ASSESSING THE ACTIVITY OF POLLINATOR SPECIES AND THEIR INTERACTIONS WITH MALE *RAFFLESIA KERRI* IN LOJING HIGHLANDS, KELANTAN

by

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DECLARATION

I declare that this thesis entitled "Assessing the Activity of Pollinator Species and Their Interactions with Male *Rafflesia kerri* in Lojing Highlands, Kelantan." is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Assessing the Activity of Pollinator Species and Their Interactions with Male *Rafflesia kerri* in Lojing Highlands, Kelantan.

ABSTRACT

Rafflesia kerri, often referred to as the "corpse flower," stands as a notable botanical wonder nestled in the Lojing Highlands of Kelantan, Malaysia. This captivating flower, known for its striking crimson petals, is the largest in Asia and the second largest globally. It draws numerous visitors, serving as a testament to the region's rich biodiversity. Despite its fame, the complicated ecological relationships of *R. kerri*, particularly regarding its pollinators, remain shrouded in mystery. This research sets out to shed light on the pollination ecology of *R. kerri* by closely examining the abundance and behavior of pollinators that visit its male flowers. This study focuses on the influence of environmental factors and different flowering stages on pollinator activity, aiming to decode the reproductive strategy of *R. kerri* and its wider implications for biodiversity conservation in the Lojing Highlands, Kelantan. Field surveys were meticulously conducted in the *Rafflesia* Conservation Park, focusing on three specific blooming stages of male *R. kerri* flowers: fresh-blooming, mid-blooming and late-blooming. During the surveys, observations and data collection took place at predetermined intervals, noting pollinator species, their behaviors and environmental conditions such as humidity and temperature. Identifying and collecting pollinator species allowed for a deeper analysis of their roles in the pollination process of *R. kerri*. Throughout the study, a total of 2,387 visits by pollinators and visitors were recorded across the three male flowers. Notably, Flower 2 received the highest number of visits, followed by Flower 1 and Flower 3. Visits generally increased as the blooming progressed, except for Flower 2, which experienced a decline during the rainy late-bloom stage. Among the visitors, *Drosophila* sp. was the most frequent, followed by *Lucilia* sp. and *Simulium* sp., with *Lucilia* sp. and *Chrysomya* sp. being identified as potential pollinators. This study offers valuable insights into the pollination ecology of *R. kerri*, underscoring the significant impact of environmental factors and blooming stages on pollinator activity. These findings highlight the complicated dynamics of *R. kerri*'s reproductive strategies, contributing to our understanding and conservation of biodiversity in the Lojing Highlands.

Menilai Aktiviti Spesies Pendebunga dan Interaksi Mereka dengan Bunga Jantan *Rafflesia kerri* di Tanah Tinggi Lojing, Kelantan.

ABSTRAK

Rafflesia kerri, sering dirujuk sebagai "bunga bangkai," merupakan keajaiban botani yang terkenal di Tanah Tinggi Lojing, Kelantan, Malaysia. Bunga yang menawan ini, terkenal dengan kelopak merah menyala, adalah yang terbesar di Asia dan kedua terbesar di dunia. Ia menarik banyak pengunjung, menjadi bukti kekayaan biodiversiti di kawasan ini. Walaupun terkenal, hubungan ekologi kompleks *R. kerri*, terutamanya dengan pendebunganya, masih tidak diketahui. Penyelidikan ini bertujuan untuk menjelaskan ekologi pendebungaan *R. kerri* dengan mengkaji secara terperinci kelimpahan dan tingkah laku pendebunga yang mengunjungi bunga jantannya. Kajian ini memfokuskan pada pengaruh faktor persekitaran dan peringkat pembungaan terhadap aktiviti pendebunga, bertujuan untuk menyahkod strategi pembiakan *R. kerri* dan implikasi luasnya terhadap pemuliharaan biodiversiti di Tanah Tinggi Lojing. Tinjauan lapangan dijalankan dengan teliti di Taman Pemuliharaan *Rafflesia*, memfokuskan pada tiga peringkat pembungaan tertentu bunga jantan *R. kerri*: bunga baru mekar, bunga sedang mekar, dan bunga akhir mekar. Semasa tinjauan ini, pemerhatian dan pengumpulan data dilakukan pada selang masa yang telah ditentukan, mencatatkan spesies pendebunga, tingkah laku mereka, dan keadaan persekitaran seperti kelembapan dan suhu. Pengenalpastian dan pengumpulan spesies pendebunga membolehkan analisis mendalam tentang peranan mereka dalam proses pendebungaan *R. kerri*. Sepanjang kajian, sejumlah 2,387 kunjungan oleh pendebunga dan pengunjung direkodkan merentasi tiga bunga jantan. Bunga 2 menerima jumlah kunjungan tertinggi, diikuti oleh Bunga 1 dan Bunga 3. Kunjungan umumnya meningkat seiring dengan kemajuan pembungaan, kecuali untuk Bunga 2, yang mengalami penurunan semasa peringkat akhir mekar yang hujan. Pendebunga yang paling kerap mengunjungi adalah *Drosophila* sp., diikuti oleh *Lucilia* sp. dan *Simulium* sp., dengan *Lucilia* sp. dan *Chrysomya* sp. dikenalpasti sebagai pendebunga potensial. Kajian ini menawarkan wawasan berharga mengenai ekologi pendebungaan *R. kerri,* menekankan peranan penting faktor persekitaran dan peringkat pembungaan terhadap aktiviti pendebunga. Penemuan ini menyoroti dinamik yang rumit dalam strategi pembiakan *R. kerri,* menyumbang kepada pemahaman dan pemuliharaan biodiversiti di Tanah Tinggi Lojing.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Rafflesia kerri'*s* renowned for its grand appearance and it also can attract many visitors to come to the captivating Lojing Highlands of Kelantan, Malaysia, (Norhazlini et al., 2020). *R. kerri also* known as the "corpse flower," the *R. kerri* is an interesting and extraordinary parasitic species that holds its own in botanical circles. These floral giants draw attention to the region's extraordinary biodiversity by weaving an ecological significance with their mysterious pollinator species (Meijer, 1997).

The focal point is *R. kerri*, a species with gigantic flowers and striking crimson hues (Norhazlini et al., 2020). For this parasite plant to successfully reproduce, complex interactions with its surroundings especially pollinators are essential. An important function of the male *R. kerri* is to start the reproductive process in the plant. The complicated patterns indicate the entire flora provides the biological trends present in the Lojing Highlands.

Pollinators within the dense vegetation are essential to *R. kerri's* survival. The connective tissue of the ecosystem is made up of pollinators like insects and birds. Motivated by the search for nectar or other nutrients, they unintentionally engage in plant-pollinator interactions within a complex web of interdependence through their foraging behavior (Hor et al., 2020). These pollinators are drawn to *R. kerri's* blossoms because of their scent and appearance, which helps the plant become pollinated.

A thorough understanding of the ecological situation in the Lojing Highlands may be obtained by looking at the interactions between pollinator species and the male *R. kerri* (Norhazlini et al., 2021). The delicate equilibrium between the charismatic plant and its pollinators defines this special ecosystem. Understanding the evolutionary processes that have produced the ecosystem of this place is made possible by observing the floral giant and the daily activities of its visitors.

The research contributes to our comprehension of the life cycle of *R. kerri* and its reliance on pollinators, while also offering significant perspectives on the wider consequences for biodiversity and preservation in the Lojing Highlands.

