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DIVERSITY AND ABUNDANCES OF BATS AT BANDING LAKESIDE INN

by

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A report submitted in fulfillment of the requirements for the degree of
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DECLARATION

I declare that this thesis entitled “Diversity and Abundance of Bats at Banding Lakeside Inn” 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 the candidature of any other degree.

Signature :

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Diversity and Abundances of Bat at Banding Lakeside Inn, Hulu, Perak

ABSTRACT

Over the course of 16 trap nights, this study examines the variety and number of bat species at the Banding Lakeside Inn in Hulu, Perak. Six distinct species of bats, including *Taphozous melanopogon*, *Cynopterus horsfieldii*, *Cynopterus brachyotis*, *Cynopterus sphinx*, *Rhinolophus sp.*, and *Hipposideros dyacorum*, were represented among the 60 individual bats that were caught. Four distinct locations in the Banding Lake region were sampled over the course of a week Trail 1, Trail 2, the border of Banding Inn Lake, and an ancient agarwood farm. For the assembly and capture day, four traps (two harp traps and two mist nets) were put up in the afternoon each day. Measurements and references from the books "Bats of Krau Wildlife Reserve" by (Kingston et al.,2009) and "Field Guide to the Mammals of South-East Asia" by (Francis et al.,2019) were used to identify the species. Every day, curves representing the accumulation of newly identified species were drawn. The study's conclusions lay the groundwork for further ecological research and conservation initiatives while also advancing our knowledge of the variety and number of bats in the Banding Lakeside Inn region. Appendix B contains photos of the persons that were apprehended.

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Kepelbagaian dan Kelimpahan Kelawar di Banding Lakeside Inn, Hulu, Perak

ABSTRAK

Sepanjang 16 malam perangkap, kajian ini mengkaji kepelbagaian dan bilangan spesies kelawar di Banding Lakeside Inn di Hulu, Perak. Enam spesies kelawar yang berbeza, termasuk *Taphozous melanopogon*, *Cynopterus horsfieldii*, *Cynopterus brachyotis*, *Cynopterus sphinx*, *Rhinolophus sp.*, dan *Hipposideros dyacorum*, telah diwakili antara 60 kelawar individu yang ditangkap. Empat lokasi berbeza di rantau Tasik Banding telah dijadikan sampel sepanjang seminggu Laluan 1, Laluan 2, sempadan Tasik Banding Inn dan ladang gaharu purba. Untuk hari perhimpunan dan tangkapan, empat perangkap (dua perangkap kecapi dan dua pukut kabut) dipasang pada sebelah petang setiap hari. Pengukuran dan rujukan daripada buku "Bats of Krau Wildlife Reserve" oleh (Kingston et al.,2009) dan "Panduan Lapangan untuk Mamalia Asia Tenggara" oleh (Franciset et al.,2019) digunakan untuk mengenal pasti spesies. Setiap hari, lengkung yang mewakili pengumpulan spesies yang baru dikenal pasti dilukis. Kesimpulan kajian itu meletakkan asas untuk penyelidikan ekologi dan inisiatif pemuliharaan selanjutnya sambil turut memajukan pengetahuan kami tentang pelbagai dan bilangan kelawar di wilayah Banding Lakeside Inn. Lampiran B mengandungi gambar orang yang telah ditangkap.

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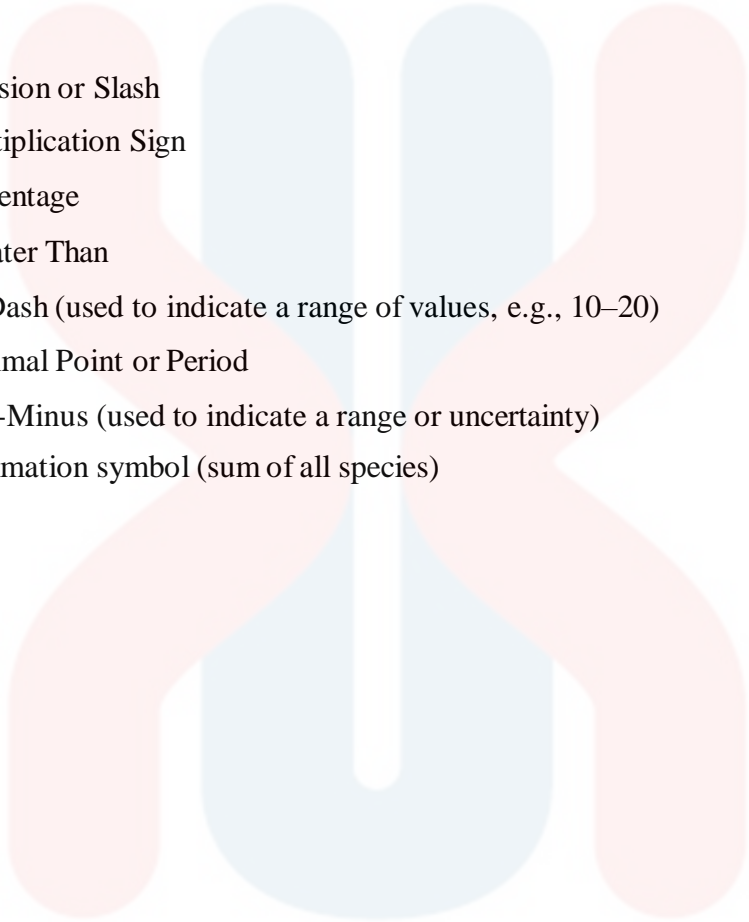
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LIST OF ABBREVIATIONS

p.m.	Post Meridiem (afternoon)
a. m.	Ante Meridiem (morning)
g	Gram(s)
mm	Millimeter(s)
m	Meter(s)
kHz	Kilohertz
DAC	Data Accumulation Curve or Species Accumulation Curve
IUCN	International Union for Conservation of Nature

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LIST OF SYMBOLS

/	Division or Slash
×	Multiplication Sign
%	Percentage
>	Greater Than
--	En Dash (used to indicate a range of values, e.g., 10–20)
.-	Decimal Point or Period
±	Plus-Minus (used to indicate a range or uncertainty)
Σ -	Summation symbol (sum of all species)

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CHAPTER 1

INTRODUCTION

1.1 Background of study.

With over 1400 species identified, Bats are the second largest order of mammals . As a result, bats contribute significantly to both the local mammalian faunas of the tropics and temperate zones, as well as the variety of the class as a whole. Even with the extensive research and careful observation of experts, particularly in the last several years, the field of *chiropteran* characteristics still has a very large amount of unexplored territory. Not only are the numbers of species and genera unclear, but so are the divisions among taxa (Kortner A. et al., 2016).

