterflies in the study area was Pieridae with 108 total number of individuals documented. Andary and Wojtaszek (2008) described the butterfly species composition and specific species abundance; Shi and Yang (1999) evaluated the butterfly species diversities with Shannon-Wiener Index, Species Accumulative Curve (SAC), Individual Rarefaction, Pielou's, Margalef index and the results also showed that the butterfly community had high diversities and evenness. This study on habitat preference showed general agreement and specifically suggested that the highest number of species was in the edge forest habitats, suggesting that resources such as nectar and host plants were more accessible in those areas. This paper reveals the importance of study area, Lata Hokkaido for butterfly conservation and stresses the further research and conservation efforts in this region for sheltering this rich spectrum of Lepidopteran fauna.

UNIVERSITI
MALAYSIA
KELANTAN

Kepelbagaian Butterfly (Order: Lepidoptera) di Lata Hokkaido Jeli, Kelantan

ABSTRAK

Penyelidikan ini memfokuskan kepada kepelbagaian rama-rama (Order: Lepidoptera) di Lata Hokkaido, Jeli, Kelantan, yang merupakan kawasan tropika, bertujuan untuk meramalkan kepadatan spesies, intensiti, dan taburan di kawasan tersebut. Kaedah berjalan transek telah digunakan untuk mengambil sampel spesies rama-rama dalam kajian lapangan yang sistematik selama 14 hari. Sebanyak 53 spesies rama-rama telah direkodkan, tergolong dalam lima keluarga: Nymphalinae, Pierinae, Papilioninae, Lycaeninae, dan Hesperinae. Taburan keluarga: Keluarga rama-rama yang paling banyak ditemui di kawasan kajian adalah Pieridae dengan jumlah keseluruhan 108 individu yang didokumentasikan. Andary dan Wojtaszek (2008) menerangkan komposisi spesies rama-rama dan kelimpahan spesies tertentu; Shi dan Yang (1999) menilai kepelbagaian spesies rama-rama menggunakan Indeks Shannon- Wiener, Kurva Akumulasi Spesies (SAC), Pengurangan Individu, Pielou's, Indeks Margalef, dan keputusan menunjukkan bahawa komuniti rama-rama mempunyai kepelbagaian dan keseragaman yang tinggi. Kajian ini mengenai keutamaan habitat menunjukkan persetujuan umum dan secara khusus mencadangkan bahawa bilangan spesies tertinggi berada di habitat pinggir hutan, menunjukkan bahawa sumber seperti nektar dan tumbuhan perumah lebih mudah didapati di kawasan tersebut. Kajian ini mendedahkan kepentingan kawasan kajian, Lata Hokkaido untuk pemuliharaan rama-rama dan menekankan usaha penyelidikan dan pemuliharaan yang lebih lanjut di kawasan ini untuk melindungi spektrum fauna Lepidoptera yang kaya.

UNIVERSITI
MALAYSIA
KELANTAN

TABLE OF CONTENT

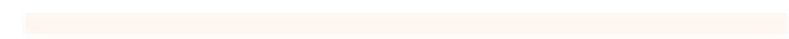
	PAGE
DECLARATION	i
ACKNOWLEDGEMENT	ii
ABSTRACT	iii
ABSTRAK	iv
TABLE OF CONTENT	v-vi
LIST OF FIGURES	vii
LIST OF TABLES	viii
LIST OF ABBREVIATIONS	ix
CHAPTER 1 INTRODUCTION	
1.1 Background of Study	1-2
1.2 Problem Statement	2-3
1.3 Objectives	3
1.4 Scope of Study	3-4
1.5 Significant of Study	4
CHAPTER 2 LITERATURE REVIEWS	
2.1 Morphology of Butterfly	5-7
2.2 Life cycle of Butterfly	8-11
2.3 Diversity and distribution of Butterfly	11-12
2.4 Importance of Butterfly	12-14
2.5 Comparison Between Butterfly and Moth	14-16
CHAPTER 3 MATERIAL AND METHOD	
3.1 Study Area	17
3.2 Materials	18
3.3 Methods	19
3.3.1 Butterflies Sampling	19-21
3.3.2 Data Analysis	21-24
CHAPTER 4 RESULT AND DISCUSSION	
4.1 Overall Species Richness and Abundance	25-34
4.2 Diversity Indices	35

CHAPTER 5 CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION	36-37
5.2 RECOMMENDATION	38
REFERENCES	39-43



UNIVERSITI



MALAYSIA



KELANTAN

LIST OF FIGURES

No.	TITLE	PAGES
2.1	General Morphology of Butterfly (Sources: Yasmin et al., 2023)	5
2.2	Head Structure of Butterfly (Source:“Lepidopteran - Metamorphosis, Wings, Antennae Britannica,” 2023)	6
2.3	Life-cycle of Butterfly (Source: Butterfly Life Cycle Pop-up Book, 2021)	8
3.1	An illustrative map depicting the precise geographical location of the designated study region. (Sources: Goggle Earth, 2024)	18
3.2	Aerial net (A) and baited trap (B)	20
3.3	Locality of line transect in Lata Hokkaido Glamping Park (Sources: Goggle Earth, 2024)	21
4.1	Species Accumulation Curves of Butterfly species collected at Lata Hokkaido Jeli, Kelantan	30
4.2	Number of Species collected from each subfamily of butterfly at Lata Hokkaido Jeli, Kelantan	31
4.3	Rarefaction curves for Butterfly species	34

LIST OF TABLES

No.	TITLE	PAGES
3.1	List of materials that will be used in this study	18
4.1	List of butterfly species in Lata Hokkaido, Jeli, Kelantan	27-29
4.3	IUCN Red List status of butterfly species collected at Lata Hokkaido Jeli, Kelantan	32-34
4.2	Diversity Indices of butterflies in Lata Hokkaido Jeli Kelantan	35
4.3	Pielou's Evenness Index	35

UNIVERSITI
MALAYSIA
KELANTAN

LIST OF ABBREVIATIONS

DMG	Margalef's Diversity Index
E	East
J'	Pielou's Evenness Index
H'	Shannon-Wiener Diversity Index
IUCN	International Union for Conservation of Nature
N	North



UNIVERSITI
MALAYSIA
KELANTAN

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The term "lepidoptera" is derived from the ancient Greek terms "lepis" and "pteron," which respectively mean scales and wings. The word "lepid-" is derived from the Latin word "lepidus" which is similar in meaning. Consequently, the name "lepidoptera" encompasses any insect that possesses scales on its wings. Both naturalists and persons from diverse fields are well-acquainted with the taxonomic order Lepidoptera, encompassing butterflies and moths. Butterflies are insects classified under the order Lepidoptera and the superfamily Papilionoidea under the insect order Lepidoptera (Nieuwerkerken et al., 2011; Kawahara & Breinholt, 2014). There is a vast array of butterfly species (Majumder et al., 2013).

Butterflies are classified under the group Papilionoidea. Based on the latest study conducted by Shields in 1989, it is estimated that there might be a total of 17,280 distinct species of butterflies worldwide. Butterflies and moths are both kinds of insects, which are classified under the class Insecta. Insects account for more than 58% of the world's total known biodiversity, making them the most abundant and diverse group of organisms. They possess the capability to thrive in virtually all environments, except for open water, and may be observed inhabiting land, air, and underwater habitats. Butterflies have always captivated collectors and other enthusiasts due to their symbolic representation of the abundance and vitality of the surrounding ecosystem. The butterfly group is often regarded as the most popular among all insect groups. The region including Thailand, Peninsular Malaysia, and Singapore is expected to have a

diverse array of butterflies, with over 1,400 distinct species identified.

Butterflies and moths are distinguished from other insects by their unique features, such as their coiled proboscises (mouthparts) and huge, vibrant wings. Butterflies, unlike many other insects, are generally admired and acknowledged for their beauty and charm. Butterflies are important study subjects in the fields of ecology, evolution, and conservation biology (Ghazanfar et al., 2016). They also hold cultural significance and are admired for their attractive appearance (Ghazanfar et al., 2016). Butterflies provide a significant and useful contribution to ecosystems worldwide.

1.2 Problem Statement

There is a significant lack of information regarding the diversity, distribution, and population dynamics of butterflies in Lata Hokkaido Jeli, Kelantan. This is surprising considering that butterflies are widely acknowledged as important indicators of ecosystem health and contributors to biodiversity. The lack of information is a significant issue that hampers our ability to develop and implement effective conservation measures to protect these species and their habitats.

The complexity of the situation is exacerbated by the potential impact of threats such as habitat fragmentation, climate change, and other anthropogenic activities on butterfly populations in the area. These variables may be influencing butterfly populations. The proposed research aims to address the existing knowledge gap by conducting comprehensive field surveys and utilising advanced statistical methods to assess the survey findings. The objective of this project is to create an extensive inventory of butterfly species present in Lata Hokkaido, analyse patterns of diversity and distribution, and investigate the influence of environmental factors such as temperature, humidity, vegetation, and other biotic and abiotic factors on butterfly

species richness.

This research will not only enhance the scientific comprehension of the butterfly diversity in Lata Hokkaido, but it will also offer crucial insights for the organisation and supervision of conservation efforts aimed at ensuring the long-term survival and welfare of these species in the area. This is because doing so will guarantee that the research is conducted in a manner that achieves both of these objectives.

1.3 Objectives

To determine the diversity of the order lepidoptera at Lata Hokkaido Jeli, Kelantan

1.4 Scope of Study

This study will focus on investigating the diversity of butterflies belonging to the order Lepidoptera that can be found in Lata Hokkaido, a specific geographical location of interest. The study aims to conduct a comprehensive examination of the many species of butterflies present in the region, including their distribution and the variables that impact the diversity of butterfly species.

A comprehensive study will be conducted to examine the diverse ecosystems present in Lata Hokkaido and their interactions with different butterfly species. The study will additionally examine the impact of environmental factors, such as temperature, humidity, and vegetation, on the establishment of the butterfly diversity in the region. The research will involve doing field surveys to gather data on the diverse types of butterflies and their population levels in different settings.