1.2 Problem Statement

Rafflesia is an organism that lacks the ability of self-locomotion and unisexual flower, that depends on pollinators for reproduction. The presence of pollinators enables the transferring of pollen from the male flower to the stigmas of the female *Rafflesia* flower, through the pollination process. Although *R. kerri* is noble for its largest species in Peninsular Malaysia, the information about its pollination ecology remains limited and mostly anecdotal, which might be due to its short flowering period. Moreover, most ecological studies documented *Rafflesia* visitors without providing further information about their role as pollinators, especially *R. kerri* (Hor et al., 2020; Banziger, 1991; Beaman et al., 1988).

Regardless, the activities of pollinators and visitors toward the male flower of *R. kerri* are in doubt. Various factors influence the interaction between the pollinators and visitors with the flowers, such as altitude, temperature and relative humidity. The abundance of pollinators and visitors varied for every flower due to the ability of the flower to attract pollinators and visitors. The study by Hor et al. (2020), documented the potential pollinators and visitors and their activities during the blooming of the *R. kerri* flower. Yet, her study was limited to one male flower of *R. kerri* which was unable to conclude the whole pollination biology of the *R. kerri*. Thus, a proper study of the pollination biology of *R. kerri* needed to be documented. The study should consider the various factors that influence the abundance and behavior of the pollinators and visitors towards the male flower of *R. kerri*.

1.3 Objective

The objectives of this study are:

i. To identify the pollinator species associated with male *Rafflesia kerri* in Lojing Highlands

ii. To evaluate the pollinator's activity in response to varying conditions of the male *Rafflesia kerri.*

1.4 Scope of Study

The study was conducted at the *Rafflesia* Conservation Park in the Lojing Highlands, Kelantan, starting from March 2024 and continuing through September 2024. The primary focus of this study was to understand several aspects of the pollination mechanism of *R. kerri*. To gather this information, the research kicked off by conducting a survey to identify when the *R. kerri* flowers were in bloom at the location.

To gain a comprehensive understanding of pollinator behavior, observations were made at various stages of the *R. kerri*'s blooming cycle, including the early stage when the flower is fresh and new (1-3 days old), the mid-blooming stage (4-5 days old) and the later stages of blooming (6-8 days old). These observations were conducted at different times of the day, specifically in the morning (between 9.00 and 10.00 a.m.), around noon (between 12.00 and 1.00 p.m.) and in the evening (between 3.00 and 4.00 p.m.). The observer maintained a distance of one meter from the flower to avoid interfering with natural interactions.

The study also collected specimens of the observed pollinators. These specimens were later used for identification and analysis to determine the specific species involved in pollinating *R. kerri*.

1.5 Significance of Study

R. kerri is a rare and endemic plant species. This study aims to contribute information regarding the pollinators and their behavior towards the *R. kerri* male flower. Understanding the *R. kerri* flower visitors and its role in reproduction could provide valuable insights into its biology, ecology and conservation requirements, aiding conservation programs and broader ecosystems. Additionally, studying the roles of pollinators in the reproduction of *R. kerri* will enhance the conservation of the species, making it a potential ecotourism product where this could be the economic approach to generate revenue for local communities, supporting infrastructure development, conservation initiatives and overall well-being. The tourism industry can also create job opportunities, contributing to employment and economic growth.

The study of *R. kerri* can raise public awareness about Malaysia's biodiversity, fostering environmental stewardship and sustainable practices and potential ecotourism, potentially leading to the development of a new bio-industry based on sustainable tourism in Lojing Highland, Kelantan.

CHAPTER 2

LITERATURE REVIEW

2.1 The Family of Rafflesiaceae

2.1.1 Overview and General Description

Rafflesia is one of the sporadic parasitic plants that is only found in the tropical forests of East and Southeast Asia such as Malaysia, Thailand, the Philippines, Indonesia and Brunei. *Rafflesia* is known to be endoparasite to the genus of *Tetrastigma* (Vitaceae) vines. These gigantic flowers lack of stems, leaves, roots and photosynthetic tissue that grows by embedding their cells within the stem and root tissues of their host as strands. It means that the plant could get the nutrients and water (Kuijt, 1969). Peculiarly, the plant only emerges as ephemeral flowers during sexual reproduction from the roots of the lower stems of the host plants.

Most of the *Rafflesia* possess a large, bowl-shaped floral chamber formed by a perianth tube and a diaphragm. The flowers range in size, which could be varied from 10 cm to meters according to their genera and species. Additionally, *Rafflesia* flowers are admitted as "Corpse Flower". The reason behind the metaphorical name is that *Rafflesia* flowers mimic rotting in odor, color and texture. These unique characters enable *Rafflesia* flowers to attract the flowers pollinators and visitors. These dioecious plants depend entirely on pollinators for reproduction.

2.1.2 The Complex Taxonomy History of Rafflesiaceae

An early study in the classification and identification of Rafflesiaceae is complicated. Davis (2008) claimed that this is due to the high reduction in vegetative parts, modification of reproductive structures and anomalous molecular evolution of Rafflesiaceae family members. Ribulose-biphosphate carboxylase/oxygenase (RuBisCO) and other plastid genomes were commonly used in the identification of phylogenetic inference in green plants. Unfortunately, Molina et al. (2014) claimed that the genus *Rafflesia* is the first parasitic plant that contains no recognizable remnants of the chloroplast genome.

Historically, Rafflesiaceae were classified based thoroughly on morphological features. Early in the study, Rafflesiaceae were considered as *sensu lato*; in the broad sense of nine genera. Consequently, Harms (1935), reconstructs the Rafflesiaceae heterogeneity; four out of nine genera were classified as distinct groups, then identified as tribes under Rafflesiaceae. A review article by Nur Hayati and Walck (2016), highlighted that the taxonomy classification of *Rafflesia* was followed by a comprehensive treatment by Meijer (1997). Since the invention of the treatment, a variety of novel species from Malaysia, the Philippines and Indonesia have been discovered and elucidated.

On the other hand, according to the first molecular phylogenetic study by Deoxyribonucleic Acid (DNA) sequencing, Rafflesiaceae is categorized under the order of Malpighiales with three genera namely *Rafflesia*, *Rhizanthes* and *Sapria* (Barkman et al. 2004, 2007; Wurdack and Davis, 2009). The studies also revealed that *Rafflesia* evolution was affected by the gene that might been transferred from their host; *Tetrastigma* (Molina et al., 2014; Krause, 2015 and Davis and Wurdack, 2004).

R. kerri is a member of the Rafflesiaceae family, which falls under the Malpighiales order. The classification of *R. kerri* encompasses multiple hierarchical levels, such as kingdom, division, class, order, family, genus and species according to the Malaysia Biodiversity Information System (MyBIS). Table 2.1 shows a comprehensive outline of the taxonomy of *R. kerri*.

Table 2.1: Taxonomy of *Rafflesia kerri* (Source: Malaysia Biodiversity Information System (MyBIS))

Kingdom	: Plantae
Division	: Magnoliophyta
Class	: Magnoliopida
Order	: Malpighiales
Family	: Rafflesiaceae
Genus	: *Rafflesia*
Species	: *kerri* Meijer

2.2 The Discovery Genus of *Rafflesia*

Genus of *Rafflesia* was named after Sir Stamford Raffles, whose are the progenitor of The British Colony of Singapore and the head of the explorer mission in 1818. The first specimen was found by French explorer botanist, Louis August Deschamps during his expedition to Asia and the Pacific from 1765 to 1842. The specimen, *R. patma* was found in Java in 1797 (Meijer, 1997). Unfortunately, in 1798, during the war between France and British in 1798, his ship was confiscated by the British and all his notes and documents were snatched.