The bat communities in Southeast Asia have received far less attention than they deserve. Malaysia is an essential nation for global bat conservation efforts.133 species were counted overall during the country with 110 species of bats identified in Malaysia's peninsula (Lim L et al.,2017). of all the people ten species that have been officially recorded in the nation are included. *Hipposideros coxi*, a species that is threatened, is one that, according to the (IUCN Red List, is endangered. 2016, IUCN).

Major concerns to bat populations include habitat loss and hunting. However, throughout time, other problems have also surfaced, including bat illnesses and climate change. Although the degree of habitat fragmentation caused by human activity is considerably lower for bats than for other animal groups it nevertheless has an impact on the structure of bat assemblages (Meyer et al.,2016).

According to the foraging area, roosting options, and food supplies all affect the diversity of bats in a given location. Because they may travel several km in a single night between forest areas and utilize matrix habitat, bats have the ability to reach materials that are widely dispersed across the ecosystem. Nonetheless, certain insectivorous bat species have a restricted area of feeding because they cannot travel great distances in their energetically costly flight (Russo et al., 2016).

Forest bats are strongly dependent on the forest structure for foraging and roosting however certain bats that can be found in other types of flora are influenced by the size of wing, type of maneuverability, roosting places, and also feeding type (Patriquin and Barclay et al.,2017). Therefore, the purpose of this study was to examine the bat species' evenness, species richness, and diversity among three types of forests: urban, secondary, and primary.

1.2 Problem Statement.

This issue statement probably took into account inquiries about bat species identification, historical population trends, evaluation of previous habitat quality, and possible risks such as habitat destruction. In order to preserve the historical richness of bats in the region, it would have given previous conservation efforts and research programmers on bat diversity at Banding Lakeside Inn a defined direction.

1.3 Objectives.

- a) The determine the diversity and abundances of bat at Banding Lakeside Inn.

1.4 Scope study.

Using the Shannon and Simpson index, bat diversity in lakeside resorts was compared by species richness. In order to obtain data for this study, bats were captured for one week in the aforementioned sites using harp traps and mist nets. Every bat that was caught was put through a battery of tests, which included morphometric measurements using a dial calliper (Ecotone-Poland 150/0.1 mm), species identification, sex, and digital scale calibration (500 g × 0.1 g, Ohaus). (Baagoe et al., 2015).

1.5 Significant Study

The isolated and biologically varied island of Banding Lakeside Inn was well-known for its unusual animals and lush vegetation. Bats were recognized as crucial elements of the island's ecology, contributing significantly to seed dissemination, pollination, and pest control. On the other hand, nothing was known about the variety of bat species that called Banding Lakeside Inn home. By identifying the species that are present and looking into their preferred habitats, this study aims to provide a full assessment of the bat population. The findings have significance for upcoming conservation efforts and provide insightful information on the biological dynamics of the island (Furey N. M., and P. A. Racey et al., 2016).

CHAPTER 2

LITERATURE REVIEW

2.1 Distribution of bats in Malaysia

With over 140 species identified, Malaysia is home to a diverse range of bats, accounting for around 25% of the global bat population. In Malaysia, bats may be found in many different types of habitats, such as urban areas, caverns, and woods. The distribution of bats in Malaysia has been the subject of several investigations. In their extensive study of bats in Peninsular Malaysia in 2002, Davison and Zubaid identified 106 species. They discovered that although they were also found in montane forests, caverns, and urban areas, lowland woods were home to the majority of bat populations (Azlan et al., 2016).

Study on Borneo's bat diversity, identified 87 species. They discovered that although they could also be found in montane forests, oil palm farms, and caves, lowland rainforest were home to the greatest number of bats. used ecological niche modelling to investigate the distribution of bats on Malaysia's peninsula. They discovered that regions with a lot of forest cover, cold temperatures, and heavy rainfall were the most likely to harbour bats. According to these research, bats represent a significant part of Malaysia's biodiversity and are found across the nation.

To completely comprehend the distribution of bats in Malaysia and to pinpoint the problems facing their populations, more investigation is required (Mohd Nor et al., 2018).

2.2 Morphology of bat

A unique group of animals, bats have acquired some amazing flight-related abilities a thin membrane of skin covering their enlarged fingers, arms, legs, and tail forms their wings. A web of bones, cartilage, and muscles supports this membrane. In addition to these flight-related adaptations, bats also have a lightweight skeleton, strong muscles, and a streamlined body (Racey P .A et al., 2016). A bat's forelimbs are extensively altered for flying. The wing membrane of a bat is formed by the fusion of its elongated fingers. In addition to the enlarged arm and forearm bones, the shoulder joint has been altered to provide a broad range of motion. A bat's thumb is normally free and used for grooming. After that, a bat's hindlimb, which are utilized for walking and roosting, are comparatively short. Bats usually have claws on their feet, which they utilize to hold onto their roosting places (Adams R. A. M. et al., 2017).

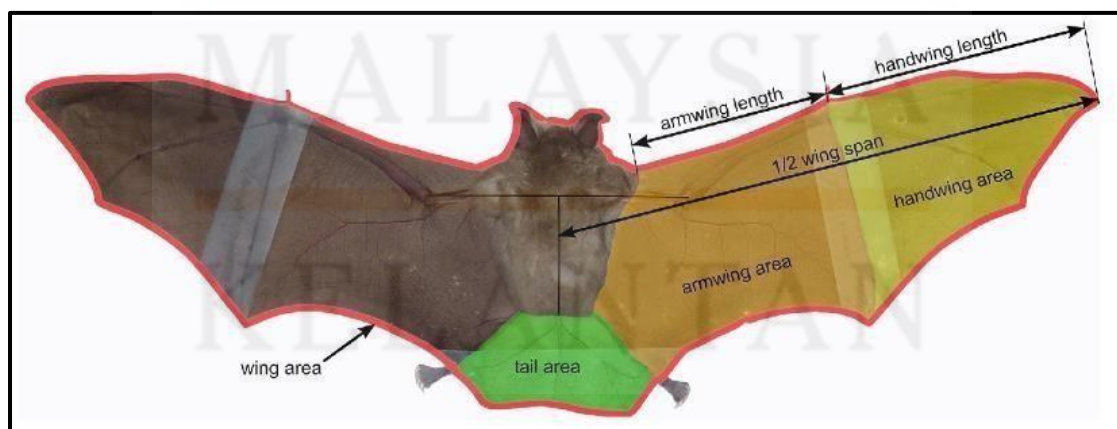


Figure 2.1: Show the morphology of bat Length and area measurements taken for each analyse wing photograph.