The collected data will be used to create a comprehensive catalogue of butterfly species present in Lata Hokkaido, as well as to analyse patterns of

biodiversity and distribution. To provide context for the study's findings, the research will also incorporate a comprehensive examination of previously published literature pertaining to the diverse range of butterflies present in the region.

1.5 Significance of Study

The main aim of this study was to assess the biodiversity of butterflies (Lepidoptera: Heterocera) in Lata Hokkaido Jeli, Kelantan. The transect method was employed, using aerial nets and bait traps, in order to minimise any potential adverse effects on the species being studied while still obtaining valuable research data.

The aims of this study are to assess the variety of the lepidoptera order in Lata Hokkaido and to investigate the relationship between plants and butterflies in the research area at Lata Hokkaido. The findings of this study, which document the butterfly species present at Lata Hokkaido will fill in the gap of knowledge about butterflies diversity for future reference and conservation effort.

CHAPTER 2

LITERATURE REVIEW

2.1 Morphology of Butterfly

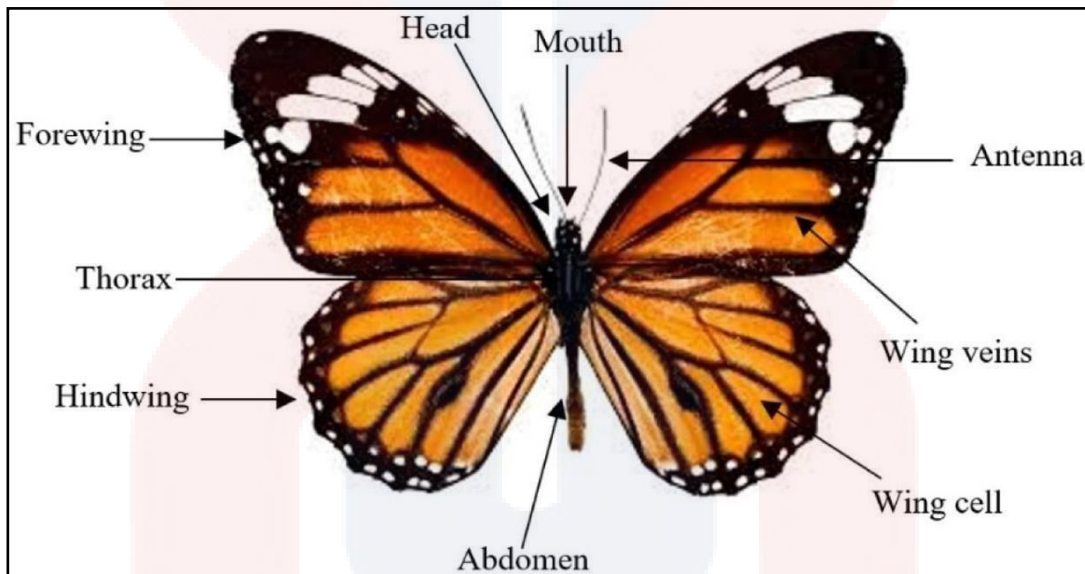


Figure 2.1: General morphology of butterfly (Source: Yasmin et al., 2023)

A butterfly is an insect belonging to the order Lepidoptera, known for its varied and vivid designs, which make them one of the most visually impressive species in the insect realm. Examining the appearance of organisms offers intriguing knowledge about their life cycle, behaviours, and adaptations for survival (Perveen & Khan, 2017). Figure 1 depicts the various elements of butterfly form. The butterfly's morphology is distinguished by its tripartite body, comprising the head, thorax, and abdomen. A butterfly possesses a pair of sizable compound eyes, a pair of antennae, a proboscis, six legs, and four wings that are vividly coloured. Every one of these elements serves a crucial function in the butterfly's ability to survive and reproduce (Perveen & Khan, 2017).

The anterior region of the organism displays a conspicuous arrangement of compound eyes, antennae (often referred to as feelers), and a mouth. The thoracic region of the body possesses three sets of appendages, namely the forelegs, midlegs, and hindlegs, in addition to pairs of wings that exhibit vivid hues. The abdominal region contains essential organs, including the digestive and reproductive systems, as well as other important organs (Kirton, 2018).

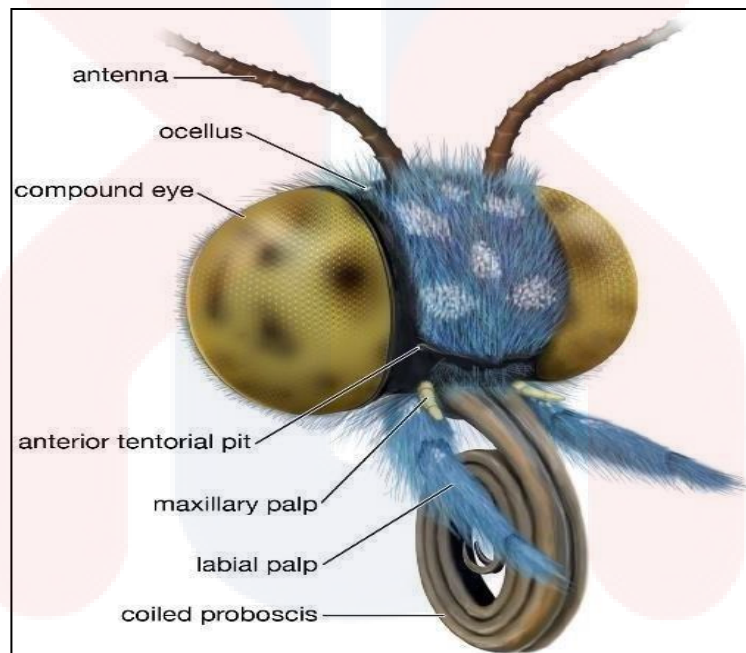


Figure 2.2: Head structure of butterfly (Source:“Lepidopteran - Metamorphosis, Wings, Antennae | Britannica,” 2023)

The head segment of a butterfly serves as the feeding and sensory center. It is characterized by its modest size, round or elliptical form, and sclerotized organization. The upper-middle region of the head is referred to as the frons. Below the frons is the clypeus, and below that is the labrum. On either side of the labrum, the edges of the mandibles may extend beyond and/or underneath, along with various parts of the maxillary palps. This is true even when viewed from the front (Chapman, 2009). The antennae of a butterfly, as seen in figure 2, serve as sensory organs that enable the butterfly to detect scents in the air, ranging from the pheromones of a potential partner

to the fragrance of flowers. Additionally, they aid in the detection of motion and contribute to balance and direction. The complex eyes of a butterfly's head are used to discern the colour patterns on flowers and the wings of other butterflies. The butterfly possesses a proboscis, which is a specialized sucking-tube located behind its head. This proboscis is used for the purpose of feeding, namely for sipping nectar from flowers, fruit juices, tree sap, water, or other fluids (Abang, 2006).

The thoracic segment is located posterior to the head and is the second section of the body. The thorax is composed of three articulated segments known as the prothorax, mesothorax, and metathorax. Each segment possesses pairs of articulated legs that allow them to firmly grasp the surface they are clinging to. The mesothorax and metathorax segments each bear a pair of wings (Abang, 2006). The mesothorax is connected to the front pair of wings on both sides, whereas the metathorax is connected to the posterior pair of wings. The thorax is where the organs of movement are located. The abdomen constitutes the third segment of the human body. The structure is composed of 10–11 segments that gradually narrow towards the finish. Each segment has membranes that enable articulation and movement. Within the field of Lepidoptera systematic, they have served as a significant and valuable resource for character information (Douglas et al., 2024). Certain caterpillars possess four pairs of prolegs, often situated on the third to sixth segments of their bodies. Additionally, there is an individual pair of prolegs at the anus, equipped with little hooks known as crotchets. These prolegs aid in both gripping and walking (Perveen & Khan, 2017).

2.2 Life cycle of Butterfly

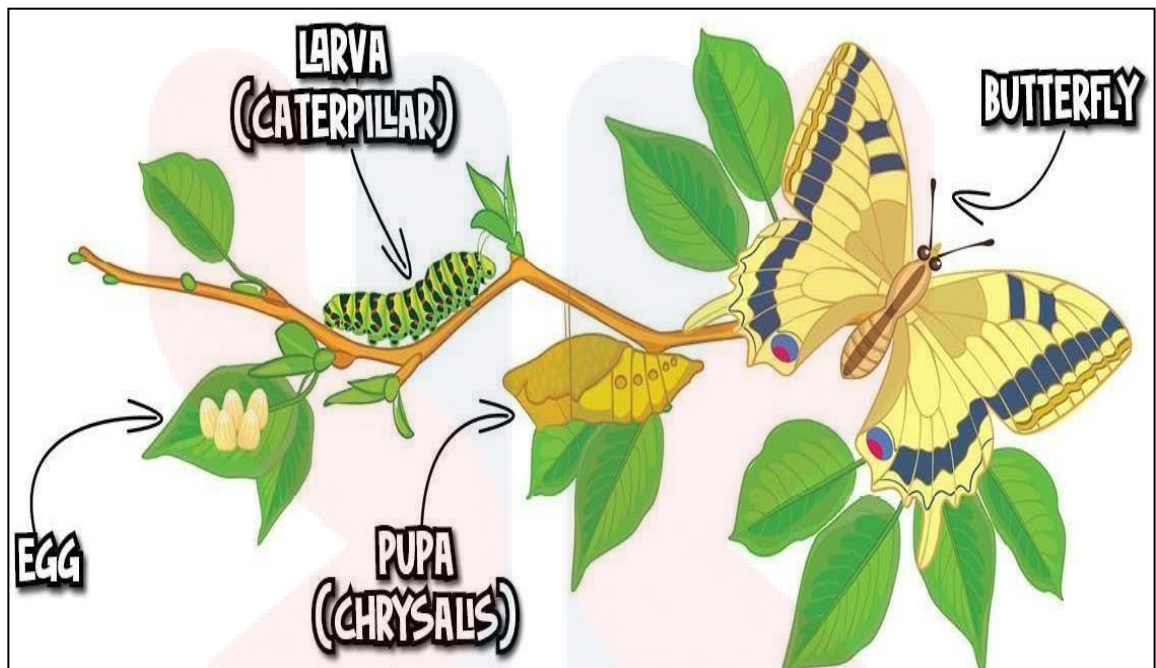


Figure 2.3: Life-cycle of butterfly (Source: Butterfly Life Cycle Pop-up Book, 2021)

Butterflies play a crucial role as herbivores and pollinators and are utilized as model organisms in various ecological and evolutionary disciplines. Butterflies, like other animals, have internal communities of microbes. However, our understanding of their relationships with these symbionts is limited (Hammer et al., 2014). Butterflies are not solely alluring to garden flower pollinators; their primary objective is to marry and reproduce effectively. Diagram 3 illustrates the sequential stages of the butterfly's lifecycle start from eggs stage to an adult butterfly. Similarly, caterpillars must not only consume and accumulate energy, but also safeguard themselves against hungry predators (Balmer, 2007). Butterflies, similar to moths, experience a comprehensive life cycle with four distinct phases of development: the egg, larva or caterpillar, pupa or chrysalis, and the adult (Abang, 2006). During their early stages of development, they do not resemble an adult and are thus described as undergoing a full transformation when they reach the pupal stage (Kirton, 2018).