From 1782 to 1818, Joseph Arnold, who's a British botanist found another *Rafflesia* specimen, which he named after the expedition leader Sir Stamford Raffles and himself; (*Rafflesia arnoldii*) in Sumatra (Hsuan, 1978).

2.3 The Distribution of *Rafflesia* Species in Malaysia

To date, there are 42 *Rafflesia* species have been identified in Asia and some are still waiting for taxa characterization (Adam et al, 2022). In Malaysia, *Rafflesia* are discovered in the tropical rainforest of Peninsular, Sabah and Sarawak. Adam et al (2022); Siti-Munirah et al (2021), Norhazlini et al. (2021b); Ahmad Puad et al. (2020); Abdul Wahab et al. (2018); Sofiyanti et al. (2016); Zulhazman et al. (2010); Wong et al. (2009) Latiff & Wong (2003), Nais (2001); Meijer (1997); Mat Salleh & Latiff (1989). documented 14 species of *Rafflesia* distributed all over Malaysia, which are nine in Peninsular Malaysia and five in Sarawak and Sabah (Table 2.3)

Table 2.3: Checklist and Distribution of *Rafflesia* Species in Malaysia.

No.	***Rafflesia* species**	**State (Location Discovered)**
1.	*R. cantleyi*	Kelantan, Pahang (Pulau Tioman), Perak and Terengganu
2.	*R. azlanii*	Perak
3.	*R. kerri*	Perak and Kelantan
4.	*R. tiomanensis*	Pahang (Pulau Tioman)
5.	*R. su-meiae*	Kelantan
6.	*R. sharifah-hapsahiae*	Pahang
7.	*R. parvimaculata*	Pahang
8.	*R. tunku-azizahiae*	Pahang
9.	*R. tengku-halimii*	Pahang and Perak
10.	*R. hasseltii*	Sarawak
11.	*R. keithii*	Sarawak and Sabah
12.	*R. pricei*	Sarawak and Sabah
13.	*R. tuan-mudae*	Sarawak
14.	*R. tengku-adlini*	Sabah

(Sources: Adam et al (2022); Siti-Munirah et al (2021), Norhazlini et al. (2021b); Ahmad Puad et al. (2020); Abdul Wahab et al. (2018); Sofiyanti et al. (2016); Zulhazman et al. (2010); Wong et al. (2009) Latiff & Wong (2003), Nais (2001); Meijer (1997); Mat Salleh & Latiff (1989).)

2.3.1 *Rafflesia kerri* in the State of Kelantan

R. kerri only can be found in Kelantan, Perak and Southern Thailand. Almost all *Rafflesia* species grow well in moist and shady areas; meaning natural and forest conservation parks. *R. kerri* was first discovered by Scottish physician A. F. G. Kerr at Khao Pho Ta Lung, Renong Province, Southern Thailand in 1929 (Meijer, 1984).

In Kelantan state, *R. kerri* was first tracked down at Bukit Tepuh, the border of Kelantan-Thailand. In the year 1992, other specimens were found at Mount Stong State Park and Mount Chamah, Kelantan. The latest update on the distribution of *R. kerri* in Kelantan was documented by Fauzan et al. (2021), where 26 populations were mapped in Lojing Highlands, Kelantan.

2.4 Ecology of Genus *Rafflesia*

Rafflesia are parasite plants where it is dependable on their host plant. Despite that, the *Rafflesia* host plant needed moist and shady areas; where forest slopes and located nearer the stream inside the forest are the most suitable for the *Rafflesia* to grow and reproduce. Conditions such as host plant health, forest environment, water resources and photoperiod are the crucial values that affect the growth of *Rafflesia* (Akhriadi et al., 2010).

Southeast Asia is known for its tropical climate. This climate is affecting the flowering season of *Rafflesia*. No exact wet or dry season causes the variation of flowering season of plants in tropical forests. In the study of *Rafflesia*, there is no information regarding the phenology of *Rafflesia* available. Since the *Rafflesia* grows beneath the trees, at the forest floor, the effects of photoperiod and rainfall might be hard to observe (Nais and Wilcock, 1998).

2.5 The Importance of *Rafflesia*

In Malaysia, the existence of *Rafflesia* become a symbol of Malaysia's rich biodiversity. The presence of *Rafflesia* has become a part of revenue for Malaysian economic income. Ecotourism is defined as *"The responsible travel to natural areas that conserves the environment, sustains the well-being of local people and involves interpretation and education"* (Cambridge Learner's Dictionary, 2012) Conservation of *Rafflesia* has become a central attraction and it is often featured in ecotourism campaigns (Barkman 2000). Despite this, *Rafflesia* is considered a protected species under the country's National Heritage Act 2005 and is actively preserved by both the government and local communities. Some *Rafflesia* species have been listed as rare plant species and vulnerable to extinction in certain areas.

For decades, *Rafflesia* has been used for a variety of medicinal occasions. In Thailand, *R. kerri* buds and flowers are considered a special delicacy. In some folk beliefs, the *Rafflesia* are claimed to have the effects of aphrodisiacs for men. Nais (2001) stated that *R. kerri* is harvested as herbals and the tea medicine is claimed to act as a sexual stimulant.

The tonic made of *Rafflesia* is good for relieving the fever and backaches. The traditional medicinal product (Faizal Tonic and Pil Buasir) is said to contain extraction of *Rafflesia* as reported by Banziger (1991) in Kedri et al., (2018). Besides being used as folk herbalism, the *Rafflesia* flowers are utilized as fodder for swine-fed (Barcelona et al, 2009).

Some species such as *R. zollingeriana* are used as *jamu* (a traditional herbal tonic) in Java island (Damayanti et al., 2014). The buds are collected and dried for longer storage. In Javas' pre-Islam Hindu culture, the *Rafflesia* are the symbols of nature's reproductive forces (Blume 1825). The *jamu* that contains extraction from

Rafflesia buds is used to end internal bleeding, compress the womb and restore fatigue during the postpartum.

Meanwhile, the *Rafflesia* extracts are still indistinct to claim to have medicinal purposes. The preliminary phytochemical analysis by Jubli (1984), shows that there are no basic properties for *Rafflesia* purported as medicines. Moreover, the buds and flowers of *Rafflesia* are rich in tannins and phenols. These phytochemicals are toxic to humans if taken in excess quantity. (Wong and Latif, 1994)

2.6 The Reproduction Mechanism of *Rafflesia kerri*

Rafflesia are enormous flowers, where buds will arise from the stem or root of the host plants. Dependable to its host plants (*Tetrastigma* spp.) to meet its description; no stem, leaves or roots. *R. kerri* parasitized the vines of the Liana's genus. It grows by spreading its haustorium (absorptive organ) inside the vine tissues (Shaw, 2017). Meanwhile, the *Testrastigma* are climber vines, which depend on other woody trees for structural support and to get enough sunlight. This interaction between *Rafflesia* - *Tetrastigma*-trees, is notable as hyperparasites.

Rafflesia has the appearance of being species-specific; naturally, some *Rafflesia* species are only infested by one to three species of *Tetrastigma*. To date, only seven out of 57 recognized *Tetrastigma* species are reported as host plants (Nais, 2001). *T. diepenhorstii* is the most recorded as host for *Rafflesia* species (Wan Zakaria et al., 2016).

2.6.1 Lifecycle of *Rafflesia kerri*

Infected vines of *Tetrastigma* will swell and the 2-4 cm in diameter of *Rafflesia* will appear on the trailing stems or roots of the woody vines of *Tetrastigma.* The buds will grow up to 20 cm in diameter (Kedri et al., 2018). It takes nine months for the buds to grow. After that, the buds start to open and bloom. It takes 7-8 days for the flower to bloom and rot right after the blooming.

