ASSEMBLAGES OF NOCTURNAL BEETLES (COLEOPTERA) IN FOREST RESEARCH INSTITUTE MALAYSIA (FRIM) RESEARCH STATION, JELI USING PORTABLE LIGHT TRAP

By

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DECLARATION

I declare that this thesis entitled "Assemblages of Nocturnal Beetles (Coleoptera) In FRIM Research Station, Jeli using Portable Light Trap" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

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Date : 24 July 2025

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Assemblages of nocturnal beetles (Coleoptera) in Forest Research Institute Malaysia (FRIM) Research Station, Jeli using portable light trap.

ABSTRACT

This study aimed to examine the assemblages of nocturnal beetles (Coleoptera) at the Forest Research Institute Malaysia (FRIM) Research Station in Jeli, using portable light traps for data collection. Sampling was conducted over a period of 28 nights, with two light traps set up each evening, operating for a total of 12 hours to capture beetles active during nocturnal hours. A total of 23 individual beetles were collected, representing three families: Scarabaeidae, Eulichadidae, and Cicindelidae. The Scarabaeidae family emerged as the most abundant, comprising approximately 65% of the total specimens, with *Phyllophaga sp.* identified as the dominant species within this family. In contrast, the Cicindelidae family was represented by a single individual, making it the least abundant family in the study. The species accumulation curve indicated that the sampling effort was sufficient to capture the majority of beetle species present in the study area. Environmental factors, particularly rainfall, were found to influence beetle activity and capture rates. The data provide valuable baseline information on the diversity and distribution of nocturnal beetles within a tropical forest ecosystem, highlighting the need for further research with larger sample sizes and seasonal variations to better understand beetle assemblages and their ecological roles.

Kumpulan kumbang nokturnal (Coleoptera) di stesen penyelidikan (FRIM) Jeli menggunakan perangkap cahaya mudah alih.

ABSTRAK

Kajian ini bertujuan untuk meneliti kumpulan kumbang nokturnal (Coleoptera) di Stesen Penyelidikan Institut Penyelidikan Hutan Malaysia (FRIM) di Jeli, dengan menggunakan perangkap cahaya mudah alih untuk pengumpulan data. Pensampelan dijalankan selama 28 malam, di mana dua perangkap cahaya dipasang setiap malam dan beroperasi selama 12 jam untuk menangkap kumbang yang aktif pada waktu malam. Sebanyak 23 individu kumbang telah dikumpulkan, mewakili tiga keluarga iaitu Scarabaeidae, Eulichadidae, dan Cicindelidae. Keluarga Scarabaeidae merupakan keluarga yang paling dominan, membentuk kira-kira 65% daripada jumlah spesimen, dengan *Phyllophaga sp.* dikenal pasti sebagai spesies utama dalam keluarga ini. Sebaliknya, keluarga Cicindelidae hanya diwakili oleh satu individu, menjadikannya keluarga yang paling kurang terdapat dalam kajian ini. (Species Accumulation Curve) SAC menunjukkan bahawa usaha pensampelan yang dilakukan sudah mencukupi untuk menangkap sebahagian besar spesies kumbang yang ada di kawasan kajian. Faktor persekitaran, terutamanya hujan, didapati memberi pengaruh terhadap aktiviti kumbang dan kadar penangkapan. Data yang diperoleh memberikan maklumat asas yang penting mengenai kepelbagaian dan taburan kumbang nokturnal dalam ekosistem hutan tropika, serta menekankan keperluan untuk kajian lanjut dengan saiz sampel yang lebih besar dan variasi musim bagi memperkaya pemahaman tentang kumpulan kumbang dan peranan ekologi mereka.

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FRIM	FOREST RESEARCH INSTITUTE MALAYSIA
AM	Ante meridiem
PM	Post meridiem
SAC	SPECIES ACCUMULATION CURVES

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Coleoptera, commonly known as beetles, represent the most diverse order within the Insect Class, encompassing a staggering 442,000 described species, making them the largest group of organisms at a comparable taxonomic level. This vast diversity of beetles is reflected in their wide array of ecological roles and habitats, ranging from forest floors to aquatic environments. The significance of Coleoptera's diversity has been emphasized in multiple studies, highlighting their dominance within the insect kingdom (Bouchard et al., 2017; Goczał et al., 2024; Smith & Marcot, 2015; Stork et al., 2015). They are not only abundant in number but also exhibit remarkable morphological and behavioural variety, which has allowed them to adapt to a wide range of environmental niches.

In Malaysia, the Coleoptera order is particularly diverse, with over 120 families described. This diversity is a testament to the rich tropical environment of Malaysia, which supports a high level of biodiversity. Some studies have indicated that the number of beetle species in Malaysia continues to rise as research on the region's fauna progresses, making it one of the hotspots for Coleopteran biodiversity in Southeast Asia (Goczał et al., 2024). As one of the most ecologically significant insect groups, beetles play crucial roles in various ecosystems, including decomposition, pollination, and serving as prey for other animals, making their study essential for understanding the broader environmental health of Malaysia.

This study aimed to explore the assemblages of nocturnal beetles within selected habitats in FRIM Jeli. By examining factors such as habitat type and environmental conditions, this research contributed to understanding how these assemblages varied and what influenced their distribution. Despite their ecological importance, nocturnal beetle communities were less frequently studied than their daytime counterparts, resulting in significant knowledge gaps regarding their species diversity, distribution, and the various ecological roles they fulfilled (Jones & Smith, 2022). Closing these gaps was crucial for understanding how different species contributed to ecosystem health, especially in biodiversity-rich areas increasingly threatened by environmental issues like habitat fragmentation, deforestation, and climate change (Nguyen et al., 2021).

Secondly, these beetles helped maintain the equilibrium of natural environments by breaking down organic matter and aiding in the flow of energy. These beetles frequently interacted with other organisms and their environment (Basset et al., 2012).

By highlighting the ecological roles and responses of nocturnal beetles to environmental changes, this study guided practices aimed at preserving natural habitats and supporting the resilience and integrity of ecosystems (Miller & Gonzalez, 2024).