Female butterflies typically deposit eggs on or in close proximity to the habitats of their offspring following mating, once their eggs have reached full maturity (Kirton, 2018). Butterflies deposit their eggs on particular host plants, also known as larval food plants. The process of oviposition, or the deposition of eggs, exhibits variation among different species. Certain species deposit their eggs individually, while others do so in bunches. The eggs are frequently subject to specific modifications (Abang, 2006). An egg is a developing organism enclosed within a rigid outer covering. The shell can exhibit various forms and may be beautifully adorned with ridges, holes, and numerous small projections like as spines and hairs. Certain species of butterflies apply adhesive and occasionally poisonous glue to their eggs as a defensive mechanism against predators (Kirton, 2018). After the eggs hatch, the recently emerging caterpillar starts by consuming the tough outer layer, and then proceeds to feed on its host plant (Balmer, 2007). Caterpillars are highly susceptible to many predators such as birds, insects, and lizards, which frequently feast on these butterfly larvae. Consequently, their physical characteristics are typically influenced by their imperative to defend themselves. Poisonous caterpillars may exhibit vivid colors as a defense mechanism to deter predators, or possess sharp spines that can cause irritation if touched or consumed. Certain caterpillars have highly distinctive and somewhat combative characteristics, including horns, intimidating tail lashes, and deceptive eyespots. Several other caterpillars employ passive yet effective strategies to defend themselves against predators, such as utilizing camouflage or concealing themselves within or under the vegetation (Balmer, 2007). The larvae, sometimes known as caterpillars, of the order Lepidoptera have an eruciform morphology. A caterpillar is a soft, elongated, and highly segmented creature, possessing a distinct head capsule and three pairs of thoracic legs. It is commonly referred to as an eating machine, as this stage primarily

focuses on food. They mostly exhibit phytophagous behaviour, which means they primarily consume plant matter. Some organisms consume plant foliage, whereas others consume fruits and other plant components. Typically, the majority of species experience five distinct stages of development known as larvae stages or instars before transitioning into the dormant or inactive chrysalis or pupal stage (Abang, 2006).

Once the caterpillar has reached its maximum size, it actively searches for a suitable spot to undergo a period of rest known as the pupa or chrysalis stage. The butterfly species may choose to hide its eggs in many locations such as under a leaf, behind a rolled or folded leaf shelter, on a stem, within cracks on a tree trunk, on the ground under leaves, or even in a shallow earth excavation. The caterpillar secures the end of its body to a surface by utilizing silk thread. Additionally, depending on the species, it may also utilize silk threads to create a grid-like structure in the central region of its body, attaching itself to the surface on both sides. Subsequently, after undergoing its last molts, the caterpillar undergoes a metamorphosis and becomes a pupa. During this process, the pupa gradually develops its own form, structure, and coloration as its outer shell solidifies (Kirton, 2018). The majority of pupae exhibit exceptional camouflage, closely mimicking desiccated foliage, branches, newly formed buds, and even avian excrement, particularly those belonging to the Swallowtail genus. Certain pupa casings are adorned with spines, while others that house poisonous butterflies will display their inedible nature (Balmer, 2007). During the later stages of pupation, the pupa undergoes a darkening process, revealing the wing patterns that will be present on the adult butterfly. The pupa will rupture, allowing the emerging butterfly to ingest air, facilitating the subsequent splitting of the pupal integument. The growing adult endeavours to liberate itself by moving its legs and

abdomen. After a period of rest, blood will circulate via the wing's venation system. This will empower the emerging adult to soar. The newly emerged adult butterfly will actively search for a suitable partner in order to engage in reproduction and deposit eggs. This will culminate the life cycle (Abang, 2006).

2.3 Diversity and Distribution of Butterfly

Butterflies are a very varied group of insects, exhibiting significant diversity and distribution variations across many environments and geographies. They fulfill an ecological function in nature by acting as bio-indicators to preserve the quality of habitats and ensure the stability of ecosystems (Karmakar et al., 2022). Butterflies are widely recognized as the most well-known group of insects due to their big size, vibrant appearance, ease of collection, and broad popularity. This makes them highly valuable for studying insect diversity and conservation efforts (DeVries et al., 1997). Butterfly studies have been utilized as examples of the wide range of insects found in tropical regions. Various research papers (Vane & Ackery, 1984; Brown, 1991; DeVries, 1987, 1997; Lamas, Robbins & Harvey, 1991; Malcolm & Zalucki, 1993; Robbins et al., 1996, and others) have explored this topic. Additionally, specific butterfly groups have been employed to forecast diversity patterns in conservation studies. Notable examples include the works of Kremen (1992, 1994), Kremen et al. (1993), Beccaloni & Gaston (1995), and Scriber, Tsubaki & Lederhouse (1995).

Butterflies are classified under the order Lepidoptera. This Greek term can be translated as both 'scale' and 'wing'. The most distinctive characteristic that sets them apart from other insect groups is their wing covered in scales. There are about 160,000 documented species of lepidoptera worldwide, with butterflies accounting for just approximately 10% of this total (Balmer, 2007).

A study undertaken in North East India evaluated the diversity and spatial distribution of butterflies in four distinct habitats: roadside, garden, plantation, and forest. The research documented 613 individuals representing 44 species across five families: Nymphalidae, Pieridae, Lycaenidae, Papilionidae, and Hesperidae (Karmakar et al., 2022). The peak levels of butterfly species diversity and population size were seen in the summer season (May-June) (Karmakar et al., 2022).

A study undertaken in Pakistan involved the collection and identification of 375 specimens, which revealed the presence of 24 species from 20 genera and 7 families (Khan et al., 2016). The species with the greatest population was *Pieris brassicae*, followed by *Danius chrysippus* and *Cynthia cardui* (Khan et al., 2016). The family Nymphalidae comprises twelve species, accounting for 50% of the total species. This family exhibits the highest abundance rate, as reported by Khan et al. in 2016. Butterflies are believed to have undergone a process of diversification through coevolution with plants and in response to migrations that occurred after significant geological events (Kawahara et al., 2022). The forest ecosystem exhibited the greatest variety and number of butterflies (Hailay et al., 2024).

2.4 Importance of Butterfly

In order to comprehend biodiversity, we examine biological indicators which elucidate the significance of forest ecosystems and their stewardship (Pearce and Venier, 2006, Maleque et al., 2009). These indicators are referred to as ecological indicators (Geogh, 2007). The primary objective of these indicators is to accurately measure the complex system while ensuring that no significant information is overlooked (Ferris, 1999). The primary focus of research on insect biodiversity is the impact it has on forest ecosystems (Kwon et al., 2013, Lee and Kwon, 2014, Lee

et al., 2014). In addition, insect indicator taxa have been recently employed as "indicators of biodiversity" in a different context. This usage has been referred to as "surrogates of biodiversity" in some cases. Butterflies are the most reliable indication of environmental changes in the insect world due to their abundant population, short lifespan, efficient mobility, and heightened sensitivity to environmental shifts (Lee and Kwon, 2012, Lee and Kwon, 2014, Kwon et al., 2014). The order Lepidoptera comprises both Butterflies and Moths, with Butterflies accounting for around 17,820 species (Shields, 1989). Butterflies are classified under the order Lepidoptera, which is the second largest class of insects and currently includes around 150,000 species. According to Dobson (2012), during the past decade, there has been a 72% loss in butterfly and moth species. This decline is attributed to the fact that butterflies are highly sensitive to even little environmental changes. This decline serves as a concerning indicator for potential reductions in other animal populations and highlights their role as effective indicators of biodiversity.

Butterflies are aesthetically pleasing and captivating compared to other insects, setting them apart from other members of the lepidoptera group. Butterflies contribute to pollination by transferring pollen as they move between plants. The majority of butterfly species are restricted to a particular season and habitat (Kunte, 1997). They serve as excellent indicators of environmental disturbances and undesirable activities (Kocher and Williams, 2000). Butterflies have the potential to serve as valuable ecological indicators of urbanization due to their sensitivity to changes in microclimate and temperature, as stated by Thomas et al. (1998). Butterflies are also a reliable indication of environmental health and serve as producers of ecosystem services from the initial stage (Wankhede, 2019). Webb defines pollination as the sexual reproduction process in which pollen is carried from the male parts of a flower to the

female sections of a bloom, allowing for reproduction to occur even across huge distances (Ghazanfar et al., 2016). When an adult butterfly alights on a flower to extract nectar with its proboscis, it unintentionally collects pollen on its body by contact with the anther. The butterfly transfers a portion of the pollen onto the subsequent flower it visits and accumulates further pollen. During this technique, the butterfly can effectively pollinate a multitude of flowers as it travels (Anne et al., 2020). Butterflies gather nectar from several plant species, hence causing genetic diversity in the plants. Certain butterfly species engage in long- distance migration, facilitating the transfer of pollen between distant plants. This phenomenon enhances the plants' ability to combat diseases and significantly improves their likelihood of survival (Kearney, 2021).