(Source : Carmelo Frucaino et al., 2015)

2.3 Diversity of bat

Among mammals, bats are the second most varied order, with over 1,400 species identified globally. They may be found in many different types of environments, including as urban areas, woodlands, deserts, and caverns. As seed disperses, bug predators, and pollinators, bats are vital to ecosystems. In the tropics, where they make up more than 40% of all mammal species, bat diversity is highest. Bats can account for more than 60% of all terrestrial animals in certain tropical locations. Even though there is less bat variety in temperate and polar areas, bats nonetheless play a significant role in these ecosystems (Parsons D et al., 2015).

Megachiroptera and *Microchiroptera* are the two suborders into which bats are divided. *Megabats* may have wingspans of up to six feet, making them generally bigger than *microbats*. Fruit bats, or *megabats*, are mainly responsible for the spread of seeds in tropical forests. With wingspans that seldom ever rise over three feet, *microbats* are generally smaller than *megabats* (FrickW. F et al., 2017). Since they are largely insectivores, *microbats* are crucial to the regulation of insect populations. Numerous causes, such as habitat loss, pesticide usage, and climate change, pose a danger to bat diversity. Bats are seriously threatened by habitat loss because it obliterates their places to sleep and feed. Bats might suffer from the poisoning or

direct death of their prey caused by pesticide usage. Bats are also at risk from climate change because it can interfere with their access to food and make it more difficult for them to locate roosting places (Racey P. A et al., 2016).

2.4 The Role of Bats in Ecosystem Management

Despite being feared and misunderstood animals, bats are essential to the upkeep of ecosystem health. Numerous vital functions, like as pollination, seed distribution, insect predation, and nutrient cycling, are performed by these nocturnal animals. Because of this, bats are essential to many ecosystems' health and stability, and their extinction might have grave repercussions (Barclay R. M. R et al., 2019). Pollination is one of the most significant functions that bats do. Many tropical plants, including a large number of agricultural products and forest trees, rely on bats as their principal pollinator. They are ideal for this task because of their nocturnal habits and vast flight range. For instance, avocados, mangoes, and bananas all significant crops in various regions of the world are pollinated by bats (Jung, Cet al., 2016)

Bats have several advantages, but they also face several problems, such as habitat loss, pesticide usage, climate change, and white-nose disease. Globally, bat populations are declining as a result of these dangers. For instance, the disappearance of caves and forests, two significant bat habitats, has led to the reduction of several bat species. Pesticides can kill or poison their prey, which can be harmful to bat populations. Bats are being impacted by climate change because it is changing their food sources and making it more difficult for them to locate roosting places.

Furthermore, since the disease's discovery in (Ficetola. G. F et al., 2015). White-nose syndrome has claimed the lives of millions of bats throughout North America.

2.5 Threat and challenges to global bat conservation

Hunting and gathering wildlife, including controlling and persecuting it. Approximately 13% of all bat species 137 are hunted for food or medicine, and bushmeat hunting is becoming more and more acknowledged as a serious danger to bat conservation, particularly in Southeast Asia and West and Central Africa. 3,45,46 Old World fruit bats (*Pteropodidae*) are disproportionately impacted by hunting; among the *pteropodid* bat species (92–183), around half are hunted, mostly for food, though occasionally for traditional medicine and recreational purposes as well. Huge (>100 g body mass) birds that roost in huge, easily accessible aggregations in trees or caves where they may be met with certainty are usually the most heavily targeted species (Leppanen et al., 2017).

46 Few empirical assessments of the effects of hunting on bat populations exist, despite growing knowledge and concern about bushmeat hunting, especially at noncommercial sizes (e.g., subsistence or local-scale markets). 45 The scant research that are accessible suggest that, given the dynamics of the bat population and the sizes of the local populations, the harvest rates are startlingly high and seem unsustainable. 47–51 A developing concern 52 is the harvesting of bats for tourist souvenirs, curios, and decorating, especially given the global reach of the internet market. The only species that are included in the CITES appendices that restrict or forbid trade are

those of the *Pteropus* (65 species), *Acerodon* (5 species), and *Platyrrhinus* (1 species) species⁵³ (Holmes et al., 2017)

2.6 Richness and evenness of species

According to this study, the main forest had more bat species richness and variety than the secondary and urban forests. In a natural forest, bat species richness and diversity were always higher. A high species diversity indicates that the environment is diverse and that there are few disruptions to it. However, this study demonstrated that the evenness of bats in the urban forest was higher compared to the main and the secondary forests. This was most likely due to the fact that, in comparison to primary and secondary forests, the abundance of each species was more uniformly distributed and the difference in abundance across species was minimal.

The urban forest has a high density of bats despite the limited number of individuals taken for each species. Six *Microchiroptera* species and five *Megachiroptera* species were found. *Frugivorous* bats live on fruits, leaves, and nectar of forest trees, which makes a larger dietary variety. *Fugivorous* bats mostly fed on fruit trees in addition to forest trees. Fruit trees like Jambu (*Psidium guajava*) and Rambutan (*Nephelium lappaceum*) encourage the abundance of C.

2.7 Conservation Prioritization

The major MBCRU research objective has been to understand how forest-interior bat diversity functions in largely unchanged habitat, so that we can develop and test prediction frameworks of species' vulnerability to *anthropogenic* disturbance (Fletcher et al.,2018). We want to know if habitat loss, degradation, and conversion impact bats equally and if it is feasible to create risk or vulnerability profiles that indicate which species, or subspecies, will be more or less resistant to changes in land use. The degree of specialization in diet and roost choice, abundance, local and landscape spatial distribution patterns, life history traits and reproductive phenology, longevity and population turnover rates, and landscape and temporal population variability are some of the candidate ecological determinants of extinction risk that could affect the profiles (Kingston et al.,2015). For conservation biologists, predictive frameworks are somewhat of a holy grail because they may direct conservation and intervention efforts before population declines. However, this is an ambitious research goal, and advancements have invariably reflected the advantages and disadvantages of specific funding sources.