1.1 Problem Statement

The lack of comprehensive data on the assemblages of nocturnal beetles in the Forest Research Institute Malaysia (FRIM) in Jeli presents a significant gap in research. These nocturnal beetles, which are often crucial to ecosystem functions such as decomposition, and serving as a food source for other species, remain poorly understood within this region. This research gap poses notable challenges for conservationists and ecologists working to monitor and assess the health of these ecosystems effectively. Without reliable data, it becomes increasingly difficult to develop informed conservation strategies or to predict how environmental changes may impact the beetle populations. Furthermore, the absence of targeted research on the nocturnal beetle population makes it challenging to assess their response to environmental disturbances, such as climate change. It is essential to prioritize focused research on nocturnal beetles, as it plays a key role not only in conserving biodiversity but also in understanding the wider environmental changes happening in Malaysia's tropical ecosystems. These beetles are a crucial part of the ecosystem, and their health can offer valuable insights into the overall condition of the environment.

1.3 Objective

a. To determine the nocturnal beetle family assemblages in FRIM Research Station Jeli, using Portable Light Trap.

1.4 Scope of Study

The scope of this study aimed to explore the assemblages of nocturnal beetles (Coleoptera) at the FRIM Research Station in Jeli. By utilizing a portable light trap as the primary method for sampling beetle assemblages during the night, the research ensured a thorough collection from various habitats within the research station. This method was widely recognized for its effectiveness in attracting nocturnal insects, particularly beetles, as they are strongly attracted to light sources, facilitating efficient species capture (López-Quintero et al., 2017; Tovar et al., 2021). The study focused on capturing nocturnal beetle activity and species presence over a twelve-hour period across two different locations, accounting for potential variations in their distribution. Repeated sampling sessions were conducted to provide a comprehensive dataset for analysis. The collected specimens were carefully identified, primarily to the species or genus level, using taxonomic keys to ensure an accurate representation of the beetle assemblages in the area. To further analyse the beetle population, the data included an analysis of the percentage presence of different beetle families across the sampled areas. This helped identify which families were most prevalent in the research station and provided a deeper understanding of the habitat preferences and distribution patterns of the nocturnal beetles in this region. The results offered valuable information on how beetles interacted with their environment and how environmental changes may have influenced their populations.

1.5 Significance of Study

The study of nocturnal beetle assemblages at FRIM Researched Station, Jeli, was significant for several reasons. First, nocturnal beetles (coleoptera) were key components of terrestrial ecosystems, playing an important role including decomposition, pollination, and as prey for other organisms. The significance of this study lies in its contribution to establishing a new baseline dataset on nocturnal beetle assemblages within the FRIM Researched Station, Jeli, Kelantan. By systematically documenting species population abundance, and habitat-specific diversity, this study provides essential reference data for understanding the ecological dynamics of nocturnal beetles in a tropical forest setting. Such baseline information was needed for future research, serving as a foundation for monitoring biodiversity trends, and guiding conservation efforts. Additionally, this dataset has been invaluable to researchers investigating beetle ecology, species interactions, and their roles as bioindicators of ecosystem health. This studies not only enhances our understanding of nocturnal beetle diversity but also supports long-term biodiversity conservation initiatives and facilitates comparative studies across similar forest ecosystems.

CHAPTER 2

LITERATURE REVIEW

2.1 Morphological characteristic of Nocturnal Beetles

The morphological characteristics of nocturnal beetles, particularly their antennae, played an essential role in their survival and ecological functions, especially since these beetles primarily operated during the night. As nocturnal creatures, beetles relied heavily on sensory adaptations to navigate, locate food, communicate, and detect mates in low-light environments. The antennae of nocturnal beetles were often more specialized compared to their diurnal counterparts, reflecting the evolutionary pressures associated with their nocturnal lifestyles.

A significant aspect of beetle morphology was the presence of sensory structures known as sensilla, which were located on their antennae. Sensilla were specialized to detect chemical signals such as pheromones and environmental cues, which were essential for the survival of nocturnal beetles, as they depended on chemical communication due to the lack of visual cues at night. For example, nocturnal beetles such as those in the Scarabaeoidea family had antennal lamellae (fan-like segments), which were densely covered with different types of sensilla that detected pheromones or food sources in their surroundings (Bohacz et al., 2020). These were essential for detecting food sources, mates, or potential threats in the dark, enabling beetles to thrive in nocturnal environments.

The structure of these sensilla varied between beetle species, especially among nocturnal beetles, where specialized chemoreceptors were more pronounced to support enhanced sensory perception. Recent studies suggested that nocturnal beetles, like those in the family Lampyridae (fireflies), showed a high degree of sensory specialization in their antennae, which were adapted to detect low concentrations of chemicals such as pheromones released by mates. These adaptations enabled them to find mates even in complete darkness (Harrison et al., 2020).

Nocturnal beetles also tended to have more elongated antennae with an increased number of lamellae, which enhanced their ability to detect a wider range of chemical cues. The increased surface area of these longer antennae and the presence of specialized sensilla types like sensilla coeloconica, which were sensitive to environmental stimuli, enabled nocturnal beetles to efficiently process chemical information during their nighttime activities (Scholtz & Grebennikov, 2020). This was particularly significant for nocturnal species that relied on pheromone trails to locate potential mates or find food sources in their dimly lit environments.

Moreover, the evolutionary development of these morphological traits in nocturnal beetles underscored the adaptability of beetles to their environment. Over time, nocturnal beetles evolved highly specialized antennae and sensorial structures, making them more adept at locating food, mates, and avoiding predators in the dark. This contrasted with diurnal beetles, which relied more heavily on vision and other sensory cues. The morphological differences between nocturnal and diurnal beetles reflected

how species adapted to their ecological niches, ensuring their survival and ecological success (Ahrens et al., 2018).

In conclusion, the morphological characteristics of nocturnal beetles, particularly their specialized antennae and sensilla, were crucial to their survival in dark environments. These adaptations enabled nocturnal beetles to detect chemical signals, locate food, communicate, and find mates. The evolution of these sensory structures highlighted the unique ecological requirements of nocturnal beetles and their ability to thrive in challenging environments with minimal light.