During the blooming period, the female flower will be pollinated by the flies and fruits will be formed. The fruits contain hundreds to thousands of seeds which are packed into berries (Shaw, 2017) When the fruits are eaten by the mammals, the seeds will distribute naturally (Meijer, 1997). The miniscule seeds will germinate by spreading their absorptive organ in the vine of the host plants.

2.6.2 Morphology of *Rafflesia kerri* Flowers

Rafflesia are unisex and dioecious flowers; where both female and male flowers are separated (Sofiyanti et al., 2016). The flower part that can be observed is the only part that emerges outside the host; which is known as the petal flower consisting of five petals. The petals are described as sepals (petaloid sepals) instead of vaguely defined as perigone lobes. *Rafflesia* diaphragm is made up of adnate petals to form a dome, the true corona being greatly reduced (Peter, 2014). Both flowers smell like rotting flesh. The bad odors are the attraction for the insects such as carrion flies, that help in pollination processes. Generally, the insects transport the pollen from male to female stigmas, to succeed the pollination.

Generally, the male flower is smaller in size compared to the female. Meanwhile, the presence of pollen and stigma serve as indicators for distinguishing the male and female flowers, respectively. The male *Rafflesia* flower has a disc-like structural shape, while the female flower has a bowl-like structure. Additionally, the male flower displays red or orange colors, while the female flower of *Rafflesia* exhibits subdued shades of brown or maroon. Figure 2.6.2 below shows the difference between male and female flowers of *R. kerri*.

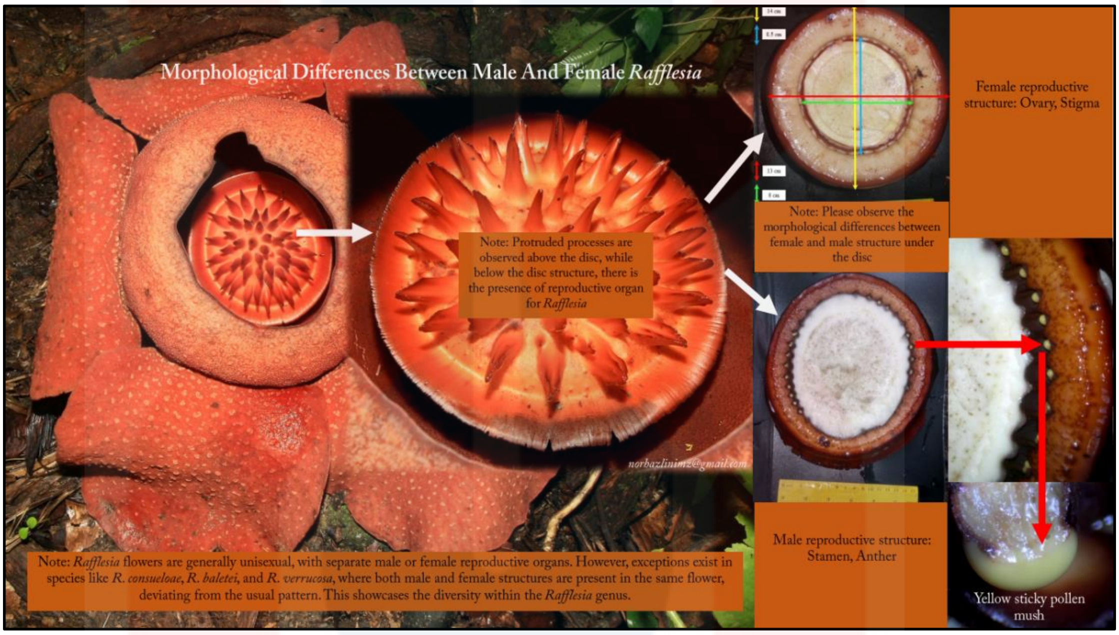


Figure 2.6.2. Morphological Differences Between Male and Female Flower of *Rafflesia*. (Illustrated by Norhazlini M.Z.)

2.6.3 The Pollinators of *Rafflesia kerri*

Pollination plays a crucial role in the reproductive success of plants. It ensures the transfer of genetic material between individuals and promotes genetic diversity within plant populations. By attracting carrion flies, plants like *Rafflesia* have evolved a unique strategy for pollination, relying on these flies for the transfer of pollen between flowers.

This unique form of pollination, known as carrion fly-mediated pollination, is not only fascinating but also highly effective in ensuring the survival and reproduction of these plant species. Through carrion fly-mediated pollination, plants like *Rafflesia* have found a way to deceive flies into thinking they have found a food source or a place to lay their eggs. This creative strategy benefits both the plants and the flies by ensuring the transfer of pollen and providing a potential food source for the flies (Hor et al., 2021).

This adaptation highlights the complicated and complex relationships between plants and their pollinators, showcasing the diverse strategies that have evolved to ensure successful reproduction. Overall, pollination is a vital process for plant reproduction and some plants have developed unique strategies, such as carrion fly-mediated pollination. This adaptation not only ensures the transfer of pollen but also provides an interesting example of co-evolution between plants and pollinators (Norhazlini et al., 2020).

A previous study by Patino et al. (2002) proved that *Rafflesia* is an endothermic flower and the production of CO2 and other volatile constituents was likely to influence the scent emission emitted by the flower, attracting the pollinators to visit the flower.

Meanwhile, Hor et al. (2020) and Banzinger et al. (1991) have delved into the pollination biology of *Rafflesia*. As a sedentary organism with unisexual flowers, *Rafflesia* relies on pollinators to facilitate the transfer of pollen from male to female flowers. Additionally, according to Abdul-Wahab et al. (2018), successful pollination results in the development of fruits containing numerous tiny seeds, ready for dispersal by various agents, ensuring the species' continuity. Beaman et al. (1988) further asserted that operating as a sapromyophilous flower, *Rafflesia* emits a foul odor resembling decomposing flesh and displays deceptive coloring to attract carrion flies in search of food and breeding sites. However, Banzinger et al. (1991) contested the idea that *R. kerri* is a deceptive flower, pointing to the existence of slimy mush (anther exudates) beneath the male flower's disc rim, which can be consumed by flies. Moreover, the pollen serves as a source of carbohydrates, lipids and protein.

Recent investigations by Hor et al. (2020) in Lojing Highlands identified potential pollinators for *R. kerri* in Lojing Highlands, which are calliphorid flies from the genera of *Chrysomya, Lucilia* and *Hypopygiopsis*. Meanwhile, Banziger (2004) states that Diptera (Rhagonidae, Syrphidae, Anthomyiidae, Tachinidae, Sarchophagidae, Musciade, Conopidae, Ulidiidae, Drosophilidae) and Hymenoptera (Formicidae, Apinae and Andrenidae) were recognized as visitors to the blooming flower. Female carrion flies such as *Chrysomya villeneuvei, C. rufifacies, C. defixa, C. chani* and *C. pinguis* was identified as pollinators for *R. kerri*.

Nevertheless, the existing data is inadequate to definitively establish the pollination mechanism. Moreover, the infrequent occurrence of encountering the blooming flower has presented a challenge for researchers investigating the floral scent of *Rafflesia*.

The reproductive strategy of *R. kerri* heavily relies on the pollination process, which involves specific pollinator species. The primary pollinators for male *R. kerri* are flies, which are attracted to the malodorous scent emitted by the flowers. This process is critical for the transfer of pollen between individual plants, enabling fertilization and seed development (Norhazlini et al, 2020).