2.8 Food habits of *Cynopterus Brachyotis*

Regarding the bat's dietary habits, Will *Cynopterus brachyotis*, was collected via the collecting of food remnants just beneath daytime and feeding roosts. 54 plant species' fruits, 14 species' leaves, and four species' floral parts were discovered to be the bats' main sources of food. The time of year (Bumrungsri S et el.,2015). A

consistent fruit production throughout the year was made possible by phenological variations across congeneric plant species, and the findings indicate that *Ficus spp.* form an important part of the diet. Based on the variety of fruits it produces, *C. brachyotis* is thought to play a significant role in seed dispersal.

It seems that *C. brachyotis* is more omnivorous than previously believed. Seven species of the *Leguminosae* family comprised the majority of the leaves that the bats ate, followed by the *Myrtaceae*, *Moraceae*, *Rhizophoraceae*, and *Euphorbiaceae* families. Although most fruits are poor in protein, they generally give *phytophagous* bats an energy-rich diet. Bats, on the other hand, eat leaves, which are comparatively heavy in protein. We propose that leaf eating (fractional) ought to be more beneficial energetically than consuming a lot of fruit that is deficient in protein or actively pursuing moving insects.

2.9 Comparative Diversity of Bats in Two Contrasting Habitats

In the tropical rainforest, bats are an essential part of the vertebrate fauna that perform vital ecological functions including pollination and pest management (Muhammad et al.,2021). In terms of biodiversity, they rank second in the class Mammalia, behind Rodentia. Bats have a wide distribution across the planet due to their flight capabilities and play significant roles in arthropod suppression, seed dissemination, and pollination. Aside from that, its wide dispersal is also facilitated by its varied dietary, roosting, social, and reproductive practices.

Due to differences in shape and ecology, various bat species have varying preferences for different types of habitat; hence, some species are better adapted to a particular environment than the others. For example, the open spaces above the canopy or the interior of the forest complex. The capacity of a cave ecosystem to house a high number of individuals is recognized to be a determining factor for colonial species, which select their roosting place accordingly (Shazali et al., 2017). Due to their nocturnal and crepuscular lifestyle, bats have evolved, adapted, and strategized in order to avoid direct conflict with daytime birds for resources, such as food on the wings.

CHAPTER 3

MATERIAL & METHOD

3.1 Study area

Where the study was conducted Banding Lakeside Inn Gerik is set 2.4 miles away from Belum Jetty and 1.6 miles from the artificial Banding Island the Property Location With a stay at Banding Lakeside Inn in Gerik, be on a lake and minutes from Malaysian Armed Forces Monument, and close to Landmark Bridge This hotel has 7308 square feet 679 square meters of space consisting of conference space and meeting rooms Wellness, and First-Class Amenities Enjoy leisure amenities including an outdoor pool or gaze over the scenery from a garden and terrace Onsite self parking is free of charge. This motel also has a picnic area and free wireless Internet connection. Eating Savour a hearty dinner at a restaurant that welcomes visitors to the Banding Lakeside Inn fortunately lakeside inn Hotel Banding was closed in February 2019. For the location coordinate of this place is 5.5429689N, 101.3306642E.

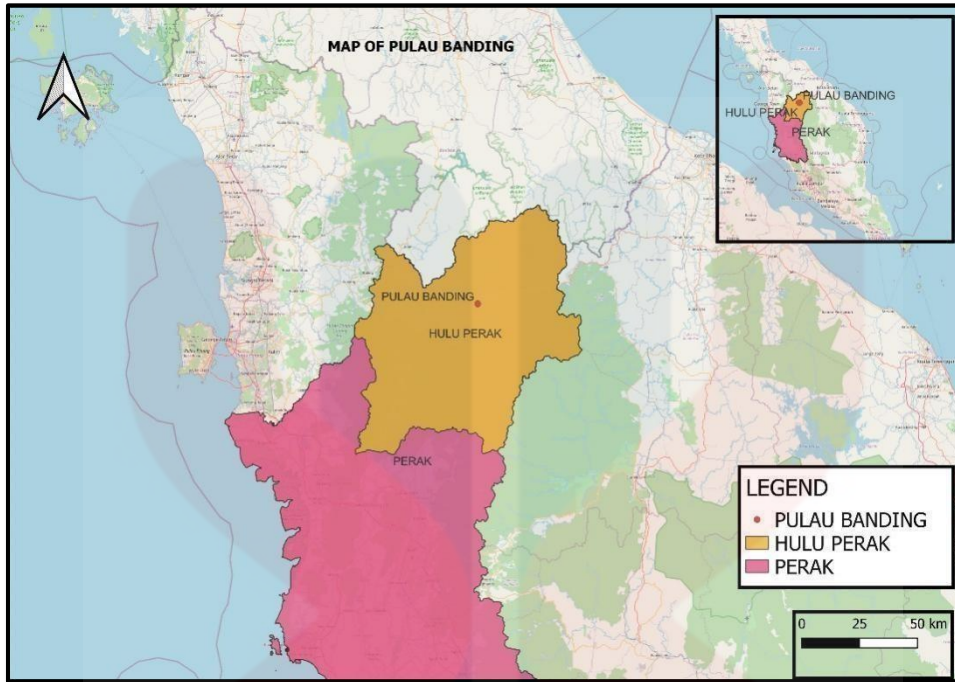


Figure 3.1: Shows the map of Pulau Banding, Perak from RBTFC Source

3.2 Material

The material use will be population data like mark and recapture materials by running Marking tools such as bands or tags for capturing and marking bats for population size estimation. besides that, there are other methods such as Population Surveys and by using Data collected from field surveys, including mist-netting and harp trapping to assess the diversity and abundance of bat populations.

3.2.1 Material

The materials used in this study are as stated in Table 1.

Table 3.1 List of materials used in this study.

Section	Materials
Sampling	<ul style="list-style-type: none"> i. Mist net ii. Harp trap iii. Headlamps iv. Cloth bags v. Specimen tags I. Notebook
Measuring and Identification	<ul style="list-style-type: none"> i. Weight balance ii. Calliper iii. Ruler iv. Headlamp v. References books <ul style="list-style-type: none"> -Bats of Krau Wildlife Reserve”by (Kingston et al.,2009). - Field Guide to the Mammals of South-East Asia by (Francis et al., 2019).