2.2 Role of Beetle

Beetles, as one of the most diverse and abundant groups within the insect class Coleoptera, played essential ecological roles that were crucial for ecosystem functioning. Their contributions spanned across nutrient cycling, pest regulation, and maintaining biodiversity, making them integral components of both natural and agricultural ecosystems. Given their significance, understanding the various roles beetles played in ecosystem dynamics was vital for the development of sustainable agricultural practices and the conservation of biodiversity.

Dung beetles, particularly those from the Scarabaeoidea family, were well-known for their role in decomposition. These beetles feed on animal faeces, breaking down organic material and releasing nutrients back into the soil. The process of dung decomposition not only aided in recycling nutrients such as nitrogen, phosphorus, and sulphur but also improved soil structure, which was essential for plant growth. Research demonstrated that the activity of dung beetles could significantly enhance soil fertility, leading to improved agricultural productivity. For instance, Goczał et al. (2020) found that the introduction of dung beetles in agricultural fields improved soil quality and increased crop yield by promoting faster decomposition and nutrient cycling. This highlighted the critical role that dung beetles played in maintaining soil health, especially in agroecosystems where soil quality directly impacted crop productivity.

Ground beetles (Carabidae), another key family within the Coleoptera order, were important natural pest controllers in agricultural systems. These beetles were predatory and fed on a variety of harmful insects such as aphids, larvae, and other crop-damaging pests. By regulating the populations of these pests, ground beetles helped reduce the reliance on chemical pesticides, making them an essential part of integrated pest management strategies. Additionally, many ground beetles feed on weed seeds, contributing to weed control and reducing competition in crop fields. Kulkarni et al. (2020) highlighted that ground beetles significantly reduced weed populations, allowing crops to grow with less competition for resources. This natural pest and weed control were particularly valuable in organic farming systems, where chemical pesticide use was minimized.

Beetles also served as valuable bioindicators for environmental health due to their sensitivity to changes in habitat quality and pollution levels. For instance, ground beetles were commonly used in environmental monitoring to assess the effects of pollution, pesticide use, and other anthropogenic activities. Shonouda and Osman (2021) emphasized that the decline in beetle populations, particularly in areas exposed to pesticides or heavy metals, could serve as an early warning sign of environmental degradation. As bioindicators, beetles provided critical data on ecosystem health, allowing for the detection of pollutants and habitat disturbances that might otherwise have gone unnoticed. This made beetles an indispensable tool for environmental monitoring, especially in agricultural landscapes where pesticide use and habitat destruction could significantly impact biodiversity.

Furthermore, beetles contributed to ecosystem health through their interactions with other organisms. In forest ecosystems, beetles played a key role in pollination, assisting in the reproductive processes of various plant species. The presence of beetles in these environments was often a sign of a healthy ecosystem, as their interactions with plants and fungi supported biodiversity. Gardner et al. (2020) noted that beetles were involved in complex interactions with plant species, helping in pollination and seed dispersal, contributing to the overall functioning of forest ecosystems. This underscored the importance of beetles in maintaining ecological balance, as their decline could have cascading effects on plant diversity and ecosystem stability.

In conclusion, beetles were vital components of ecosystems, providing essential ecological services such as nutrient cycling, pest control, and biodiversity maintenance.

2.3 The influence of moonlight on the navigational behaviour of nocturnal beetles: Implication for light trap attraction

Nocturnal beetles, especially dung beetles, have evolved fascinating ways to navigate in the dark. One of the primary ways they do this is by using moonlight, particularly the polarized light patterns the moon creates in the night sky. These polarized patterns serve as a natural map that helps beetles stay on track, allowing them to travel in straight lines as they forage for food or move away from dung piles. However, it’s interesting to note that during certain phases of the moon, such as when the moonlight is brightest, beetles don't seem to be as attracted to light traps. This suggests that their natural reliance on the moon’s light for navigation makes them less interested in artificial lights.

During brighter phases of the moon, such as a full moon, beetles are less likely to be drawn to light traps. Research has shown that beetles tend to be more active when the moon is full, and they rely more on the moon's polarized light to navigate than on artificial light sources. The moon’s polarized light provides consistent and reliable cues for beetles to follow, so artificial light sources don’t have the same appeal. For example, a study by Foster et al. (2021) found that during the full moon, dung beetles preferred moonlight over artificial light, indicating that their natural behaviour is strongly linked to the light patterns in the sky. The moon’s light helps them maintain their orientation, which is essential for their natural activities, such as burying dung and helping with nutrient cycling in the environment.

On the other hand, during phases when moonlight is weaker, like during a new moon or when the sky is cloudy, beetles may become more attracted to artificial light sources, such as those in light traps. Without the strong guidance of the moon, beetles may struggle to navigate and thus rely more on artificial lights to orient themselves. This change in behaviour is likely because the absence of polarized moonlight makes it harder for beetles to use their usual natural navigation methods. As a result, they may become disoriented and more likely to be attracted to artificial light sources, even though these aren't their first choice (Ahrens et al., 2020). This flexibility in their behaviour shows how beetles can adjust to varying light conditions based on what's available.

In conclusion, the polarized light from the moon plays a crucial role in helping nocturnal beetles navigate. During phases with brighter moonlight, beetles rely on the natural light for efficient movement and are less drawn to light traps. However, when the moon is less bright, beetles may become more attracted to artificial lights. Understanding how beetles respond to different phases of the moon helps us better understand their behaviour and shows how their reliance on natural light cues can influence their interaction with artificial light sources. This knowledge is important not only for studying beetle behaviour but also for ensuring their conservation in environments where light pollution might interfere with their natural habits.

2.4 Light Traps: Design and Efficacy

The use of light traps exploits the positive phototaxis of insects, attracting them to specific wavelengths of light. Recent designs employing LED technology have proven highly efficient. LED traps, particularly those emitting ultraviolet and blue light, have shown to be as effective as traditional mercury-vapor lamps while being more energy-efficient and environmentally friendly (Pachkin et al., 2022). The adoption of conical light traps has further enhanced insect capture rates by reducing interference from non-target species. The innovative light traps designed by the Federal Research Centre of Biological Plant Protection in Krasnodar incorporate UV LEDs and are powered by small, portable batteries. This design enables their deployment in remote areas with limited power supply. Additionally, the inclusion of separating insect receptacles minimizes the capture of beneficial insects, ensuring a focused approach to pest management.