Butterflies serve as a source of nourishment for various creatures, including birds, reptiles, and amphibians. Additionally, caterpillars can serve as a meal for scorpions and ants. The eggs of certain flies and wasps function as parasitic organisms within the body of a caterpillar, where they consume and derive nourishment from it. If the butterfly populations decline, the populations of birds, mice, and other creatures that depend on them as a food source will also decrease. This loss will result in the complete breakdown of the entire ecosystem (Ghazanfar et al., 2016). Certain butterfly larvae, such as Hoverfly larvae, act as predators of hazardous insects like aphids. This makes caterpillars a valuable tool for biological pest control (Ehrlich & Gilbert, 1973).

2.4 Comparison Between Butterfly and Moth

Despite both moths and butterflies belonging to the same insect family, they are distinct types of insects. Both moths and butterflies belong to the taxonomic category Lepidoptera, which encompasses a staggering number of over 180,000 distinct species of both moths and butterflies. Furthermore, numerous subspecies exist

to further differentiate each category of insect. Butterflies and moths exhibit numerous disparities in their physical characteristics and behavioral patterns (Ahasan et al., 2023).

Regarding behavior, the majority of butterflies are active during the day, while most moths are active during the night. However, there are exceptions to this pattern, as there are moths that fly during the day and butterflies that fly at twilight (Kirton, 2018). Butterflies are predominantly active during the day, engaging in flight. Moths typically exhibit nocturnal behavior, being active and flying during the nighttime hours. Nevertheless, many species of moths, like the buck moth, exhibit diurnal behavior, whereas certain species of butterflies are crepuscular, meaning they are active around dawn and twilight (Brown, 2018). Moths possess a wing-coupling structure called a frenulum, which can be used to compare their anatomy. Butterflies lack frenulums. Frenulums serve to connect the forewing and hind wing, enabling synchronized movement of the wings during flight (Ma et al., 2021).

Butterflies and moths exhibit variations in their coloration, patterns, and sizes. Butterflies frequently exhibit vivid hues and possess expansive wings. This is due to the fact that numerous species of butterflies possess a mild toxicity that can be harmful if consumed by avian, mammalian, or reptilian creatures. In the natural world, prey animals frequently employ vibrant hues such as yellow, orange, and red as a means of communicating their toxicity to potential predators. Butterflies exhibit a wide spectrum of colors, encompassing hues such as red, orange, yellow, green, blue, purple, pink, and several shades in between. Conversely, moths are typically non-toxic when consumed by predators. Hence, moths are frequently ingested by mammals, amphibians, reptiles, and birds. Moths employ a strategy of reducing their size and depending on camouflage as a means of evading such predators. Moths typically

exhibit a range of colors including different tones of gray, brown, black, tan, beige, or white. While there exist a limited number of sizable and vibrant ones.

Moths possess antennae that resemble little leaves and have a higher quantity of olfactory nerve receptors compared to butterflies. This aids moths in detecting nutrition and other organisms. These antennae possess remarkable sensory capabilities and have been utilized in scientific research to create 'smellicopters'. Butterflies possess slender antennae that are clubbed at the end, resembling the flat side of a kirby-grip. Additionally, they are equipped with sensors that aid in their olfactory perception (Komala et al., 2023).

CHAPTER 3

METHODOLOGY

3.1 Study Area

This study was conducted at Lata Hokkaido Jeli, Kelantan at Lata Hokkaido Glamping Park Jeli, Kelantan (5°38'56.6"N 101°45'41.3"E). Figure 3.1 shows Lata Hokkaido, situated near Lata Janggut in Jeli, possessed distinctive natural features and offered a captivating landscape that was ideal for engaging in adventurous and leisurely pursuits such as camping and hiking. The region of Lata Hokkaido possessed abundant flora and wildlife, rendering it an ideal location for conducting research on the variety of butterflies. In Lata Hokkaido, temperatures typically range from warm to hot year-round, reflecting the region's tropical climate. On average, temperatures in the area can range from around 25 to 32 degrees Celsius and receives approximately 3,000 to 4,000 millimeters of rainfall annually.

UNIVERSITI
MALAYSIA
KELANTAN



Figure 3.1: An illustrative map depicting the precise geographical location of the designated study region. (Sources: Goggle Earth, 2024)

3.2 Materials

Table 3.1 presents a variety of instruments utilised for capturing and examining butterflies, such as butterfly traps, aerial nets, triangular paper, insect pins, spreading boards, and tagging insects.

Table 3.1: List of materials that will be used in this study.

Material	Function
Aerial Net and Bait Trap	To capture several species of butterflies
Triangle Paper	To incorporate gathered butterfly species
Insect Pin	To mount insects
Spreading board	For insect mounting and storing
Labeling insect	Entomological information or data

3.3 Methods

3.2.1 Butterflies Sampling

To capture butterflies, an aerial net and a bait trap were used. Multiple subsequent studies in the literature provided extensive descriptions of various designs for bait traps. It was highly recommended that individuals who wished to perform a bait trap study acquaint themselves with several methods for constructing a bait trap (Poza et al. 2008).

The study utilized an aerial net as an efficient method to capture airborne butterflies inside the study area. The passive approach involved employing a bait trap equipped with bait to ensnare specimens. The bait used comprised fermented banana. The bait released a powerful fragrance that enticed the butterfly into the trap. Bait traps were effective in capturing various organisms, particularly fruit-eating butterflies.

These butterflies belonged to a group that was not derived from a common ancestor, and their adult stage mostly involved feeding on rotting fruits and other organic matter. They could be readily lured using baited traps (Lucci et al., 2014). The dimensions of a bait trap were not standardized, and they differed among authors. Nevertheless, it was crucial for a bait trap to have a sufficient height of 100-130 cm in order to effectively prevent butterflies from escaping after they were trapped. Additionally, the trap's diameter should be wide enough, preferably no less than 25 cm, to accommodate the capture of larger owl butterflies (Satyrinae: Brassolini). A conical structure positioned within could effectively hinder the escape of butterflies, with an entrance width of around 20 cm (Lucci et al., 2014).



Figure 3.2: Aerial net (A) and baited trap (B)

The study was conducted using two sampling methods, each lasting for a continuous period of 14 days. The sampling period spanned from February 20, 2024, to March 17, 2024, covering a duration of 14 days.

A transect line was set up along the Lata Hokkaido trail, covering a distance of about 300 meters, as shown in Figure 3.3. The butterflies were gathered throughout the specified area for the trail transect using a single aerial net (Figure 3.2) from 8 am to 12 pm. The same personnel were consistently employed throughout the sampling period to ensure impartiality in this study.

Ten bait traps were utilized and positioned around 10-15 meters apart throughout the transect walk (Figure 3.3). The bait trap was placed at an elevation of around 1 meter above the ground and was inspected twice a day, specifically at around 11 am. The collected butterflies were enclosed in triangular paper and conveyed to the Natural Museum at UMK Jeli Campus. The specimens were labeled, and their taxonomy was ascertained based on their unique physical traits. All butterflies were identified using the "Naturalist's Guide to Butterflies of Malaysia: Peninsular

Malaysia, Singapore, and Southern Thailand" (2018), supported by credible online sources, and further validated through consultation with an entomologist from the Faculty of Earth Sciences at the University Malaysia Kelantan (UMK).

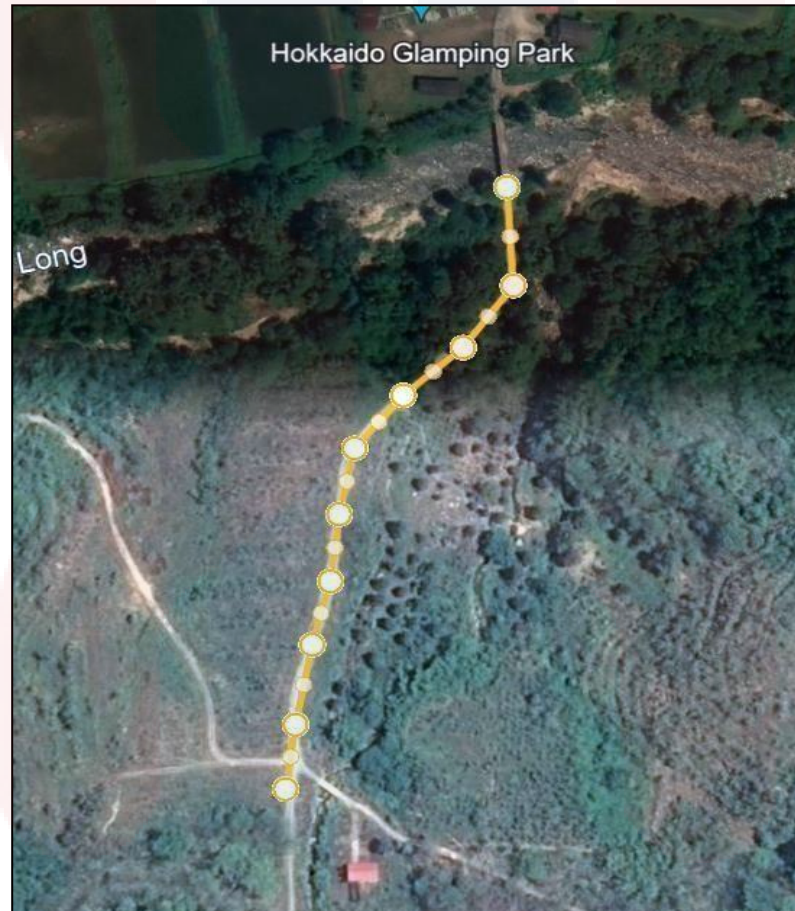


Figure 3.3: Locality of line transect in Lata Hokkaido Glamping Park (Sources: Goggle Earth, 2024)

3.2.2 Data Analysis

The acquired data for the investigation were examined using five different diversity indices: the Shannon-Wiener Diversity Index, the Rarefaction Diversity Index, species accumulation curves, Pielou's Index, and the Margalef Diversity Index. Ecologists frequently employ this particular diversity index to assess the number and evenness of species within their environment.

a) Shannon-Wiener diversity index (H')

The Shannon-Wiener diversity index formula according to Krebs (1989):

$$H' = - \sum p_i \ln p_i \quad (\text{Equation 3.1})$$

Where:

H' = Shannon-Wiener Index

p_i = Ratio n_i / N

n_i = Number of individual species -i

N = Total number of population

b) Rarefaction Diversity Index

Rarefaction analysis, as proposed by Birks and Line in 1992, provides an estimation of the level of palynological diversity within and between sequences. It calculates the number of taxa that would have been discovered if all the pollen counts were equal. The lowest count in the sequence(s) of interest is typically used as the reference value. The understanding of palynological richness as an indication of historical biodiversity is intricate and now inconclusive (Odgaard, 1996, 1999). The Rarefaction Index was used to analyse the data obtained on butterflies at Lata Hokkaido Glamping Park in order to assess their variety.

c) Species Accumulation Curves

Species accumulation curves, also known as species-richness curves, collector's curves, or species effort curves, are employed to approximate the species count within a specific geographical region. One can determine the overall number of species in an area by analysing data published in consultants' reports or by cross-checking consultants' estimates of species richness (Thompson and Withers 2003). This curve represents the analysis of data collected on butterfly species in Lata Hokkaido Glamping Park. The purpose of this study was to analyse the species accumulation curve, which provided data on the gathered butterflies, in order to assess the diversity of butterfly species.

d) Pielou's Index

The Pielou index is a quantitative tool used to assess the evenness of butterfly distribution throughout a community. The Pielou index is a numerical value that ranges from 0 to 1. When the relative abundances of species deviate from evenness, the value of 1 representing perfect evenness decreases to zero.

$$J' = H' / \ln S \quad (\text{Equation 3.2})$$

Where,

H' = the number derived from the Shannon diversity index

S = species richness (number of species)

e) Margalef's index

Margalef's index was used as a simple measure of species richness (Margalef, 1958).

$$\text{Margalef's index} = (S - 1) / \ln N \quad (\text{Equation 3.3})$$

Where :

S = total number of species

N = total number of individuals in the sample

In = natural logarithm

CHAPTER 4

RESULT AND DISCUSSION

4.1 Overall Species Richness and Abundance

In total, 303 butterfly specimens have been identified and recorded, representing 53 species from 14 subfamilies within 5 family (Table 4.1). Family Pieridae recorded the highest number of individuals, predominantly from the subfamily Coliadinae. Conversely, the subfamily Curetinae within the family Lycaenidae, was represented by a single species and recorded as the lowest individual count among all subfamilies. Overall, the family Nymphalidae collectively accounted for 119 individuals, distributed among the subfamilies Danaeinae (20), Satyrinae (53), Morphinae (1), Nymphalinae (10), Heliconiinae (2), Limenitidinae (32) and Charaxinae (1). The Pieridae family, with a total of 108 individuals, comprised of the subfamilies Coliadinae (60) and Pierinae (48). The family Papilionidae was represented by 15 individuals, all within the subfamily, Papilioninae, recorded the lowest count among all butterfly families. The family Lycaenidae with a total of 34 individuals, consist of two subfamilies, Curetinae (1) and Lycaninae (33). Finally, the family Hesperiiidae accounted for 27 individuals, distributed across the subfamilies Hesperinae (22) and Pyrginae (5).

The most abundant species recorded in this study was *Mycalesis mineus* (33), meanwhile the least abundant species recorded as singletons were *Euploea radamanthus*, *Danaus melanippus*, *Lethe mekara*, *Lethe europa*, *Thaumantis klugius lucipor*, *Cirrochroa orissa*, *Vindula dejone*, *Pantoporia hordonia*, *Polyura hebe*

plautus, Eurema sari, Catopsilia pomona, Papilio memnon agenor, Graphium antiphates, Atrophaneura varuna, Curetis santana malayica, Pseudozizeeria maha, Catochrysops panormus, Halpe ormenes vilasina, Eetion elia and Tagiades japetus.



UNIVERSITI

MALAYSIA

KELANTAN

Table 4.1: List of butterfly species in Lata Hokkaido Jeli, Kelantan.

Family	Subfamily	Species	Common Name	Abundance
Nymphalidae	Danainae	<i>Euploea radamanthus</i>	Magpie Crow	1
		<i>Ideopsis similis</i>	Blue Glassy Tiger	5
		<i>Danaus melanippus</i>	White Tiger	1
		<i>Parantica melaneus</i>	Chocolate Tiger	2
		<i>Parantica aspasia</i>	Yellow Glassy Tiger	6
		<i>Euploea mulciber</i>	Striped Blue Crow	5
	Satyrinae	<i>Ypthima pandocus corticaria</i>	Common three-ring	3
		<i>Mycalesis mineus</i>	Dark Banded Bush Brown	33
		<i>Mycalesis patiana</i>	Mottled Bush Brown	9
		<i>Lethe mekara</i>	Common Red Forester	1
		<i>Ypthima baldus</i>	Common Five-ring	3
		<i>Ypthima huebneri</i>	Common Four ring	3
		<i>Lethe europa</i>	Bamboo Tree Brown	1
	Morphinae	<i>Thaumantis klugius lucipor</i>	Dark Blue Jungle Glory	1
	Nymphalinae	<i>Hypolimnna bolina</i>	Great Egg-fly	8
		<i>Ariadne merione</i>	Common Castor	2
	Heliconiinae	<i>Cirrochroa orissa</i>	Banded Yeoman	1
		<i>Vindula dejone</i>	Lesser Cruiser	1

	Limenitidinae	<i>Pantoporia hordonia</i>	Common Lascar	1
		<i>Neptis hylas</i>	Common Sailor	19
		<i>Tanaecia julii</i>	Common Earl	5
		<i>Tanaecia pelea</i>	Malayan Viscount	1
		<i>Neptis leucoporos</i>	Burmese Sailor	3
		<i>Tanaecia iapis puseda</i>	Horsfield's Baron	3
	Charaxinae	<i>Polyura hebe plautus</i>	Plain Nawab	1
Pieridae	Coliadinae	<i>Eurema sari</i>	Chocolate Yellow Grass	1
		<i>Catopsilia pomona</i>	Lemon Emigrant	1
		<i>Eurema hecabe</i>	Common Grass Yellow	49
		<i>Eurema nicevillei</i>	Malayan Grass Yellow	9
	Pierinae	<i>Leptosia nina</i>	Psyche	29
		<i>Appias lycida</i>	Chocolate Albatross	4
		<i>Pieris brassicae</i>	Cabbage White	2
		<i>Appias nero</i>	Orange Albatross	2
		<i>Delias hyparete metarete</i>	Painted Jezebel	4
		<i>Appias libythea</i>	Striped Albatross	7
Papilionidae	Papilioninae	<i>Papilio memnon agenor</i>	Great Mormon	1
		<i>Papilio polytes</i>	Common Mormon	10
		<i>Graphium antiphates</i>	Five-bar Swordtail	1
		<i>Atrophaneura varuna</i>	Common Batwing	1

		<i>Pachliopta aristolochiae</i>	Common Rose	2
Lycaenidae	Curetinae	<i>Curetis santana malayica</i>	Malayan Sunbeam	1
	Lycaninae	<i>Caleta elna</i>	Elbowed Pierrot	11
		<i>Jamides celeno</i>	Common Cerulean	20
		<i>Pseudozizeeria maha</i>	Pale Blue Grass	1
		<i>Catochrysops panormus</i>	Silver Forget-Me-Not	1
Hesperiidae	Hesperiinae	<i>Suastus gremius</i>	Palm Bob	3
		<i>Potanthus omaha</i>	Lesser Dart	3
		<i>Isma iapis iapis</i>	Plain Tufted Lancer	6
		<i>Halpe ormenes vilasina</i>	Dark Banded Ace	1
		<i>Eetion elia</i>	White Spot Palmer	1
		<i>Ancistroides nigrita</i>	Chocolate Demon	8
	Pyrginae	<i>Pseudocoladenia dan</i>	Fulvous Pied Flat	4
		<i>Tagiades japetus</i>	Common Snow Flat	1

Species accumulation curves (SAC), was plotted to estimate butterfly species richness in Lata Hokkaido Jeli, Kelantan and to assess the adequacy of sampling efforts. Various curve-fitting models frequently yield distinct predictions for species richness, even when the effort is constant. Furthermore, the error increases as the extrapolation towards the entire species count becomes bigger (Thompson et al., 2003). Figure 4.1, shows the species accumulation curve (SAC) of butterflies in Lata Hokkaido Jeli Kelantan. The species accumulation curves continue to exhibit growth on the fourteenth day. The rise in numbers demonstrates the presence of both known and unknown butterfly species inside the study site. The graph displays a consistent upward

trend from the first day to the fourteenth day, reaching a total of 53 recorded species. According to the statistics, the graph remains flat or horizontal from day 9 to day 11, and also on day 13 and 14. Based on this representation, it can be inferred that Lata Hokkaido possesses a wide range of butterfly species and is likely to have undiscovered species, as indicated by the upward trend in the graph on the final day of sampling. However, due to time constraints, the sampling session had to be halted.