The choice of flies as pollinators is not random, but rather a result of a co-evolutionary relationship between *R. kerri* and its pollinators. The plant strategically mimics the scent of decaying flesh to attract flies that are normally associated with decomposing matter. Inadvertently, the flies pick up pollen from the male flowers while seeking out potential breeding sites, becoming unwitting carriers in the reproductive process of *R. kerri* (Benziger, 1991; Hor et al., 2021).

The mutualistic symbiosis between male *R. kerri* and pollinator species primarily flies, is a captivating example of interaction. The plant entices the flies through its malodorous flowers, which mimic the scent of decaying flesh, creating a deceptive yet irresistible attraction. In response to this olfactory cue, the flies are lured toward the flowers with the expectation of finding a suitable environment for egg-laying or feeding (Wee et al., 2018).

During their engagement with the male flowers, the flies come into contact with the anthers that are laden with pollen. As they forage or explore the flower for potential breeding sites, the flies unintentionally transfer the pollen onto their bodies. Although unaware, the flies play a crucial role in the reproductive cycle of *R. kerri* by becoming unwitting carriers of pollen (Norhazlini et al., 2020)

The subsequent phase of this interaction involves the departure of the pollen-laden flies from the male flowers. Guided by their attraction to foul odors, the flies actively search for other *R. kerri* flowers, where they are once again enticed by the scent. However, this time, they unknowingly deposit the pollen onto the receptive stigma of the female flowers, facilitating fertilization. This complicated interaction not only ensures the continuation of the *R. kerri* species but also emphasizes the plant's reliance on its chosen pollinator species for successful reproduction (Norhazlini et al., 2020)

CHAPTER 3

MATERIALS AND METHOD

3.1 Description of the Study Area

The study is conducted in the *Rafflesia* Conservation Park, Lojing Highlands of Kelantan, Peninsular Malaysia as shown in Figures 3.1a and 3.1b. The majority of the local community in this area is from the *Temiar* ethnic group, constituting part of the Senoic Indigenous population in Malaysia, including Kelantan (Hackson, 2005).

The study area is within the geographical coordinates of (S 4.648315940524822 in the south and E 101.50134543769626) in the east. The Lojing Highlands, are characterized by hill and montane dipterocarp forests and represent a relatively modest settlement. This area is positioned at an elevation of 610-1500 meters above sea level and can be accessible both from Gua Musang in Kelantan and from Cameron Highlands in Pahang. The selection of the Lojing Highlands as the study site is further supported by the fact that *Rafflesia* thrives in high-altitude environments characterized by optimal climatic conditions.

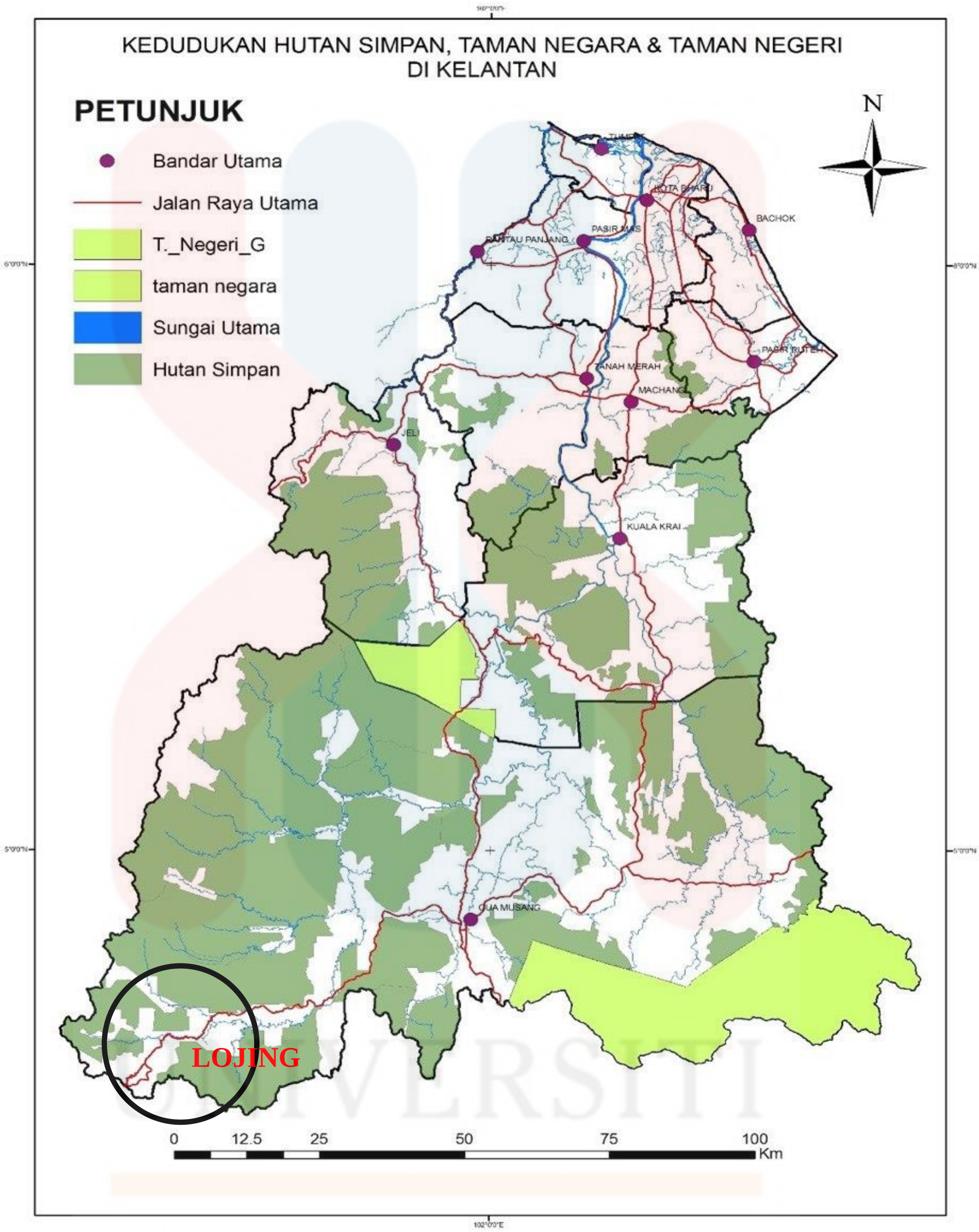


Figure 3.1a. Locations of study area forest reserves, national park and state park in Kelantan, Malaysia. (Source: Zulhazman Hamzah., 2012).