2.5 The Effect of Rainfall on the Attraction of Nocturnal Beetles to Light Traps and Their Activity

The behaviour and seasonal activity of nocturnal beetles, particularly in relation to their attraction to light traps, are influenced by several environmental factors, including rainfall. Rainfall, as an abiotic factor, plays a crucial role in shaping the population dynamics, movement patterns, and ecological functions of nocturnal beetles. Understanding how rainfall impacts these beetles' behaviour, particularly their attraction to light traps, is important for effective pest management and for monitoring beetle populations.

Nocturnal beetles, especially species like *Oryctes owariensis*, are often monitored using light traps, which attract the beetles due to their natural nocturnal activity and attraction to light sources. The study by Boate and Otayor (2020) on *O. owariensis* highlights the importance of environmental conditions, particularly rainfall, in influencing the beetles' attraction to light traps. The study found that during the dry season (from January to April), there was a marked increase in beetle captures, suggesting that these beetles are more active and more likely to be attracted to light traps during periods of lower rainfall. This observation aligns with findings from other studies, which suggest that beetles tend to exhibit higher activity during dry conditions, likely due to the more favourable environmental conditions for foraging and mating. In contrast, during the wet season (from June to September), the study showed a significant decrease in beetle captures. This decline in attraction to light traps can be attributed to the negative effects of rainfall on beetle activity. As rainfall increases, humidity and temperature conditions fluctuate, which can affect beetles' movement and reduce their responsiveness to light sources. Chen et al. (2019) also noted that heavy rainfall can extend the developmental time of immature beetles, which indirectly influences the behaviour and activity of adult beetles. In the case of *O. owariensis*, the increased humidity during the wet season likely disrupts their ability to forage efficiently and lowers their activity levels, reducing their attraction to light traps. The results of Boate and Otayor's study showed that in June and July, very few beetles were captured, and during August and September, no beetles were trapped at all.

Rainfall also plays a role in modifying the beetles' microhabitats. As rain affects soil moisture, humidity, and temperature, these changes can either hinder or encourage beetle activity. As shown by previous research, such as the work of Suttle et al. (2007), these fluctuations in environmental conditions can disrupt trophic interactions, including those between beetles and their food sources. When rain causes plants to release volatile compounds like glucosinolates, it can interfere with beetles' foraging behaviour, as these plant metabolites may disrupt their ability to locate suitable food sources (Zhu et al., 2014). In addition, rainfall can alter the microclimatic conditions around light traps, affecting beetles' ability to navigate and increasing the likelihood of them being repelled by the light sources (Kobori & Amano, 2003).

Despite the observed decrease in beetle activity during rainy conditions, it is important to note that the dry season is not solely a period of increased activity for nocturnal beetles. The interaction between rainfall and beetle activity is complex and can vary depending on the species, the type of environment, and the seasonal patterns of rainfall. For instance, studies have indicated that some beetle species show varying degrees of attraction to light traps based on factors such as temperature, humidity, and the specific light wavelength used (Venard-Combes & Mariau, 1983).

In conclusion, rainfall has a significant impact on the attraction of nocturnal beetles to light traps and their overall activity. The findings from Boate and Otayor (2020) provide valuable insight into the seasonal abundance of beetles, showing that lower rainfall during the dry season correlates with higher activity and greater attraction to light traps. On the other hand, during the wet season, the increased rainfall and associated changes in environmental conditions hinder beetles' movement and reduce their responsiveness to artificial light sources. These findings underscore the importance of considering environmental factors like rainfall when studying beetle behaviour and using light traps in ecological monitoring and pest management. Future research should continue to explore the interaction between rainfall, temperature, and beetle activity to develop more effective strategies for monitoring and controlling beetle populations.

2.6 Data Analysis of Insect Biodiversity

Species accumulation curves (SACs) are a common and useful way to understand how many species live in an area and whether we've done enough sampling to find most of them. Basically, these curves show how the total number of species found increases as we collect more samples or individuals. At the start, the number of species found rises quickly because new species keep showing up. But after a while, the curve flattens out, meaning we're mostly finding the same species and not many new ones. This flattening helps us figure out if we've sampled enough or if more effort is needed.

In the past decade, scientists have improved how they use SACs by adding statistical tools that make it easier to compare different studies and estimate the total number of species, even if the sampling isn't complete (Colwell et al., 2012). This is especially important in places like tropical rainforests, where there are lots of species but many of them are rare and hard to find.

There are also handy software tools like iNEXT and vegan (Hsieh et al., 2016; Chao et al., 2014) that help researchers work with SACs by adjusting for differences in how much sampling was done and giving better estimates with confidence levels. These tools make it easier to be sure that comparisons between different studies or sites are fair and meaningful.

More recently, species accumulation curves have been combined with modern techniques like environmental DNA (eDNA) analysis, which lets scientists detect species from traces of DNA left in the environment (Bush et al., 2020). This means we can find species that might be missed by traditional sampling, especially in tricky environments or when looking for rare animals.

In tropical rainforests, where insect diversity is extremely high, SACs are really helpful for making sense of how many species live there. Earlier studies, like the one by Basset et al. (2015), used SACs to show how species richness changes depending on how much and where you sample. More recent work by Wong et al. (2023) mixed traditional identification methods with DNA tools to get a better picture of insect diversity, and they used SACs to check if their sampling was enough.

SACs are also useful in conservation. They can help track how species numbers change over time, especially in response to things like habitat loss or climate change. For example, Magurran et al. (2015) showed that fish communities in the ocean were becoming less diverse over time by looking at their species accumulation curves. This kind of approach can also be used on land to watch how animal communities change.

CHAPTER 3

MATERIALS AND METHOD

3.1 Study Area

This research was conducted at the Forest Research Institute Malaysia (FRIM) Research Station in Jeli, Kelantan. The station is situated within a dense lowland tropical rainforest, which provides an ideal habitat for studying nocturnal beetle assemblages. Two portable light traps were installed at specific locations within the forest at coordinates 5°39'12" N, 101°40'33" E (Trap 1) and 5°39'29" N, 101°40'16" E (Trap 2). These traps were used to capture beetles active during nighttime.