3.2.2 Mist net

Mist nets are used by ornithologists and bat biologists to capture bats for banding or other scientific *endeavours*. Mist nets are made of nylon or polyester mesh that is stretched between two poles and are often built like volleyball nets. The most popular size kinds of nylon net are 2 meters in height and 7 to 12 meters in width. Typically, the finest varieties with a mesh of 16 to 20 mm are employed. 3–5 shelves must be present in the nets. Mist nets have shelves composed of horizontally stretched strands that create a puffy, loose pocket. A bat that hits the net coils itself in this little alcove. The size of the mesh of the netting is determined by the size of the species that is being targeted for capture. The mesh sizes of a single mesh square can be determined by measuring either one of its sides or its diagonal. The dimensions displayed here are diagonal. Typically, little passerines are captured using a mesh of 30–38 mm (Carol E et al.,2016).



Figure 3.2: Mist netting for capturing bat from sciences new explore

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3.2.3 Harp trap

An alternative to mist nets or bat detectors for bat surveys is a harp trap. They are especially helpful when there is a clear path through a forest that bats may use to channel themselves while in flight. Harp traps are made composed of a frame that can be hanging or freestanding that holds two or four rows of nylon strings. The bats will soar through the nylon strands and land safely in a collecting bag beneath. The capture bag has strong, transparent plastic baffles to keep the bats from escaping and is composed of breathable, water-resistant green cotton canvas. Harp traps are said to be more successful in assessing bat populations than mist nets because they do not entangle the bats, possibly catching a larger number of individual bats (Flynn, J et al.,2022).



Figure 3.3: Harp trap's for capturing bat from research gate

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3.3 Method

3.3.1 For field method

The investigation was conducted at the Banding Lakeside Inn using four-bank harp traps, which we positioned approximately one metre above the ground, and mist nets supported by two poles. The Banding Lakeside Inn Hotel was selected since it is home to several *Taphozous Melanopogon* species. Similarly, mist netting and harp traps are installed to collect data in the vicinity of the trace area behind the office building and the apartment building. Ultimately, three areas of the site are positioned surrounding the former agar wood plantation.

Bats who are captured and tangled in the nests or the collecting bag of the harp trap are taken out every hour, between 5:00 p.m. and 5.30 p.m. Every day, this procedure takes place just before dawn and after dusk. We reset both sets of two-bank harp traps and two mist nets (lengths of 2, 6, 9, 12, and down 30.5 m) every night. By 5:00 p.m., nets and traps were placed, and the next day, they were closed between 12:00 and 1:00 a.m. Before closing them the next day, the nets were examined every two to three hours after being monitored every 20 minutes for the first six hours. Every night, three or four harp traps were inspected (Mam. J et al., 2011).

Before recording the bats' sex, life stage, and external measurements, safely place them in cotton bags and use a Vernier calliper to measure the bats' forearm, tail, tibia, hind foot, and ear length. We using a portable analytical balance with a

sensitivity of ± 0.01 g, the mass of every bat was recorded. Utilizing the descriptive measures of each bat, such as mass and forearm length, the Body Condition Index was constructed (Francis C.M. et al., 2016). When negative values were present, the body mass scale was adjusted to account for them. The resulting underweight, optimal, overweight, and obese categories were then separated by 0.5 difference margins. We using the identification key provided below, we were able to identify the bats to the species level. At the catch site, the bats were released back into the wild at the conclusion of the data collection (Kingston T et al., 2019).

3.3.2 Data analysis

3.3.2.1 Species Accumulations Curve

The data collected from sampling was analyses using a data accumulation curve (DAC), also known as a species accumulation curve (SAC), sample coverage curve, or collector's curve, is a graphic representation of the cumulative number of new species, genera, or other taxa as a function of sampling effort. It is a common tool used in ecology, biodiversity research, and systematic to assess the effectiveness of sampling methods and to estimate the total number of species (or other taxa) present in a particular area or group of organisms (Ellison, A. M et al., 2020). The individual based on species accumulation curve records the cumulative increase in richness against the number of individuals.

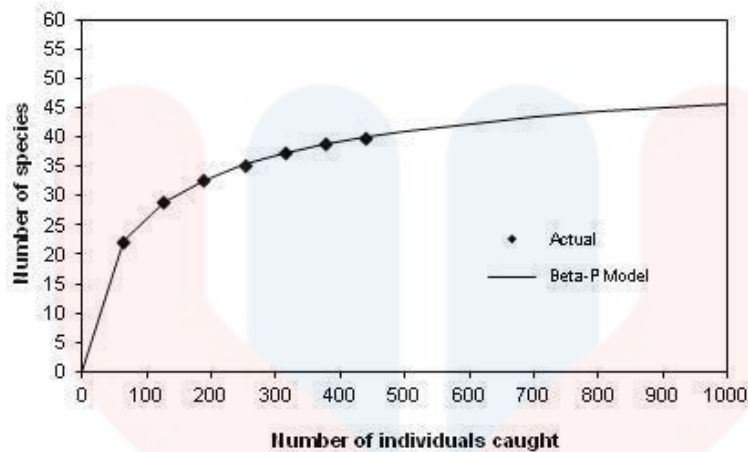


Figure 3.4: Species accumulation curve

3.3.2.2 Shannon-Wiener Diversity Index

The Shannon–Wiener diversity index (H'), often referred to as the Shannon–Weaver index or just the Shannon index, is a metric used in ecology to quantify the species variety within a particular community ecologists subsequently began using it to gauge the variety of biological systems clade Shannon created it in 1948 to estimate the information content in a communication system.

This is how the Shannon diversity index is determined:

$$H' = - \sum_{i=1}^s P_i \ln P_i$$

Wherever :

P_i = the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individual found (N)

\ln = natural log

Σ = the sum of the calculations

S = the number of species

The dimensionless Shannon diversity index has a range of 0 to infinity. Greater diversity is indicated by a larger value of H' , and lesser diversity is indicated by a lower value. When H' is equal to 0, it means that the community contains only one species.