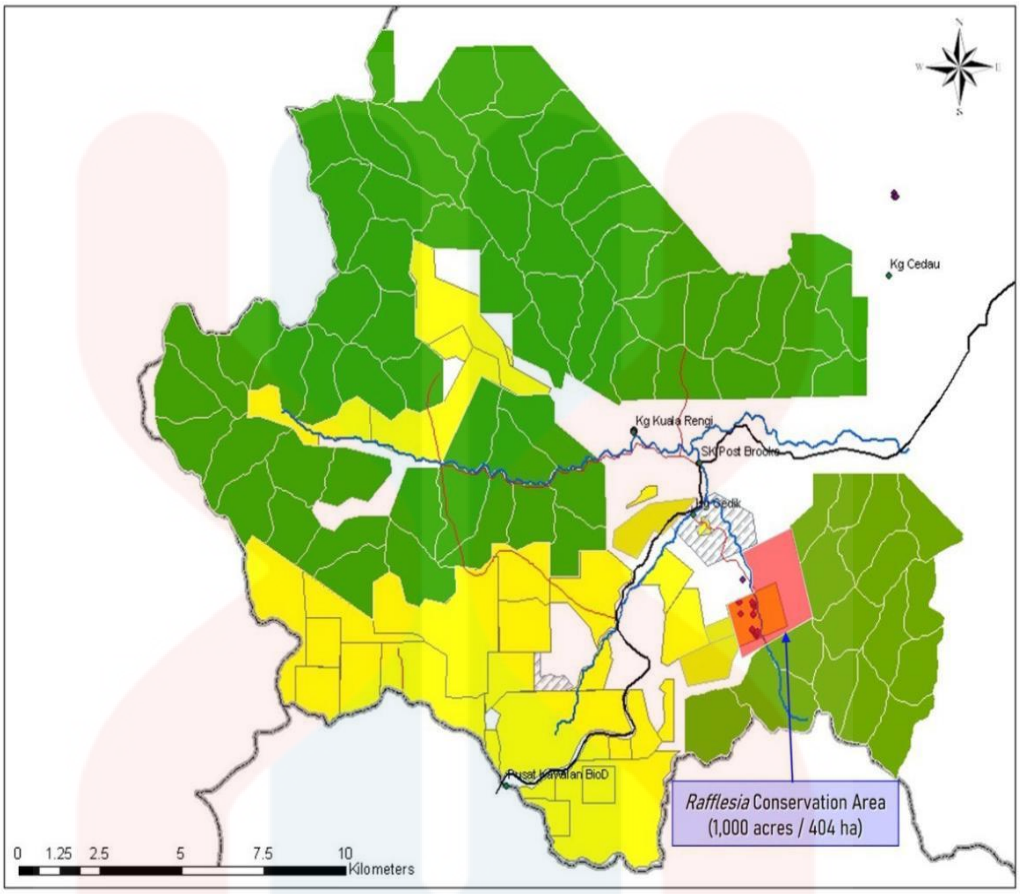


Figure 3.1b. Close-up view of the study area; *Rafflesia* Conservation Area, Lojing Highlands Kelantan, Malaysia. (Source: Zulhazman Hamzah., 2012).

3.2 Materials

The materials used in this study are listed in Table 3.2 below.

Table 3.2: List of materials used in the study and their functions

No.	Equipment	Function
1.	Aerial Nets	Used to catch pollinators that visit the *R. kerri*
2.	Killing Jar	Used to kill captured insects (pollinators) quickly and with minimum damage.
3.	Insect Pin	Pins and mount blocks and vials for keeping specimens.
4.	Cotton Wool and Ethyl Acetate	Used to kill or make insects faint which is the cotton wool is soaked with ethyl acetate that will release toxic gas.
5.	Digital Single-lens reflex	To aid in better vision by recording and observing. Such as enlarging distance objects.
6.	Indoor Digital Thermometer	Used for measuring corresponding ambient temperature and Humidity.
7.	Binocular Microscope	Observing the different parts of the insects.
8.	Digital Microscope Camera	Used to capture the insect's images.
9.	Insect Display Box	Used to protect the collected insect specimens.

3.3 Methods

The methodology employed in this study was designed to align with and address the specific objectives outlined for the research. This ensures that the methods implemented are tailored to achieve the intended goals and contribute meaningfully to the study's outcomes. Figure 3.3 below illustrates how the study was conducted.

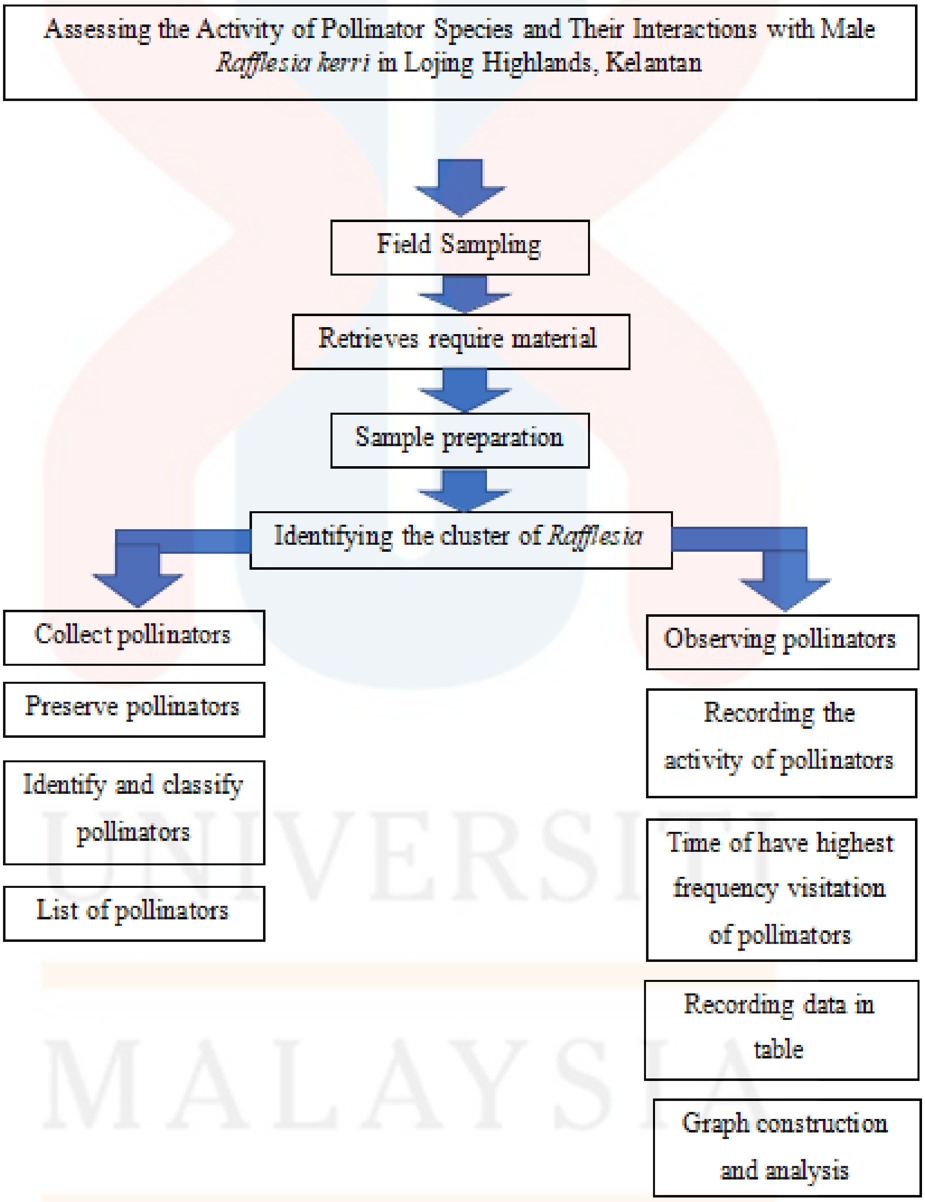


Figure 3.3: Flowchart of the study

3.3.1 Field Survey and Sampling

In November 2023, a preliminary survey was carried out to plan a systematic document and record the flowering periods of *R. kerri* within the *Rafflesia* Conservation Park, located in the Lojing Highlands. Then, the data collection was done from 14 February until 3 March 2024. During the field sampling, careful observations were made to assess the presence of pollinators and relevant specimens were collected for further analysis. The specimens were subsequently transported to the laboratory at Universiti Malaysia Kelantan (UMK) for a more in-depth study. The entirety of the collected data was undergone thorough analysis and documentation as part of the research process.