The surrounding forest is dominated by mature dipterocarp trees, forming a dense and continuous canopy layer. This canopy regulates the microclimate by maintaining lower temperatures and higher humidity levels, which are conducive to nocturnal insect activity. Beneath the canopy, the understorey is composed of a variety of shrubs, young trees, ferns, and climbing plants, creating a structurally complex environment that provides shelter and resources for numerous insect species.

The forest floor is covered by a thick layer of leaf litter and decomposing organic material, which serves as an essential habitat and food source for many beetle species. This layer supports important ecological processes, including nutrient cycling and decomposition. Satellite imagery and field observations indicate that the study site remains relatively undisturbed by human activities, preserving its natural state and ecological integrity.

The proximity of the FRIM Jeli Research Station enables effective monitoring and maintenance of sampling equipment throughout the study period. Overall, the FRIM Jeli Research Station offers a rich and well-preserved natural environment, making it an excellent location for research on nocturnal beetle diversity and their ecological roles within tropical rainforest ecosystems.

Figure 3.1: Base map of study area, FRIM Research Station, Jeli Kelantan

3.2 Materials

The lists of apparatus and materials that had been used in this study. The apparatus and materials as shown in Table 3.1

Table 3.1: Apparatus and materials that had been used for sample collection.

Process	Materials
Trap Installation	Portable Light Trap
Collecting process	Forceps
Preservation	70% Ethanol Relaxing jar

3.3 Method

3.3.1 Sample Collection

For this study, I set up two portable light traps to collect nocturnal beetles (Coleoptera). The traps were positioned at 7:00 PM and left stationary throughout the night, remaining in place until 7:00 AM the following day. Each trap operated for a full 12-hour period to maximize the chances of capturing a wide range of species during the beetles' active hours. This method followed established practices for nocturnal insect collection, where artificial light was used to attract beetles (Smith et al., 2010).

At 7:00 AM, I carefully collected the samples from the light traps. Each specimen was then identified to the species level, whenever possible, and preserved in 70% ethanol. Ethanol was widely regarded as an effective preservative for insect samples, as it helped maintain the specimens' morphological integrity for later analysis (Williams et al., 2015). Once preserved, the samples were stored in the laboratory for further study and analysis

3.3.2 Preservation of Nocturnal Beetles

After collection, the beetles were preserved in 70% ethanol to ensure they were fully euthanized and to maintain their physical features for identification and further analysis. Ethanol is commonly used in entomological research because it stops any biological processes, ensuring that the beetles are no longer alive. The use of 70% ethanol is important, as this concentration preserves the specimens without causing excessive hardening or distortion of their tissues. It also prevents dehydration, which helps keep the specimens in a suitable condition for accurate identification and future pinning (Merritt et al., 2019). Ethanol is widely recognized for its effectiveness in preserving insect specimens over long periods, making it a reliable preservative in entomology (Williams, 2015).

3.3.3 Sample Identification

Once the beetles were collected and preserved, they were identified to the family, genus, and species levels by examining their key morphological features. This process mainly involved looking at the body, head, antennae, and legs traits that are commonly used to identify beetle species. The shape and size of the body, as well as specific features of the head and antennae, helped distinguish between different genera and species within the same family (Johnson & Smith, 2011). Additionally, the structure of the legs, which can vary greatly depending on the beetle's behaviour or environment, was also important in confirming the species and genus (Jones et al., 2014). After identification, all specimens were carefully recorded with their taxonomic details, making sure the information was available for future reference and analysis.

3.4 Data Analysis

In this study, the family composition of nocturnal beetles collected with portable light traps was analysed. Due to the relatively small sample size of 23 individuals, the Species Accumulation Curve (SAC) was used instead of more complex diversity indices like the Shannon-Wiener Index, which are generally more appropriate for larger datasets. The SAC showed how species richness increased with additional sampling and provided a straightforward method to assess whether the sampling effort was sufficient to represent the beetle families in the study area (Colwell et al., 2012; Chao et al., 2014; Gotelli et al., 2018).

FYP FSB

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Beetles Assemblages

Based on table 4.1, a total of 23 individual beetles were collected, representing three families of Coleoptera: Eulichadidae, Scarabaeidae, and Cicindelidae. These findings provide an overview of beetle diversity in the study area, although further research would be needed to gain a deeper understanding of the factors that influence nocturnal beetle populations.

Table 4.1: Nocturnal beetles collected in FRIM

Coleoptera Family	Species	Number of Individual
Eulichadidae	*Eulichas funbris*	5
Scarabaeidae	*Lepidiota stigma*	2
	Phyllophaga sp.	10
	Anomala cuprea	5
Cicindelidae	*Cicindela aurulenta*	1
Total Individual	Total Species	23

4.2 Species Accumulation Curve

Based on Figure 4.1, The species accumulation curve (SAC) was created based on the data collected each day during the 28-day sampling period. The curve illustrates how the number of species increased over time as more samples were taken. The SAC shows that the number of species initially increased rapidly, with several new species recorded in the earlier days. By Day 5, there was a noticeable jump in species count, but the rate of increase began to slow down after that. The curve continued to rise, but the addition of new species became much smaller as the study progressed, reaching a plateau around Day 20. This pattern shows that the majority of species were captured early in the sampling period, with only a few additional species recorded towards the end. The levelling off of the curve indicates that the sampling effort may have reached a point where most species had already been recorded.