3.3.2.3 Species Evenness

The distribution of abundance among the species in a community is referred to as species evenness. When every species in a sample has the same abundance, species evenness is at its greatest. Relative abundances change when evenness gets closer to zero. Another way to characteristic species evenness is by indices, such.

$$E = \frac{H'}{H_{max}}$$

Variable :

H' = the value of the Shannon-Wiener Diversity Index

H_{max} = species richness

H_{max} is denoted by species richness, which is the number of species present in a community. It can be calculated by :

$$H_{max} = \ln S$$

Variables :

S = The number of species

Greater evenness is indicated by higher values in the index, which spans from 0 to a maximum value. A community exhibiting high evenness displays a fairly uniform distribution of individuals across various species, whereas low evenness implies that a small number of dominant species may exist within the community.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Species diversity and abundances bat at Banding Lakeside Inn.

16 trap nights were used to collect a total of 60 individual bats, representing six different bat species: *Taphozous Melanopogon*, *Cynopterus Horsfieldi*, *Cynopterus Brachyotis*, *Cynopterus Sphinx*, *Rhinolophus*, and *Hipposideros Dyacorum*. The sampling effort implemented in this study consisted one week of trapping at four different sites within the Banding Lakeside Inn. Picture of these individuals can be viewed in Appendix B. The species were identified by using the measurements taken and referencing the book *Bats of Krau Wildlife Reserve* by (Kingston et al.,2009) and *Field Guide to the Mammals of South-East Asia* by (Francis et al.,2019).

Taphozous Melanopogon was the most common species caught; forty bats were counted and evaluated in the Lake Banding Lakeside Inn vicinity. There were only six distinct species identified, including five for individual *Cynopterus Brachyotis*, seven for *Cynopterus sphinx*, one each for *Rhinolophus* and *Hipposideros Dyacorum*, and one each for *Cynopterus Horsfieldi*. The reason for the variation in the number captured is that the *Taphozous Melanopogon* bat species is found in the habitat area of abandoned structures. Favour s crowded, covered locations. In the meantime, only bats that fly at a low level can be caught, indicating a bias in

bat sampling at Banding Lakeside Inn. This is because the species and individual numbers of insect bats and other fruit bats are less likely to be caught due to the predation of the mist net, which is less than 3 meters high. Six species in all were found in this sample region. Species accumulation curves were plotted daily during the sample day since it was crucial to record newly identified species.

Species accumulation curves for bat species found at Lake Banding Lakeside Inn is displayed. Despite 16 nights were trapped, the curve did not reach the asymptotic level, suggesting that there may be additional species to be discovered. Future studies on the variety of bats in this region are necessary since this problem could have resulted from insufficient sampling efforts made during this study. Further sampling is necessary going forward, since the curve for the Lakeside Inn Benchmark may have reached an asymptotic level had further sampling been completed.

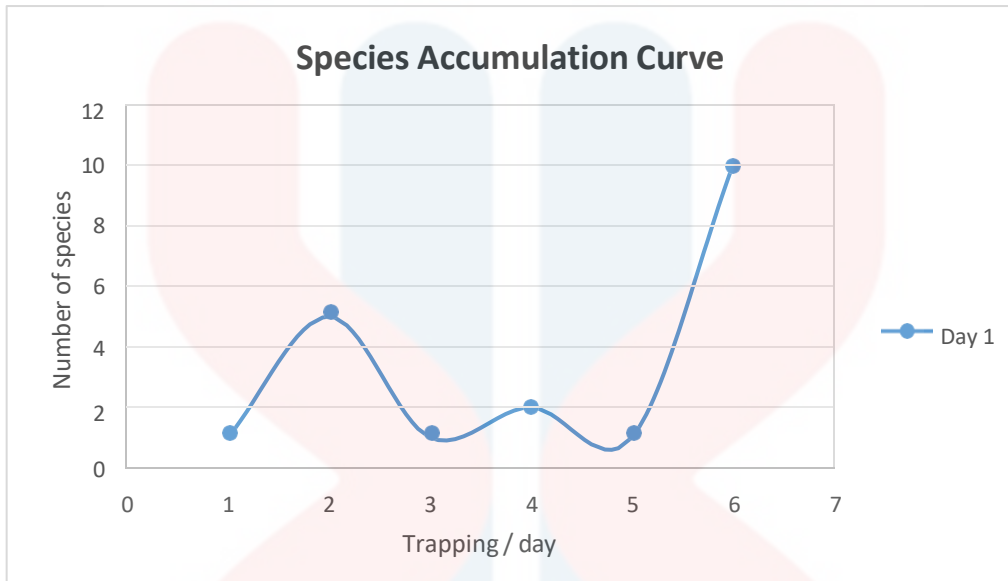


Figure 4.1: The species accumulation curve of bat species at Banding Lakeside Inn

The list of bat species collected during this investigation at three separate locations the ancient Agar wood farm, the Banding Lakeside Inn, Trail 1 and Trail 2 in Hulu, Perak is displayed below. The IUCN Red List of Threatened Species (2023) and the Red List of Mammals for Peninsular Malaysia Version 2.0 (PERHILITAN, 2017) were consulted to determine the status of each species.

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Table 4.1 Species number of individual data collection and IUCN status for Banding Lakeside Inn.

Species	Number of Individual	Data collection point	IUCN status
Emballonuridae <i>Taphozous</i> <i>Melanopogon</i>	40	Inn Banding Edge Lake	LC
Pteropodidae <i>Cynopterus</i> <i>Horsfieldi</i>	6	Trail 1 areas	LC
<i>Cynopterus</i> <i>Brachyotis</i>	5	Old Agar wood farm, Trail 1 areas	LC
<i>Cynopterus</i> <i>Sphinx</i>	7	Trail 2 areas	LC
Rhinolophidae <i>Rhinolophus</i> <i>hipposideros</i>	1	Trail 1 areas	LC
Hippodyspsidae <i>Hipposideros</i> <i>Dyacorum</i>	1	Old Agar wood farm	LC
Total Number of Individual	60		
Total Number of Species	6		
Number of Families	4		

4.1.1 Shannon- Wiener Diversity and Evenness Index

The Shannon-Weiner Diversity Index, first put out by Claude Shannon ,is another popular diversity index that also takes into account species richness and evenness. An alternative name for it is Shannon's Diversity Index. The idea of uncertainty is connected to the index. For this study, the Shannon- Wiener diversity index calculated 1.189 The Shanon-Wiener Diversity Index as calculated by referring to the total 60 of the individual that was captured at Banding Lakeside Inn, Perak. Table 4.2 shows the total number of species evenness is 0.608. The highest evenness in this study represented by *Hipposideros Dyacorum* which is the evenness 7.56.

Table 4.2 Shannon- Wiener diversity and evenness index for Banding Lakeside Inn.