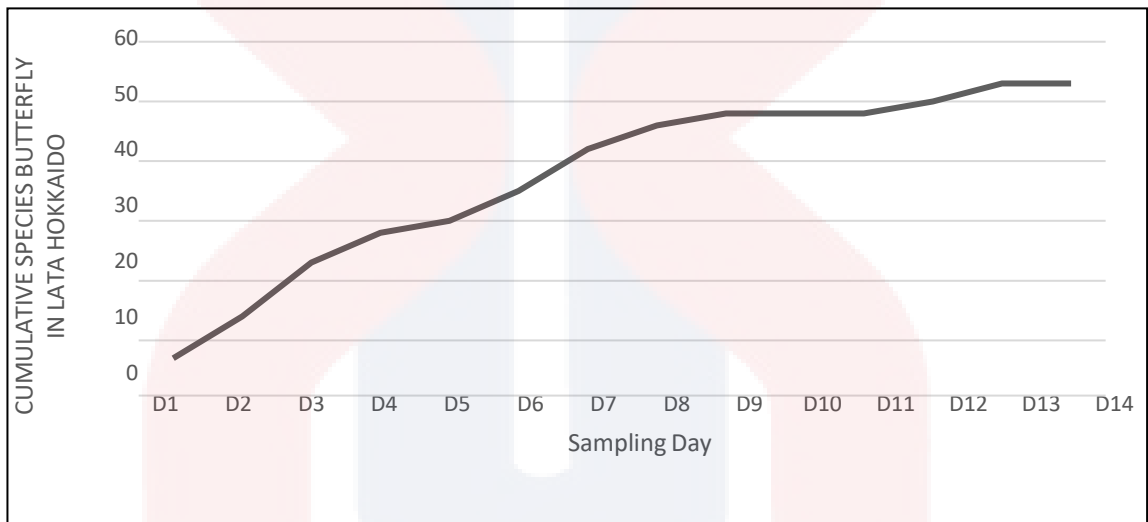


Figure 4.1: Species Accumulation Curves (SAC) of butterfly species collected at Lata Hokkaido Jeli, Kelantan

Subfamily Nymphalinae has the highest number of documented species, with a total of 9 species captured (Figure 4.2). There are a total of 21 individuals belonging to the butterfly species in the subfamily Nymphalinae. Despite recording the most species, Nymphalinae has just half the number of individuals compared to Coliadinae, with 21 and 60 species respectively. The subfamily Ceoliadinae, which includes the Common Grass Yellow (*Eurema hecabe*), has the largest number of unique species. These species are found in a wide range of habitats including grasslands, open fields, agricultural areas, roadsides, and gardens (Kirtan, 2021). This adaptability allows them to thrive in diverse environments, increasing their chances of survival and reproduction. *Eurema hecabe* also exhibits a high reproductive rate, with multiple generations per year in favorable conditions. Furthermore, these species are most active

throughout the early hours, specifically from 8 am to 11 am which may reduce predation risk and competition for resources. Additionally, they are commonly found along roadsides and in open vegetation and can be easily captured using an aerial net due to their slow flight patterns in low places.

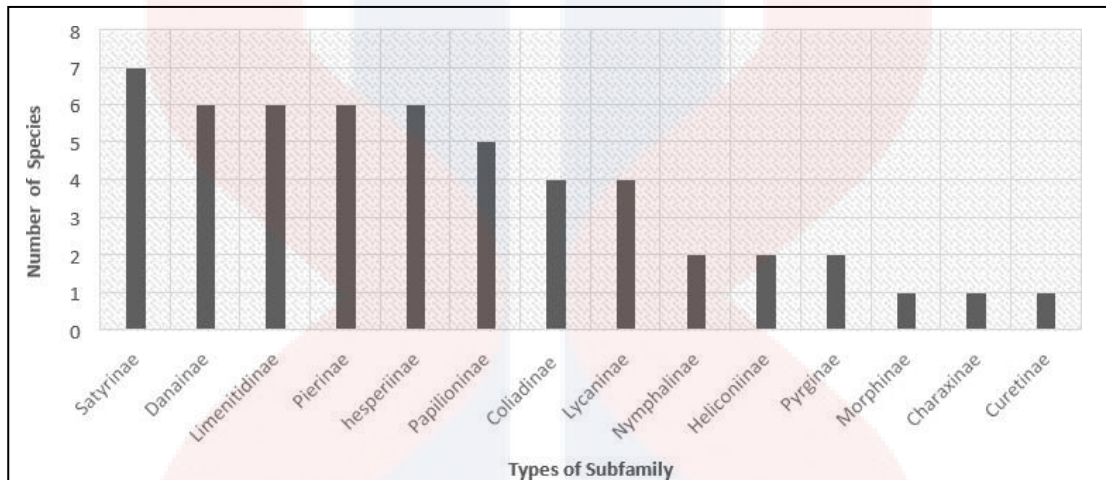


Figure 4.2: Number of Species collected from each subfamily of butterfly at Lata Hokkaido Jeli, Kelantan

The IUCN Red List is an inventory to evaluate the populations of species, their threats, and their status on conservation all over the world. In the present study, the IUCN Red list was used as the primary source of information to enumerate all recorded species of butterflies in Lata Hokkaido Jeli, Kelantan. Analyzing the data presented in the table 4.3, the author concludes that 94.4% of the represented species of butterflies do not fall under endangered species category. Four and one butterfly species are most closely related by showing the least concern and vulnerability in terms of characteristic features of the four. Table 4.3 presents decline IUCN status of butterfly species in Lata Hokkaido Jeli, Kelantan.

Table 4.3: IUCN Red List status of butterfly species collected at Lata Hokkaido Jeli, Kelantan.

Species	IUCN Red List
<i>Euploea radamanthus</i>	Not listed
<i>Ideopsis similis</i>	Not listed
<i>Danaus melanippus</i>	Vulnerable
<i>Parantica melaneus</i>	Not listed
<i>Parantica aspasia</i>	Not listed
<i>Euploea mulciber</i>	Not listed
<i>Ypthima pandocus corticaria</i>	Not listed
<i>Mycalesis mineus</i>	Not listed
<i>Mycalesis patiana</i>	Not listed
<i>Lethe mekara</i>	Not listed
<i>Ypthima baldus</i>	Not listed
<i>Ypthima huebneri</i>	Not listed
<i>Lethe europa</i>	Not listed
<i>Thaumantis klugius lucipor</i>	Not listed
<i>Hypolimnas bolina</i>	Not listed
<i>Ariadne merione</i>	Not listed
<i>Cirrochroa orissa</i>	Not listed
<i>Vindula dejone</i>	Not listed
<i>Pantoporia hordonia</i>	Not listed
<i>Neptis hylas</i>	Not listed
<i>Tanaecia julii</i>	Not listed
<i>Tanaecia pelea</i>	Least concern
<i>Neptis leucoporos</i>	Not listed

<i>Tanaecia iapis puseda</i>	Not listed
<i>Polyura hebe plautus</i>	Not listed
<i>Eurema sari</i>	Not listed
<i>Catopsilia pomona</i>	Not listed
<i>Eurema hecabe</i>	Least concern
<i>Eurema nicevillei</i>	Not listed
<i>Leptosia nina</i>	Not listed
<i>Appias lyncida</i>	Not listed
<i>Pieris brassicae</i>	Not listed
<i>Appias nero</i>	Not listed
<i>Delias hyparete metarete</i>	Not listed
<i>Appias libythea</i>	Not listed
<i>Papilio memnon agenor</i>	Not listed
<i>Papilio polytes</i>	Not listed
<i>Graphium antiphates</i>	Not listed
<i>Atrophaneura varuna</i>	Least concern
<i>Pachliopta aristolochiae</i>	Least concern
<i>Curetis santana malayica</i>	Not listed
<i>Caleta elna</i>	Not listed
<i>Jamides celeno</i>	Not listed
<i>Pseudozizeeria maha</i>	Not listed
<i>Catochrysops panormus</i>	Not listed

<i>Suastus gremius</i>	Not listed
<i>Potanthus omaha</i>	Not listed
<i>Isma iapis iapis</i>	Not listed
<i>Halpe ormenes vilasina</i>	Not listed
<i>Eetion elia</i>	Not listed
<i>Ancistroides nigrita</i>	Not listed
<i>Pseudocoladenia dan</i>	Not listed
<i>Tagiades japetus</i>	Not listed

Figure 4.3 show the rarefaction curves of butterflies in Lata Hokkaido Jeli Kelantan. These curves were extrapolated based on the number of individuals that were taken from each species of butterfly and the number of species richness's that were obtained at the study site. The curve is still rising which indicates that more species are likely to be found with additional sampling.

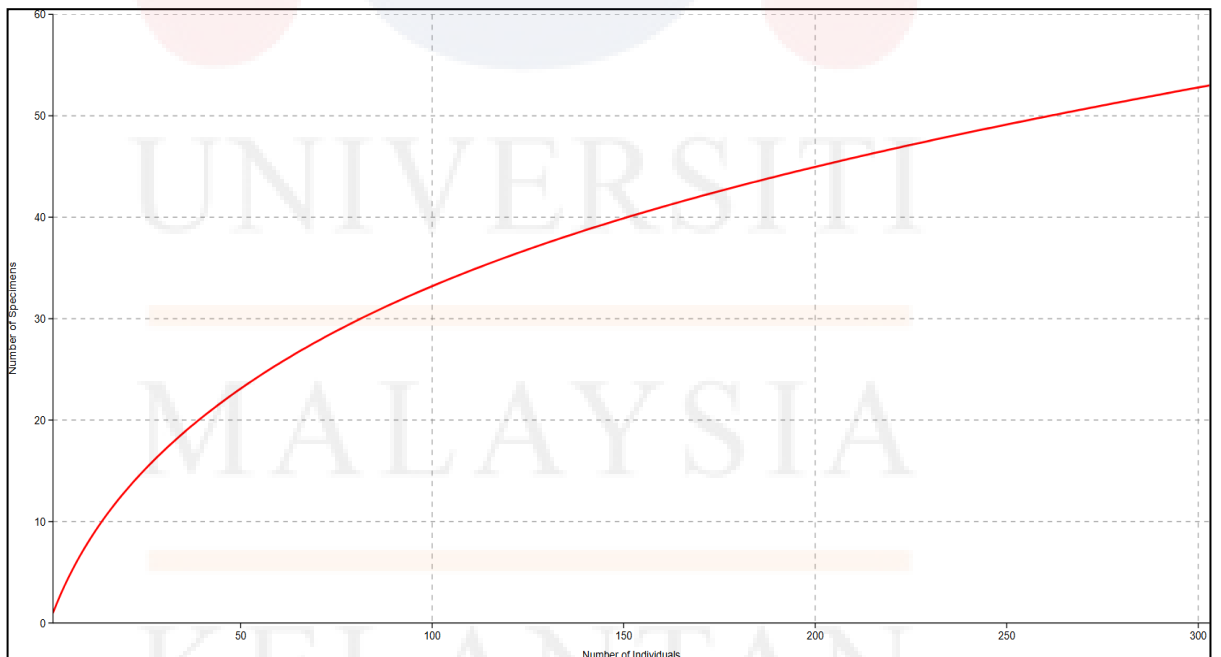


Figure 4.3: Rarefaction curves for Butterfly species

4.2 Diversity Indices

Diversity indices were calculated to measure the butterfly species diversity in Lata Hokkaido Jeli Kelantan (Table 4.2). A The Shannon Weiner Diversity Index value of $H' = 3.246$ indicates high species diversity and a relatively even distribution of individuals among species encountered. The Margalef index value of $D_{mg} = 9.101$ also suggest a relatively high diversity. This study demonstrates that Lata Hokkaido possesses a large number of species that are diversified.