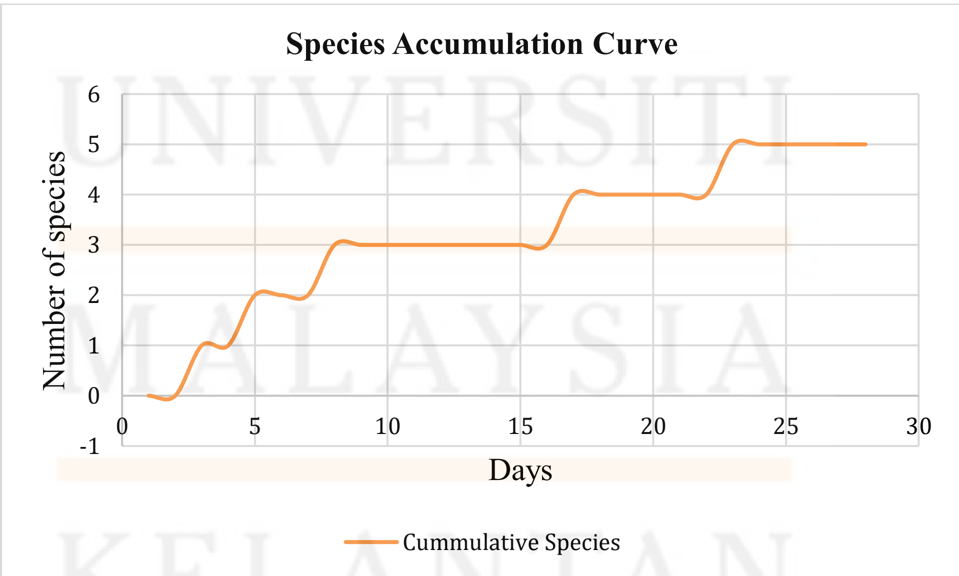

Figure 4.1: Species accumulation curve for beetle's species for 28 days.

4.3 Family Composition

The family composition of nocturnal beetles in the sample showed the distribution of beetle families within the observed assemblage. The analysis showed in the Figure 4.3 that Scarabaeidae was the most dominant family, comprising 65.2% of the total beetles observed, with 15 individuals in total. This means that Scarabaeidae was the most abundant family in the study area and was likely better adapted to the environmental conditions present in the region. In contrast, Eulichadidae accounted for 30.4% of the total beetle population, with 7 individuals, making it the second most common family in the sample. Finally, Cicindelidae, with only 1 individual (representing 4.3% of the total sample), was the least abundant family in the dataset. This low relative abundance means that Cicindelidae was either rarer in the area or more specialized in terms of habitat requirements. The Figure 4.2 which is family composition analysis allowed for the observation of the relative contribution of each family to the overall beetle community, highlighting the dominance of certain families.

The Scarabaeidae family played an important role in maintaining the health and balance of ecosystems, and its dominance in the sample suggested that it was actively contributing to several key ecological processes. Many species within this family are detritivores, feeding on decaying organic matter such as dung, dead plants, and animal carcasses. In doing so, they helped decompose and recycle nutrients back into the soil, enriching it and supporting plant growth. This process of nutrient cycling was vital for maintaining soil fertility and promoting the health of the ecosystem. In particular, a species within the Scarabaeidae family, was responsible for removing organic matter from the environment, reducing the habitat for harmful parasites, and redistributing nutrients deeper into the soil. This not only improved soil structure but also allowed for better water infiltration and root growth. Additionally, some

Scarabaeidae species contributed to pollination, helping to fertilize specific plants as they visited flowers for nectar, although their role in pollination was less prominent compared to other insects like bees. Beyond their direct ecological contributions, Scarabaeidae beetles also served as a food source for various predators, including birds, mammals, and reptiles, making them an integral part of the food web in the ecosystem. Finally, Scarabaeidae beetles acted as bioindicators, reflecting the health of the environment. The abundance of these beetles in the study area suggested that the habitat was rich in organic matter, relatively undisturbed, and supportive of their ecological needs. The high abundance of Scarabaeidae in the sample highlighted their ecological importance and adaptability, as well as their significant role in nutrient cycling, soil health, and biodiversity within the ecosystem.