Species	No. of Individual	P_i	H'	H_{max}	Evenness
<i>Taphozous Melanopogon</i>	40	0.1	2.302	0.230	1.094
<i>Cynopterus Horsfieldi</i>	6	0.116	2.148	0.250	1.959
<i>Cynopterus Brachyotis</i>	5	0.016	4.094	0.068	3.898
<i>Cynopterus Sphinx</i>	7	0.083	2.484	0.207	1.640
<i>Rhinolophus</i>	1	0.016	4.0943	0.068	7.497
<i>Hipposideros Dyacorum</i>	1	0.666	0.405	0.270	7.566
Total	60		1.189		0.608

4.2 The most abundant species

4.2.1 *Cynopterus horsfieldii*

Cynopterus horsfieldii, a medium-sized plant-visiting bat in the *Pteropodidae* family, is locally known as *Horsfield's* fruit bat, Larger Dog-faced Fruit Bat, or *Cecadu Pisang Besar* in Malay (Tan et al. 2019). In Peninsular Malaysia, it is also referred to be the most prevalent and prolific species (Jayaraj et al.,2012). This species is found in Vietnam, Laos, Cambodia, Thailand, and Peninsular Malaysia in mainland Southeast Asia. Additionally, Borneo, Sumatra, Java, and the other islands are home to it. *C. horsfieldii* has a face that is characteristically canine, with big eyes and straightforward, short ears.

Their wings are often large and hairless. Moreover, mature males have a dark reddish-brown collar that is milder in females, and it has grey-brown upperparts and somewhat yellowish-brown underparts . The fur of the young bat is dull buff or Grey. The hue white outlines the wing-bones and the margins of the ears. Compared to other *Cynopterus* bats, *Cynopterus horsfieldii* has cheek teeth that are wider and squarer, and its lower premolar and first lower molar have unique ridges or cusps. It is distinguished from *C. sphinx* (Greater Short-nosed Fruit Bat), which is smaller and has more rounded cheek teeth, by its bigger body size, with an average mass of 57.9 g.



Figure 4.2: Front view of *Cynopterus horsfieldii* (Adult) taken from Ecology Asia

4.2.2 *Cynopterus Sphinx*

Situated in South and Southeast Asia, the short-nosed Indian fruit bat is a species of *megabat* belonging to the *Pteropodidae* family. In addition to grasslands, they may be found in tropical woods. The adult sex ratio is heavily skewed towards women because female bats engage in fellatio to extend the time it takes for copulation. Typically, the upper body is a vivid shade of bat orange, while the lower body is paler. The fur is really delicate and silky. An adult's wingspan is around 48 cm (19 in) (Harrison, D.A et al., 2018). These bats are herbivores, thus they use scent to distinguish their favourite meal. At least thirty different plant species' fruits, flowers, and leaves are consumed by *Cynopterus sphinx*. This species has been captured in trace areas using mist net The Large Short-nosed Fruit Bat, or

Cynopterus sphinx, has undergone an evaluation to be added to the IUCN Red List of Threatened Species for 2019. *Cynopterus sphinx* is in a least concerning situation.



Figure 4.3: Front view *Cynopterus sphinx* taken from India Biodiversity Portal

4.2.3 *Hipposideros Dyacorum*

Additional common names for Roundleaf *Hipposideros Dyacorum* Dayak Environment. semi-evergreen to lowland rainforest The bat was once single and a member of the bicolor species group; it is currently categorised in the new tzter species group. (Hill & Corbet et al., 2016) around the forearm, 38–43 mm. Leaf-nosed Dayak Leaf Noseleaf The bat is small and spherical. The base of the intemarial septum is broader and more inflated than the middle, where it is smaller. In 2008, Francis and Kingston The colour of the pellagra is consistently dark brown with tinges of lighter hue. The Dayak Leaf-nosed Bat feeds on microscopic insects that live in the forest's understory. The social organisation, home range, and hollow tree roosts

of the Dayak Leaf-nosed Bat are well-known. It was found in a mist net containing *Cynopterus Brachyotis* (Payne et al., 2017). The call frequency of the F segment is in the range of 167–170 kHz. Present Circumstances and Conservation, designated as Least Concern on the IUCN Red List. The primary threat to the Dayak Leaf-nosed Bat is habitat loss. Breeding. Breastfeeding females were caught in May and June on the Thai peninsula (Phillipps et al., 2016).



Figure 4.4: Front view *Hipposideros Dyacorum* taken from Animalia

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4.2.4 *Taphozous Melanopogon*

Aphozorous melanopogon according to (Boonsong and McNeely et al., 2017), black bearded tomb bats are infrequently encountered in the Malay Peninsula. The environments that black-bearded tomb bats inhabit include disused structures, caves, cliffs, jungles, woods, and dry rural plains. They like regions that are very shaded. It comes in shades of red, multi-brown, and grey. Usually, hairs have a white tip and are progressively redder or browner towards the root. The membrane of the tail (uropatagium) has fur on it. There are several pores that enter into the throat region where the throat sac should be, but there isn't one there. *Aphozorous melanopogon* mostly consumes flying insects, however it occasionally consumes little fruits as well. *Aphozorous melanopogon* mostly consumes flying insects, however it occasionally consumes little fruits as well. Males have been observed forming a protective circle around females and their young within roosts. There appears to be a social structure in the colonies since each male has a certain region that he inhabits.



Figure 4.5: View from *Aphozorous melanopogon* taken from Animal Diversity Web

4.2.5 *Rhinolophus hipposideros*

Rhinolophus hipposideros, often known as smaller horseshoe bats, are found across central and western Europe, as well as in the northern region of Africa. They are an uncommon species, despite being widely distributed across their range, and their populations have decreased in the northern regions. They are presently only found in southwest England and Wales in the United Kingdom they were extinct in the southeast (Schober et al., 2016). The preferred habitats of lesser horseshoe bats include valleys, open grasslands, and the borders of woodlands. Although their native roosts are caves, as human populations have expanded into these areas, they have also established residences in man-made buildings such as cellars, attics, tunnels, and rooftops. They have an advantage over larger bats in that they may exploit narrow gaps and cracks as roosting spots since they are smaller (Walker et al., 2018).