Table 4.2: Diversity indices of butterflies in Lata Hokkaido Jeli Kelantan.

Diversity Index	Value
Shannon Diversity index (H')	3.246
Margalef Index (D_{Mg})	9.101

The Pielou's Evenness Index, also known as the J' index, were calculated to quantify the evenness of butterfly species distribution in Lata Hokkaido (Table 4.3). The range of the evenness index is from 0 to 1, where 0 indicates no evenness and 1 indicates perfect evenness. A Pielou's Evenness Index Value of $J = 0.4847$ suggests moderate evenness in the distribution of butterfly species recorded in this study.

Table 4.3: Pielou's evenness index

Pielou's Evenness Index (J)	Value
	0.4847

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

According to the findings that were collected during this research study that was conducted at Lata Hokkaido Jeli, Kelantan, the diversity and richness of butterfly species at the study site is remarkably high due to the result has been done by doing data analysis using the data collected in sampling day. According to the Shannon-Wiener Diversity Index and Pielou's Evenness Index, the values for H and J are respectively 3.246009 and 0.4847. On the other hand, the Margalef's Diversity Index is $DMG = 9.101$. There is a possibility that the physical characteristics of the location under study are the variables that contribute to the diversity of butterfly species encountered. The research site was encircled by flowering plants and fruit trees, both of which significantly contributed to the variety of butterfly species that were present. The secondary forest that is Lata Hokkaido Jeli, Kelantan, is where this research site was reforested in the past as a result of industrial operations that took place at that time. Therefore, the number of different kinds of butterflies is beginning to expand as they migrate into the forest and are able to adjust to their new environment. This also contributes to the diversity of butterfly species. In addition, butterfly also can be indicator for their area weather in good condition or not for environmentally conservation. The diet of certain species of butterflies, regardless of whether or not they consume fruit, was another factor that contributed to the ineffectiveness of bait traps on specific species. One particular species of butterfly

belonging to the families HesperIIDae and Satyrinae was the only one that was drawn to the bait. These findings demonstrated that conditions such as the modification of forests and the alteration of habitats have the potential to influence the variety of butterfly species that are found in this research location. The diversity of butterfly species had effectively risen in numbers in order to obtain their home in the original forest of the Lata Hokkaido, which is located in Jeli, Kelantan.

Studying the variety of Lepidoptera in Lata Hokkaido, Jeli, Kelantan, greatly enhances our comprehension of biodiversity in tropical habitats. This study elucidates the diverse array of moths and butterflies in the region, emphasising their functions in pollination and as markers of environmental well-being. Through the systematic classification and documentation of various species and their geographical range, researchers contribute crucial data that may be utilised to inform and develop conservation initiatives and tactics aimed at safeguarding these indispensable insects and their ecosystems. Furthermore, the results can be used as a reference point for future research on the effects of climate change and habitat disruption on Lepidoptera populations in Malaysia. This research not only advances scientific knowledge but also emphasises the significance of conserving biodiversity for ecological equilibrium and long-term viability.

MALAYSIA

KELANTAN

5.2 Recommendation

In order to overcome the identified shortcomings, it is recommended that another researcher offer specific topics of research to be focused on in Lata Hokkaido Jeli, Kelantan. To solve the research gap in the tropics, it is necessary to change our focus. Conducting extensive and ongoing sampling in this research area to discover and document butterfly species will greatly benefit many locations worldwide, especially those in tropical and global contexts. However, conducting study should involve examining and taking into account environmental elements that can impact the presence of specific butterfly species in a particular location, in order to comprehend their behaviour and their requirements for habitat selection. In order to rectify the discrepancy in recorded outcomes, it is important to augment the collection of data pertaining to newly discovered species. This can be accomplished by increasing the frequency of time sampling, specifically by doing observations in both the morning and afternoon. This will allow for a comparison of the activity of butterflies in a specific location at different times of the day. Extended research with a more extensive sample period can enhance the data on butterfly species in the study area. Ultimately, it is crucial to do research on a broader range of species in order to have a comprehensive understanding of what characteristics may be unique to the Lata Hokkaido Jeli species in Kelantan.

REFERENCE

- Abang, F. (2006, January 1). Butterflies of Malaysian Borneo.
- Abdul Mutholib Shahroni, Ash, I., Soenarko, & Peggie, D. (2022, November).
- Ahasan Ullah Khan, Nilufa Yasmin Poly, Dutta, S., & Alam, F. (2023). *Lepidopteran Insects Status and Diversity: A Review*. ResearchGate; unknown. Retrieved may 16, 2024 from https://www.researchgate.net/publication/365140901_Lepidopteran_Insects_Status_and_Diversity_A_Review
- Anne-kristel Bittebière, Marie-Lise Benot, & Mony, C. (2020). Clonality as a key but overlooked driver of biotic interactions in plants. *Perspectives in Plant Ecology Evolution and Systematics*, 43, 125510–125510. Retrieved may 12, 2024 from <https://doi.org/10.1016/j.ppees.2020.125510>
- Aslam, M. (2009). Diversity, species richness and evenness of moth fauna of Peshawar. *Pakistan Entomologist*, 31(2). Retrieved may 11, 2024 from <https://indiabiodiversity.org/biodiv/content/documents/635.pdf>
- Balmer, E. (2007, January 1). A concise guide to butterflies & moths.
- Bibi, M., Bibi, S., Akhtar, N., Ullah, Z., Khan, M. F., & Qureshi, I. (2022). Butterfly (Order: Lepidoptera) species richness, diversity and distribution in different localities of Battagram, Pakistan. *Saudi Journal of Biological Sciences*, 29(3), 1853-1857. Retrieved may 20, 2024 from <https://doi.org/10.1016/j.sjbs.2021.10.039>
- Biodiversity Analyst > Biodiversity Indices > Evenness Indices. (2017). Supergeotek. Retrieved may 9, 2024 from https://www.supergeotek.com/BiodiversityAnalyst_ENG_HTML/evenness_indices.htm#:~:text=Pielou%20index%20is%20a%20way,the%20species%20diverge%20from%20evenness.
- Biotropica, 5(2), 69 | 10.2307/2989656. (2023). Retrieved may 12, 2024 from Sci-Hub. <https://sci-hub.se/https://doi.org/10.2307/2989656>
- Body parts of a butterfly and its diagram. (2020, April). Butterfly Identification. Retrieved may 13, 2024 from <https://www.butterflyidentification.com/butterfly-facts/parts-of-a-butterfly>
- Brown, J. W. (2018). Patterns of Lepidoptera herbivory on conifers in the New World. *Journal of Asia-Pacific Biodiversity*, 11(1), 1–10. Retrieved may 12, 2024 from <https://doi.org/10.1016/j.japb.2018.01.008>
- Butterflies act as wildlife indicators, warning us of ecosystem changes. (2013). Blogspot. Retrieved may 9, 2024 from <https://carbon-based-ghg.blogspot.com/2012/09/butterflies-act-as-wildlife-indicators.html>

- Butterfly Life Cycle Pop-Up Book. (2021, March 20). Left Brain Craft Brain. Retrieved may 10, 2024 from <https://leftbraincraftbrain.com/butterfly-life-cycle-pop-up-book/>
- Chapman, R. F. (2009). Mouthparts. *Elsevier EBooks*, 663–668. Retrieved may 17, 2024 from <https://doi.org/10.1016/b978-0-12-374144-8.00182-x>
- DeVries, P. J., Murray, D., & Lande, R. (1997). Species diversity in vertical, horizontal, and temporal dimensions of a fruit-feeding butterfly community in an Ecuadorian rainforest. *Biological Journal of the Linnean Society*, 62(3), 343-364. Retrieved may 18, 2024 from <https://doi.org/10.1111/j.1095-8312.1997.tb01630.x>
- Douglas, A., Simpson, S., & Douglas Frontmatter, A. (2024). Retrieved june 1, 2024 from https://assets.cambridge.org/97805211/13892/frontmatter/9780521113892_frontendmatter.pdf
- Esme Ashe-Jepson, Bru, E., Connell, E., Dixit, M. K., Hargrave, J., Lavitt, T., Lam, M., Prosser, R., Roberts, B. J., Thompson, B., Bladon, A. J., & Turner, E. C. (2023). Hot topics in butterfly research: Current knowledge and gaps in understanding of the impacts of temperature on butterflies. *Insect Conservation and Diversity*, 17(1), 1-15. Retrieved may 24, 2024 from <https://doi.org/10.1111/icad.12704>
- Ferris, R. (1999). A review of potential biodiversity indicators for application in British forests. *Forestry*, 72(4), 313-328. Retrieved may 28, 2024 from <https://doi.org/10.1093/forestry/72.4.313>
- G. Komala, K. Madesh, & R. Chandralekha. (2023, September 7). *Insect Neurobiology: From Sensory System to Behavior*. ResearchGate; unknown. Retrieved june 3, 2024 from https://www.researchgate.net/publication/373715654_Insect_Neurobiology_From_Sensory_System_to_Behavior
- Ghazanfar, M., Faheem, M., Hussain, I., Iqbal, R., Younas, F., Malik, M. F., & Younas, M. (2016). *Butterflies and their contribution in ecosystem: A review*. *Journal of Entomology and Zoology Studies*, 4(2), 115-118. Retrieved may 29, 2024 from <https://www.entomoljournal.com/archives/2016/vol4issue2/PartB/4-2-36.1.pdf>
- Hailay, G., Biru, Y., & Kassie, A. (2024). Butterfly diversity and abundance at two different habitat types of Gozamen Woreda, Amhara regional state, Ethiopia. *Arthropods*, 2022(3), 153-163. Retrieved may 23, 2024 from [http://www.iaees.org/publications/journals/arthropods/articles/2022-11\(3\)/butterfly-diversity-and-abundance.pdf](http://www.iaees.org/publications/journals/arthropods/articles/2022-11(3)/butterfly-diversity-and-abundance.pdf)
- In Encyclopædia Britannica. <https://www.britannica.com/animal/lepidopteran/Form-and-function>