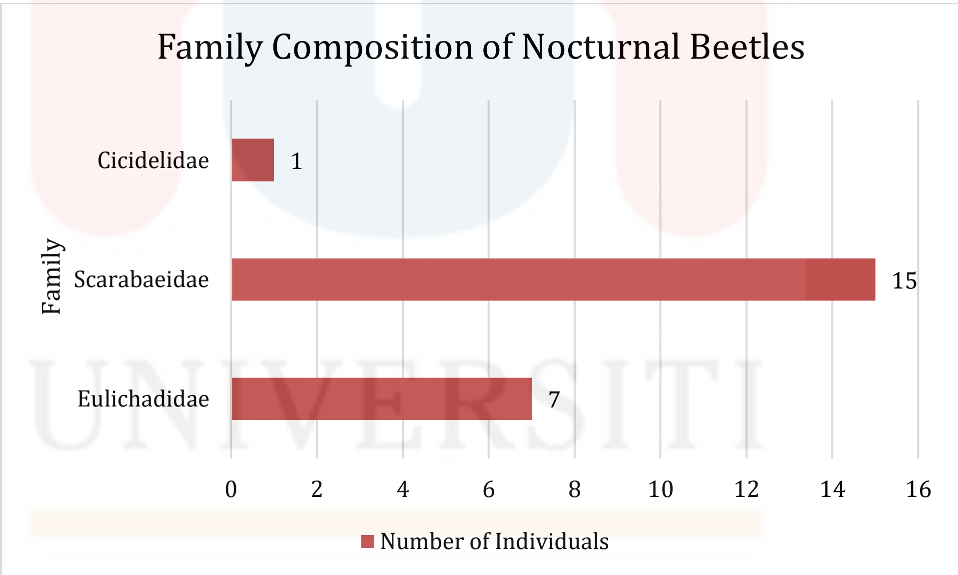

Figure 4.2: Family Composition of Nocturnal Beetles

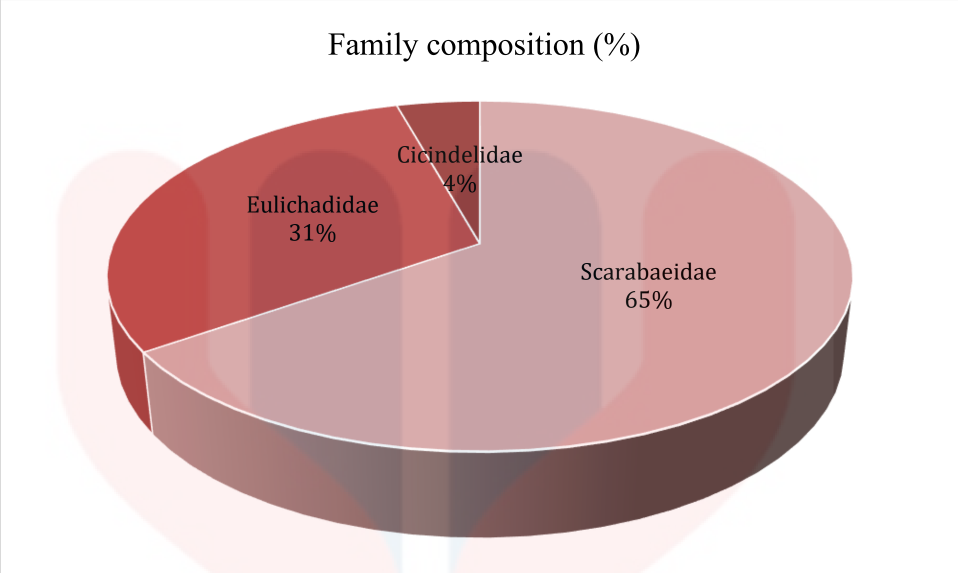

Figure 4.3: Percentage Family Composition

4.4 The most Abundance Family and Species

The high abundance of *Phyllophaga* species, commonly known as May beetles, observed at the FRIM Research Station in Jeli as showed in figure 4.2 provided valuable information about the ecological health of the area. These beetles, members of the Scarabaeidae family, play important roles in nutrient cycling and soil aeration through their feeding and burrowing activities. The presence of *Phyllophaga sp.* suggested that the ecosystem within the FRIM Research Station was functioning well, with active decomposition processes that are essential for maintaining soil fertility and supporting plant life.

The larvae of *Phyllophaga sp.*, often referred to as white grubs, primarily feed on decaying organic matter and plant roots. This feeding behaviour helps break down organic material, promoting nutrient recycling within the soil. The larvae contribute to the decomposition of fallen leaves, dead plants, and other organic matter, turning them into valuable nutrients for the soil. By doing so, they improve the availability of essential nutrients, including nitrogen, phosphorus, and potassium, which are necessary for plant growth. The larvae of *Phyllophaga sp.* play an important role in sustaining soil health, particularly in forest ecosystems where organic material from plant litter forms a large part of the soil structure. Additionally, these larvae help maintain the soil's balance by feeding on the roots of plants, aiding in the natural thinning and renewal of vegetation.

The adult *Phyllophaga sp.* beetles also contribute to the ecosystem, although their role differs from that of their larvae. Adults primarily feed on tree foliage, particularly the leaves of trees such as oaks and maples. While they are less impactful than the larvae in terms of nutrient cycling in the soil, their feeding can affect the health of trees, especially when populations are large. However, in a natural setting like the FRIM Research Station, these beetles likely help in maintaining a balance between plant and insect populations.

One of the most important ecological benefits of *Phyllophaga sp.* beetles is their burrowing activity. These beetles dig tunnels in the soil, which not only facilitates aeration but also increases the movement of water and air within the soil. This activity is essential for promoting healthy root growth and improving soil structure. Burrowing also helps in the breakdown of organic matter in the deeper layers of the soil, where it might otherwise remain undisturbed. As a result, *Phyllophaga sp.* contributes to improving soil porosity, which benefits both plants and microorganisms that inhabit the soil.

Phyllophaga sp. species are known to thrive in environments rich in organic matter, such as forests, grasslands, and agricultural fields with abundant crop residues. These environments provide an ample food source for both the larvae and adult beetles.

At the FRIM Research Station, the combination of diverse vegetation, relatively undisturbed ecological conditions, and abundant organic material created an ideal habitat for these beetles, which likely contributed to their high abundance in the area. The high population density of *Phyllophaga sp.* indicated that the station supports a thriving decomposer community, with an abundance of organic material that is effectively recycled by these beetles. This, in turn, suggests that the soil is nutrient-rich and capable of supporting a wide variety of plant and animal life.

The presence of *Phyllophaga sp.* The FRIM Research Station also shows that the ecosystem is in a state of balance. These beetles play an important role in maintaining soil health and promoting biodiversity. Their presence indicates a well-functioning food web in which decomposers, such as beetles and other insects, contribute to the breakdown of organic matter, enriching the soil and supporting the growth of plants. The abundance of *Phyllophaga* species could also point to healthy vegetation in the area, as these beetles tend to thrive in areas with diverse plant life. Their population size likely reflects the availability of food resources, which further show that the ecological conditions at the FRIM Research Station are conducive to the growth of a variety of plant species.

4.5 Rarefaction curve

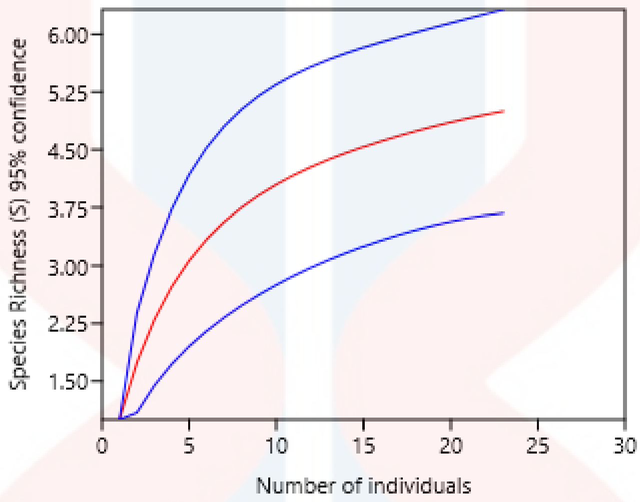

Figure 4.4: Rarefaction curve

Based on the rarefaction curve and the data, it is evident that as more individuals were sampled, species richness increased, which is consistent with the expectations of rarefaction analysis. At the start, when only a small number of individuals were sampled (0-5), species richness remained low, as only a few species were identified, such as *Cicindela aurulenta* and *Lepidiota stigma*. As the sample size increased (around 5-15 individuals), the graph showed a noticeable rise in species richness, with additional species like *Eulicha funbris* and Phyllophaga sp. being uncovered.

However, once the sample size reached around 15 individuals, the curve began to flatten, suggesting that the majority of the species present in the sample had already been captured. This pattern is typical in rarefaction curves, where the discovery of new species slows down as the number of individuals sampled increases. The confidence intervals (represented by the blue and red lines) narrowed as sampling progressed, indicating that the estimate of species richness became more reliable. Based on the results, with a sample size of 23 individuals, most of the species had been identified, and further sampling would likely result in only minor increases in species discovery.