3.3.2 Pollinator Observation and Data Collection

The study specifically concentrated on three distinct stages of the blooming cycle of *R. kerri*: the fresh blooming stage (days 1-3), the mid-blooming stage (days 4-5) and the late blooming stage (days 6-8).

To adequately prepare for the study, it is crucial to familiarize oneself with the blooming cycle of *R. kerri* and identify a particular specimen for observation. The selection of observation days for each blooming stage was meticulously planned, taking into consideration weather conditions conducive to effective observations. This comprehensive approach ensures a thorough examination of pollinator activity and behavior throughout different stages of the flowering process. This study observed the pollinators and visitors by recording the frequency of the flies visiting the flower. The result from the observation found that the flies which are pollinators and visitors rested on the perigone lobes, on the top of the flower diaphragm, on ramenta, processes and also near the flower surrounding. While observed for a few minutes, one meter far from the flower the flies with pollen stuck on their thorax can be observed because the flies fly inside the flower and crawl to the flower anther. From this observation, we can differentiate between the pollinators and visitors by observing their activities which is the frequency of the flies visiting the flower and also by referring to the previous study by Hor et al (2021).

Factors such as humidity, temperature, flower size, flower color and flower odor against the number and behavior of pollinators was measured. Moreover, such parameters were also observed against the blooming stages of the *R. kerri.*

As mentioned earlier, the observational process was divided into three main stages and the details are as follows:

1. Fresh Blooming (Days 1-3):

- Morning (9.00-10.00 am): Initial observations were focused on recording any pollinator activity around the fresh blooming *R. kerri* during the morning hours.

- Noon (12.00-1.00 pm): Subsequent observations were conducted during midday to capture potential changes in pollinator behavior.

- Evening (3.00-4.00 pm): The final observation of the day was aimed at documenting any variations in pollinator activity during the evening hours.

2. Mid-Blooming (Day 4-5):

- Observations during the mid-blooming stage followed a similar schedule as the fresh-blooming stage.

3. Late Blooming (Days 6-8):

- Observations during the late blooming stage was repeated at the designated time slots.

During each observation, meticulous records was kept, noting the types of pollinators observed (e.g., flies, beetles) and their behaviors, such as feeding or attempting pollination. Additionally, environmental factors such as temperature and humidity that may influence pollinator activity was recorded.

3.3.3 Pollinator Species Identification and Collection

Pollinators play a crucial role in the reproductive success of many plants, including the male *R. kerri*. Collecting pollinator specimens associated with male *R. kerri* allows for further identification and analysis of the specific pollinators involved in its reproduction. This information will contribute to a deeper understanding of the reproductive ecology of *R. kerri* and aid in its conservation efforts, particularly in light of the potential impacts of pollinator declines and extinction. In the study of male *R. kerri*, all pollinators observed during the observation period were photographed for identification purposes. The identification of the specimen is by referring to the previous study by Hor et al (2021), referring a book titled "The Blow Flies RES Handbook" and to Dr. Wee Suk Kling the Expertise in Calliphoridae Study which is an Entomologist of Universiti Kebangsaan Malaysia (UKM). The specimens of all pollinators, except birds, were collected and stored. To assess their effectiveness as pollinators, the visiting behavior of these insects was analyzed and they were classified as effective pollinators, occasional pollinators, or nectar/pollen thieves. Specimens of the visiting insects associated with male *R. kerri* were carefully collected for identification and further analysis.

3.3.4 Data Analysis and Interpretation

This study makes a systematic collection of pollinator specimens in conjunction with meticulous observation and documentation has yielded a comprehensive dataset for analysis. By making a systematic collection of pollinator specimens the comprehensive dataset analysis can be done by identifying the pollinator or visitor specimen species and also the interaction among the pollinators with the flower can be interpreted. This initiative aims to discern specific pollinator species and comprehend their respective behaviors under varying blooming conditions of male *R. kerri* flowers which are in the fresh-bloom, mid-bloom and late-bloom stages, with the overarching goal of unraveling the complicated relationship between the plant and its pollinators and shedding light on the nuances of their ecological interaction.

The initial phase of the analysis entails the meticulous identification of pollinator specimens. Drawing on field guides, entomological expertise and when applicable, the research team rigorously categorizes each specimen at the species level. This foundational step is crucial for elucidating patterns and variations in pollinator behavior.

The datasets are categorized based on the diverse blooming conditions of male *R. kerri* flowers, encompassing the early blooming stage (days 1-3), mid-blooming stage (days -5) and late blooming stage (days 6-8). For each blooming condition, the pollinators' and visitors' behaviors are observed, which is observing their activities, either way, the flies just rest on the flower or the flies interact with the flower which the flies crawl inside the flower and also the pollinators and visitors was identified and pollinator species are closely examined, taking into account factors such as the time of day, environmental conditions and the developmental stage of the male flower.

CHAPTER 4

RESULT AND DISCUSSIONS

4.1 The Status of *Rafflesia* Flowers and their Condition Throughout the Blooming Period

A total of three male flowers of *Rafflesia kerri* were examined throughout the blooming stages. The first male flower was found near to a gigantic rock and parallel to a small stream at the "v" shape valley with a slope of 45°. The location of this male flower is located approximately 20 meters from the main forest trail. The flower was shaded by the less dense canopy, which allowed low light intensity to penetrate and reach the flower. The flower was perfectly blooming, but due to the slope, two perigone lobes bent to keep the flower from falling into the valley. The soil surrounding the flower is partially covered with leaf litter. The flower has five perigone lobes with a whole open flower diameter of 83cm in length and 77cm in width. The diaphragm was fully open with a diameter of 31cm in length and 38cm in width as shown in Figure 4.1a.

Figure 4.1a. The male of *Rafflesia kerri* Meijer. A. The habitat of flowers. B. The fresh-blooming stage. C. The mid-blooming stage. D. The late-blooming stage.

The second male flower of *R. kerri* was found 20 meters from the stream. The flower was noted between the big buttress root of the tree. This flower was infected by the fungus during its budding stage, which caused the flower to become a disorder. This happens when the perigone lobes of the flower do not fully expand due to being infected by the fungus during the budding until the blooming stage. The soil surrounding the flower is partially covered with leaf litter. The trees provide a canopy that allows low light to penetrate the areas. This male flower has an open flower diameter of 73.5cm. Meanwhile, the flower diaphragm diameter was about 28cm in length and 33.5cm in width as shown in Figure 4.1b.

Figure 4.1b. The male of *Rafflesia kerri* Meijer. A. The fresh-blooming stage. B. The mid-blooming stage. C. The late-blooming stage. D. The habitat of a flower.

Henceforth, the third male flower was found approximately 50 meters from the stream. The flower is grown on the slope with an elevation of approximately 972 meters a.s.l. The flower is found on the buttress root of the tree. Only two perigone lobes successfully expanded while two of them leaned to the tree trunk and one of the perigone lobes folded as shown in Figure 4.1c below. The soil surrounding was partially covered with leaf litter. The canopy was highly dense and very low light could penetrate the canopy to provide light to the flower.

Figure 4.1c. The male of *Rafflesia kerri* Meijer. A. The fresh-blooming stage. B. The mid-blooming stage. C. The late-blooming stage. D. The habitat of the flower.

The examination was carried out for three blooming stages of each male flower. The summary of the result as shown is in Table 4.1 below. The examinations are based on the condition of the flower, the odor produced, the color of the flowers and the presence of insects.