The tiniest European *horseshoe* bats are called *lesser horseshoe* bats, and they are around the size of a person's thumb. Weighing just 5-9 gramme, they are slightly smaller than their near cousin, the bigger *horseshoe* bat, *Rhinolophus ferrumequinum*. Their wingspan ranges from 192 to 254 mm. They typically have a body length of 35 to 45 mm and a tail length of 23 to 33 mm. *Lesser horseshoe* bats' mating habits are not well understood. In the fall, they procreate. *Lesser horseshoe* bats are not now in danger of going extinct in the wild, but they may be in the near future, according to the IUCN, which has classified their current conservation status as vulnerable. Pollution, habitat loss brought on by human disturbance, and altered prey dynamics are the main risks to their population (2004 IUCN Red List of Threatened Specie , 2006).



Figure 4.6: View from *Rhinolophus hipposideros* taken from Animal Picture Archive

4.3 Factor That Influencing Capture Rate

The location of the sample, the weather, and the amount of sampling effort are some of the variables that affect the bat catch rate.

4.3.1 Sampling Location

The sort of bats you're pursuing and the layout of the site will ideally determine the optimal sample area for bat Banding at the Lakeside Inn. Bats that feed along forest margins do so frequently because it's convenient for them to come out of the trees and collect insects in the open. If there are any forested regions around the Lakeside Inn, seek out locations where the trees meet a field or clearing. surrounding structures If the Lakeside Inn has any outbuildings or other structures where bats may roost, these could also be suitable sites to set up mist nets because certain bat species do not like to sleep in open spaces.

Mist nets were positioned along trails as the sample location for the investigation of variables influencing bat species diversity and catch rates at Banding Lakeside Inn. Only three fruit bats were caught throughout the sample period in spite of these attempts. The species identified were *Cynopterus brachyotis*, *Cynopterus horsfieldii*, *Cynopterus sphinx*. This low capture rate raises the possibility that the efficacy of the sample technique was impacted by variables like bat activity patterns, habitat preferences, or ambient circumstances.

4.3.2 Weather

Weather Situations Bat activity may be impacted by meteorological factors as temperature, humidity, and wind speed. Bat activity usually increases with warmer temperatures, although it can also decrease with high winds or heavy rain. Although the effect of humidity, temperature, and other weather related factors on flight activity has not been well documented, ambient temperature and relative humidity have the potential to affect not only the activity of their insect prey but also the mostatically challenges that bats face while foraging and travelling (Barclay, R.M.R. et al.,2015)

Every organism has an ecological niche, or a particular set of environmental parameters that they like to live in. A region's weather patterns are an integral part of its ecosystems. This research looks at how various weather patterns different. Bat activity is known to generally rise with temperature, but to decrease with an increase in wind and precipitation (Gorman et al., 2021).

4.3.3 Sampling Effort

In this study, the sampling effort for this survey was insufficient to record the total bat population at Banding Lakeside Inn because the species accumulation curve in Figure 4.1 had to reach an asymptotic level. The sampling effort for this study has been done with 2 mist net and two bank- harp trap per night with total 16-night sampling. Two species which is *Hipposideros Dyacorum* and *Taphozous Melanopagon* were captured on bank- harp trap and the other species mostly were captured in mist net. The minimum night for sampling bats is 7 night in order to get 6 different species of bat.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

At Banding Lakeside Inn in Perak, a successful bat sample using mist nets and the harp trap technique was used to evaluate the variety of bats. This study used a variety of techniques, and the results varied depending on the species abundance, species accumulative pattern, and bat species richness level. Overall findings indicated that the diversity of bats at Banding Lakeside Inn, Perak, was adequately covered by the number of individuals of each species. Except for one species, the majority of the species found in this research were classified as Least Concern on the IUCN Red List of Threatened Species. *Horseshoe* bats, or *Rhinolophus spp* .Even though many species are classified as Least Concern because of their wide distribution and resilience, others are really labeled as Near Threatened or in higher risk categories owing to habitat loss, disturbance of roosting locations, and other threats.

5.2 Recommendation

To improve bat conservation and management, further research on bat variety is necessary. Additional bat surveys have to be conducted at Banding Lakeside Inn it contemplates developing an additional approach for the next study in this field. Mist netting: To catch bats for tagging and identification, mist nets are set up at various heights and places. Multiple Levels: To catch bats using multiple habitat strata, set up mist nets at different heights (e.g., ground level, 2-3 meters, and canopy level if feasible). Because of their species-specific habits and ecological niches, bats frequently graze at various heights. Furthermore, a lot more acoustic monitoring has to be done for conservation and research purposes involving bats. It can offer useful information on species occurrence, habitat utilization, and bat activity patterns information that is crucial for efficient planning and administration of conservation efforts. As a result, a more representative sample of the bat community may be obtained, as some species may only move or feed at particular altitudes.

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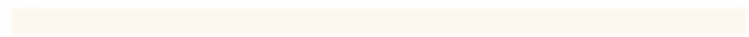
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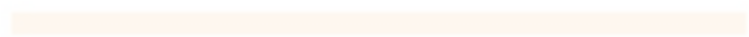
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APPENDIX A



Trace study site 2



Trace study site 1



In the Banding Lakeside Inn Hotel building



The entrance Hotel Banding Lakeside inn

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Old Agar wood farm



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APPENDIX B



Cynopterus Brachyotis



Hipposideros Dyacorum



Taphozous Melanopagon



Cynopterus horsfieldii



Rhinolophus hipposideros

APPENDIX C

An example of the bat capture data sheet used to record measurements during sampling.

BAT CAPTURE DATA SHEET

Page: _____
 State District: _____
 Recorded by: _____
 Institution: _____
 Latitude: _____
 Longitude: _____

No.	Capture Date	Band	R	Date	Time	Trap	Species	Sex	Age	Rep.	FA	Wgt.	Tb.	EC	Comments
1	16/10/2019														
2	16/10/2019														
3	16/10/2019														
4	16/10/2019														
5	16/10/2019														
6	16/10/2019														
7	16/10/2019														
8	16/10/2019														
9	16/10/2019														
10	16/10/2019														
11	16/10/2019														
12	16/10/2019														
13	16/10/2019														
14	16/10/2019														
15	16/10/2019														
16	16/10/2019														
17	16/10/2019														
18	16/10/2019														
19	16/10/2019														
20	16/10/2019														

CB = 25 (20mm)
 LB = 24 (20mm)

M = male
 F = female
 A = adult
 J = juvenile

NA = non-reproductive
 P = pregnant
 L = lactating
 R = reproductive