In conclusion, the high abundance of *Phyllophaga* species at the FRIM Research Station was indicative of a healthy and active ecosystem. The beetles' role in nutrient cycling and soil aeration highlighted the importance of decomposers in maintaining soil health and promoting plant growth. Their presence suggested that the area maintained a diverse range of decomposers and had a well-functioning soil structure. This finding further emphasized the importance of the FRIM Research Station as a site for biodiversity conservation and ecological research. The station's diverse plant life, rich organic material, and relatively undisturbed conditions contributed to a thriving ecosystem that supports a variety of beetle species, including *Phyllophaga sp.*, underscoring its ecological significance.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

A study using a portable light trap conducted at the FRIM Research Station in Jeli provided important insights into the population and diversity of nocturnal beetles in the area. Scarabaeidae was the most common of the families mentioned, followed by Eulichadidae and Cicindelidae. Temperature, humidity, and rainfall were likely environmental factors that influenced beetle distribution and behaviour. In the nutrient-rich local environment, Scarabaeidae, particularly Phyllophaga sp. thrived. On the other hand, the relatively small number of Cicindelidae may indicate a higher sensitivity to changes in the environment or more specialised habitat requirements.

To better understand species-environment interactions and take seasonal variations into account, these findings highlight the necessity of continuous monitoring and expanded sampling programs, both in terms of scope and time. This study has significance for documenting biodiversity as well as guiding conservation strategies designed to maintain ecological balance and support beetle populations that are vital for nutrient cycling and ecosystem wellbeing at FRIM Jeli.

5.2 Recommendations

Based on the results of this study, it is recommended that further research on assemblages of nocturnal beetles (Coleoptera) be carried out at the Forest Research Institute Malaysia (FRIM) Research Station, Jeli. Expanding research in this area would provide a deeper understanding of the beetle populations, their roles in the ecosystem, and the factors that influence their distribution. Since weather conditions likely play a significant role in beetle activity, future studies should gather data across different seasons and weather patterns to better understand how environmental factors like temperature, humidity, and rainfall affect nocturnal beetles.

Additionally, increasing the sample size and using a wider range of sampling methods would help capture a more diverse variety of beetle species, giving a clearer picture of the beetle community and how it functions within the ecosystem. Long-term studies are also suggested to track changes in beetle populations over time, which could provide valuable insights into the impact of climate change, habitat disturbances, and other environmental factors. Overall, further research would help to expand our understanding of nocturnal beetles and their important role in maintaining biodiversity and ecosystem health in the area.

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APPENDIX

Appendix A

Day	*Eulichas funbris*	*Lepidiota stigma*	*Phyllophaga sp.*	*Anomala cuprea*	*Cicindela aurulenta*	*Cummulative Species*
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	2	0	0	0	0	1
4	0	0	0	0	0	1
5	1	0	1	0	0	2
6	0	0	0	0	0	2
7	0	0	0	0	0	2
8	1	1	0	0	0	3
9	0	0	0	0	0	3
10	0	0	0	0	0	3
11	0	0	0	0	0	3
12	1	0	2	0	0	3
13	0	0	0	0	0	3
14	0	0	1	0	0	3
15	0	0	0	0	0	3
16	0	0	0	0	0	3
17	0	1	0	1	0	4
18	0	0	1	1	0	4
19	0	0	0	0	0	4
20	1	0	0	0	0	4
21	0	0	0	0	0	4
22	0	0	0	0	0	4
23	0	0	2	0	1	5
24	1	0	1	2	0	5
25	0	0	0	0	0	5
26	0	0	0	0	0	5
27	0	0	2	1	1	5
28	1	0	2	1	0	5

Table A: Raw data for Species Accumulation Curve

Appendix B

Figure 1: Portable Light Trap Installation

Figure 2: Portable Light Trap installation environment

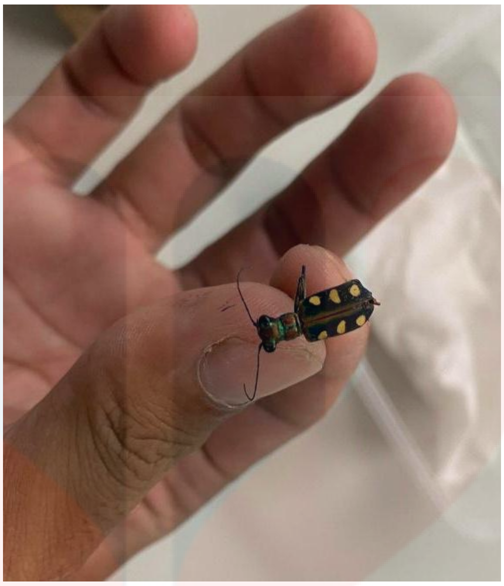

Figure 3: Picture of *Cicindela aurulenta*

Figure 4: Samples were separated and categorized after collection

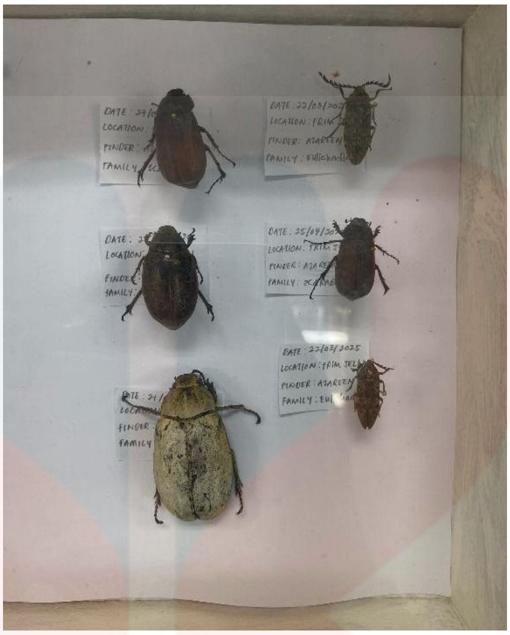

Figure 5: Preservation of Beetles collected