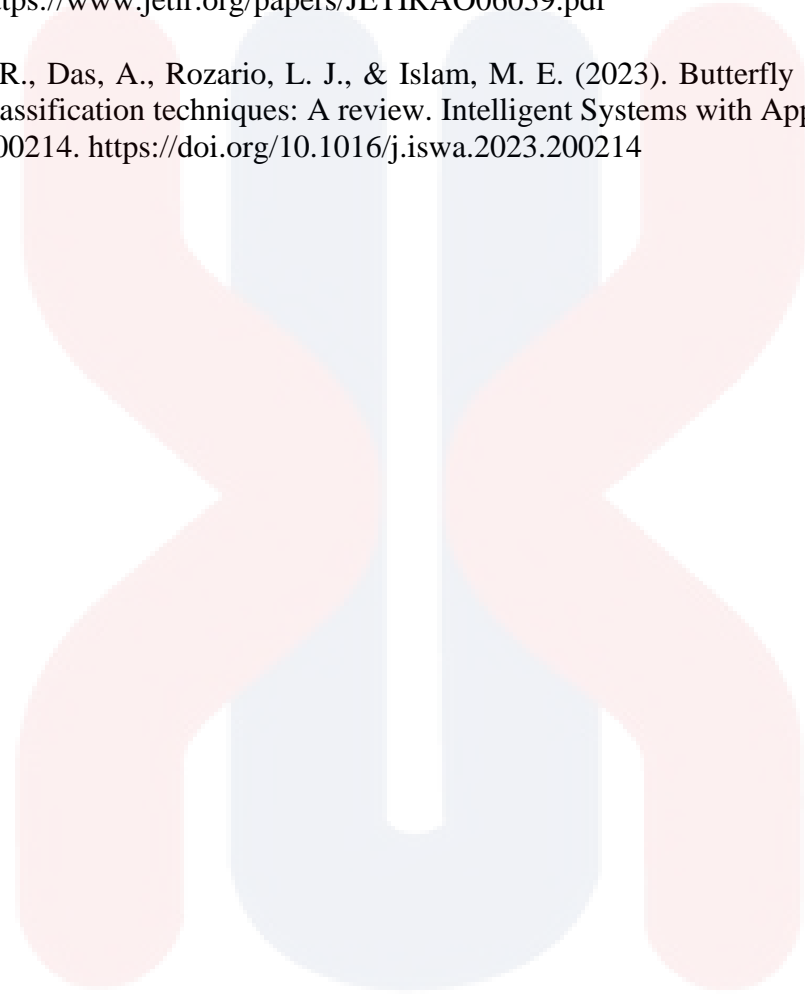
- Julia Losada Tourinho, & Lucci, V. (2009). *Population biology of Euptoieta hegesia (Nymphalidae: Heliconiinae: Argynnini) in an urban area in...* ResearchGate; Biodiversity Heritage Library. Retrieved June 10, 2024 from https://www.researchgate.net/publication/279512965_Population_biology_of_Euptoieta_hegesia_Nymphalidae_Heliconiinae_Argynnini_in_an_urban_area_in_Southeastern_Brazil
- Kawahara, A. Y., Storer, C., Paula, A., Plotkin, D., Condamine, F. L., Braga, M. P., Ellis, E. A., St, R. A., Li, X., Barve, V., Cai, L., Earl, C., Frandsen, P. B., Owens, H. L., Valencia-Montoya, W. A., Aduse-Poku, K., Dexter, K. M., Tenzing Doleck, & Markee, A. (2023). A global phylogeny of butterflies reveals their evolutionary history, ancestral hosts and biogeographic origins. *Nature Ecology and Evolution*, 7(6), 903-913. Retrieved June 6, 2024 from <https://doi.org/10.1038/s41559-023-02041-9>
- Kearney, L. (2021, March 5). How the butterfly can shape an ecosystem and why we need to protect them. *One Green Planet*. Retrieved May 17, 2024 from <https://www.onegreenplanet.org/environment/how-the-butterfly-can-shape-an-ecosystem-and-why-we-need-to-protect-them/>
- Khan, M., Ullah, H., Suleman, Anwar, M., Khan, S., Naz, F., Rafi, M., & Mehmood, S. (2016). Diversity and distribution of butterflies (Insecta: Lepidoptera) of district Dir lower, Khyber Pukhtoonkhwa, Pakistan. *Arthropods*, 5(1), 11-22. Retrieved May 14, 2024 from [http://www.iaees.org/publications/journals/arthropods/articles/2016-5\(1\)/diversity-and-distribution-of-butterflies.pdf](http://www.iaees.org/publications/journals/arthropods/articles/2016-5(1)/diversity-and-distribution-of-butterflies.pdf)
- Kirton, L. (2018, January 1). Naturalist's guide to butterflies of Malaysia. *Lepidopteran - Metamorphosis, wings, antennae*. (2023). In *Encyclopædia Britannica*. Retrieved May 28, 2024 from <https://www.britannica.com/animal/lepidopteran/Metamorphosis-wings-antennae>
- Lucci, V., Cristiano Agra Iserhard, Pereira, J., & Marcio Uehara-Prado. (2014, November 16). Studies with butterfly bait traps: An overview. ResearchGate. Retrieved May 17, 2024 from https://www.researchgate.net/publication/271703948_Studies_with_butterfly_bait_traps_An_overview
- Ma, Y., Zhao, H., Ma, T., Ning, J., & Stanislav Gorb. (2021). Wing coupling mechanism in the butterfly *Pieris rapae* (Lepidoptera, Pieridae) and its role in taking off. *Journal of Insect Physiology*, 131, 104212–104212. Retrieved May 12, 2024 from <https://doi.org/10.1016/j.jinsphys.2021.104212>
- McGeogh, M. A. (2007, January 11). The selection, testing and application of terrestrial insects as bioindicators. ResearchGate. Retrieved May 12, 2024 from https://www.researchgate.net/publication/229775996_The_selection_testing_and_application_of_terrestrial_insects_as_bioindicators
- Metamorphosis of a butterfly-associated bacterial community. (2014). *PLoS ONE*, 9(1), e86995. Retrieved May 22, 2024 from

<https://doi.org/10.1371/journal.pone.0086995>

- Mobeen Ghazanfar, Iqbal, R., Malik, M. F., & Younas, M. (2016, February 24). Butterflies and their contribution in ecosystem: A review. ResearchGate. Retrieved may 22, 2024 from https://www.researchgate.net/publication/299427719_Butterflies_and_their_contribution_in_ecosystem_A_review
- New, T. R. (2013). *Lepidoptera and conservation*. John Wiley & Sons.
- Perveen, F. K. (2017). *Lepidoptera*. BOD – Books on Demand.
- Pollution: Effects on marine communities. (2019). *Encyclopedia of Ocean Sciences*, 533-539. Retrieved may 14, 2024 from <https://doi.org/10.1016/b978-012374473-9.00052-7>
- Prasun Karmakar, Mishra, A., Borah, C., & Deka, A. (2022, September). Record on some caterpillars of butterflies (Lepidoptera: Papilionoidea) in East Java, Indonesia. ResearchGate; Indonesian Institute of Sciences. Retrieved may 14, 2024 from https://www.researchgate.net/publication/365129316_Record_on_some_Caterpillars_of_Butterflies_Lepidoptera_Papilionoidea_in_East_Java_Indonesia
- Record on some caterpillars of butterflies (Lepidoptera: Papilionoidea) in East Java, Indonesia. (2022). *Treubia*, 49(1), 25-40. Retrieved may 9, 2024 from <https://doi.org/10.14203/treubia.v49i1.4387>
- Shahroni, A. M., Shidiq, F. I. A., Soenarko, S., Irwansyah, L., & Peggie, D. (2022). Record on some caterpillars of butterflies (Lepidoptera: Papilionoidea) in East Java, Indonesia. *Treubia*, 49(1), 25-40. Retrieved may 5, 2024 from <https://doi.org/10.14203/treubia.v49i1.4387>
- Siti Zulaikha, & Muhamad. (2023, March 30). Community structure of butterflies (Lepidoptera: Papilionoidea) in Sumur Panguripan Cultural Reserve Area, Surabaya City, East Java. ResearchGate. Retrieved may 6, 2024 from https://www.researchgate.net/publication/369638726_COMMUNITY_STRUCTURE_OF_BUTTERFLIES_LEPIDOPTERA_PAPILIONOIDEA_IN_SUMUR_PANGURIPAN_CULTURAL_RESERVE_AREA_SURABAYA_CITY_EAST_JAVA
- Species accumulation curves. (2016). *Terrestrial Ecosystems*. Retrieved may 8, 2024 from [https://terrestrialecosystems.com/species-accumulation-curves/#:~:text=Species%20accumulation%20curves%20\(SAC%3B%20or,fauna%20in%20a%20particular%20area.](https://terrestrialecosystems.com/species-accumulation-curves/#:~:text=Species%20accumulation%20curves%20(SAC%3B%20or,fauna%20in%20a%20particular%20area.)
- The Butterfly Book*. (2016). Google Books. Retrieved may 25, 2024 from https://books.google.com.my/books?hl=en&lr=&id=_zGvEAAAQBAJ&oi=fnd&pg=PP4&dq=anatomy+of+butterfly&ots=lfoxRCHyV4&sig=HLSdL9EPs0Hu5khh172fOneoVsQ&redir_esc=y#v=onepage&q=anatomy%20of%20butterfly&f=false

Wankhede, C. (2019). Issue 3. Journal of Emerging Technologies and Innovative Research, 6. Retrieved may 23, 2024 from <https://www.jetir.org/papers/JETIRAO06039.pdf>

Yasmin, R., Das, A., Rozario, L. J., & Islam, M. E. (2023). Butterfly detection and classification techniques: A review. Intelligent Systems with Applications, 18, 200214. <https://doi.org/10.1016/j.iswa.2023.200214>



UNIVERSITI

MALAYSIA

KELANTAN

FYP FSB