Table 4.1: Summary of Male *R. kerri* Flower Observation

Flower	Blooming Stage	Observation
Male 1	Fresh-bloom	Sunny day (21.7-23.0°C); the flower blooms perfectly; the flower odor is not strong; the flower color is red-orange; low insect activities due to disturbance of tourist's activities;
	Mid-bloom	Sunny day (20.0-23.1°C); the flower color faded; had a strong odor; high insect activities, the flower fully expanded and cracked (flower petal rupture); pollen actively produced (sticky and yellowish);
	Late-bloom	Sunny day (20.3-22.7°C); the flower color turns dark and bruised; flower diaphragm turns dark and dry; fungus spotted at the end perigone lobe; pollen dried out; insect activities high; the flower had less odor
Male 2	Fresh-bloom	Cloudy (19.5-20.2°C); the flower color dark red; smell strong odor; high insect activities

	Mid-bloom	Cloudy (19.2-21°C); the flower color turned darker; less odor; the perigone lobe fell to the diaphragm and wet; the flower chamber started to dry; fungus spotted at the perigone lobe and decaying processes started
	Late-bloom	Rainy day (19.9-21.6°C); the flower color turned dark, the perigone lobe ruptured and less odor; fungus and black rotten area spotted at the perigone lobes; pollen dried out; diaphragm ruptured and decayed; high insect activities
Male 3	Fresh-bloom	Cloudy day (18.7-19.9°C); the flower color bright red; less odor; pollen sticky and milky; perigone expand perfectly; low insect activities
	Mid-bloom	Sunny day (19.9-21.8°C); the flower blooms perfectly; the flower color is brick red and the diaphragm color is orange; strong odor; pollen starts to dry, dark region spotted at the end of perigone lobes; the diaphragm ring starts to blackening; high insect activities
	Late-bloom	Rainy day (20.2-21.4°C); the flower color turns dark-red; less odor; the flower perigone lobes decayed; the diaphragm cracked; chamber flower ruptured and leaked; high insect activities

4.2 The List of Pollinators and Their Activities on *Rafflesia kerri*

The results show that a total of 13 species of insect visited the flowers which are *Lucilia* sp., *Chrysomya* sp., *Simulium* sp., *Drosophila* sp., *Copestylum* sp., *Oedichirus* sp., *Gryllus* sp., *Meliponini* sp., *Polybioides* sp., *Bombylius major*., *heteropsis* sp., *Circuloryptus magnus* sp. and unknown species. From the results, two of them are potential pollinators and the remaining are visitors. *Lucilia* sp. and *Chrysomya* sp. from a family of Calliphoridae (Diptera) are considered potential pollinators due to the presence of pollen sticking on their thorax as shown in Figure 4.2a. According to Hor et al. (2021), the main *Rafflesia kerri* flower visitors in the Lojing Highland are *Lucilia* sp., *Chrysomya* sp. and *Hypopygiopsis* sp. These insects are classified under the Calliphoridae family, order of Diptera which is the potential pollinators. These potential pollinators also had been mentioned in Banziger (2004) as the main pollinators of *R. kerri*. Besides Calliphoridae, the abundance of insects from various families was observed, such as Simuliidae, Sarcophaginae, Staphylinoidae, Apidae, Crytopdesmidae, Polistinae and Nymphalidae. During the, only two individual specimens were caught per species to reduce the interference. All the insects captured were identified and classified based on their family and were grouped into two groups; pollinator and visitor as indicated in Table 4.2. The morphological characteristic of the visitors is illustrated in Figure 4.2b.

Figure 4.2a Potential pollinators of *Rafflesia kerri* Meijer. A. *Lucilia* sp. (Diptera). B. *Chrysomya* sp. (Diptera)

Figure 4.2b. The visitor of *Rafflesia kerri* Meijer. A. *Simulium* sp. B. *Heteropsis* sp. C. *Polybioides* sp. D. *Teleogryllus* sp. E. *Copestylum* Sp. F. *Podabrus* sp. G. *Circulocryptus magnus* sp.

According to Hor et al. (2021), flies predominantly act as pollinators in high altitudes, such as in Lojing Highland. Customary, flies are categorized into two based on pollination syndrome behavior; myophily and sapromyophily. Myophily flies typically feed on nectar and pollen and regularly visit those flowers. Meanwhile, sapromyophily flies will attracted to sapromyophilous plants; the flower that mimics the odoriferous items. As in the pollination process of *R. kerri*, pollinators were attracted to the flower as it provided them food by imitating the odor of carcasses or dung. Although there will be no reward for visiting the flower, some flowers such as *Rafflesi*a have a part of the flower that can slow down the flies from leaving. The complex structure of the *Rafflesia* diaphragm allows the flies to spend more time exploring it. Moreover, the flower produces a strong unpleasant odor as it grows and approaches its late blooming stage. Not only that, the bright red color of the flower could attract visitors too.

Table 4.2: The Visitors Observed for Three Male Flowers of *Rafflesia kerri* Found Within the *Rafflesia* Conservation Park

Common Name	Species	Family	Order	Pollinator / Visitor
Greenbottle fly	*Lucilia* sp.	Calliphoridae	Diptera	Pollinator
Bluebottle fly	*Chrysomya* sp.	Calliphoridae	Diptera	Pollinator
Black fly	*Simulium* sp.	Simuliidae	Diptera	Visitor
Redheaded fly	*Drosphila* sp.	Sarcophaginae	Diptera	Visitor
Hoverflies	*Copestylum* sp.	Syrphidae	Diptera	Visitor
Charlie ant	*Oedichirus* sp.	Staphylinoidae	Coleoptera	Visitor
Soldier Beetle	*Podabrus* sp.	Cantharidae	Coleoptera	Visitor
Bee	*Xylocopa* sp.	Apidae	Hymenoptera	Visitor
Millipede	*Circulocryptus magnus* sp.	Cryptodesmisdae	Diplopoda	Visitor
Wasp	*Polybioides* sp.	Polistinae	Hymenoptera	Visitor
Sting-less bee	*Meliponini* sp.	Apidae	Hymenoptera	Visitor
Butterfly	*Heteropsis* sp.	Nymphalidae	Lepidoptera	Visitor
Cricket	*Teleogryllus* sp.	Gryllidae	Orthoptera	Visitor

Naturally, as illustrated in Figure 4.2c, the flies will settle down on any objects near the flower when they arrive. In some cases, when the flies regularly visit the flower or after some zig-zag flying above the flower, they will directly land on any part of the flower. Throughout the observation, insects were found to crawl and/or fly randomly all over the part of the interior flowers. Similar to Banziger (1991) and Hor et al. (2021), both Calliphoridae flies landed on the perigone lobes first and after a few seconds, the flies flew onto the diaphragm, before probing the diaphragm surface with its labellum for nutrient intake. The Calliphoridae also walk and/or fly onto the diaphragm, toward the rim and gaze into the central dish for a few seconds, continuing to fly and landing on the central dish more often. The flies sometimes landed on the center tip before continually crawling to the base of the column, by following the anther groove, guided by the hairs on the ridges between the flower's vertical grooves, then crawling slowly into the dead end of the anther cavity. The flies are seen to disappear because it is crawling under the disk's column by moving forth and backward for a few minutes before they reemerge from another point of the tube's base. According to Hor et al., (2021), during this time, the flies proceeded upward in a groove due to the force made up by the ridge hairs, causing the dorsal part of the fly's thorax to contact effectively with the diagonally down-in-ward pointing anthers. Beamen (1988) assumes that the flies found no edible reward in the anther cavity and could go no further inside of the anther cavity and at the point where the thorax of the flies contact with the anther. The flies either continue to crawl in the interior or fly directly out.

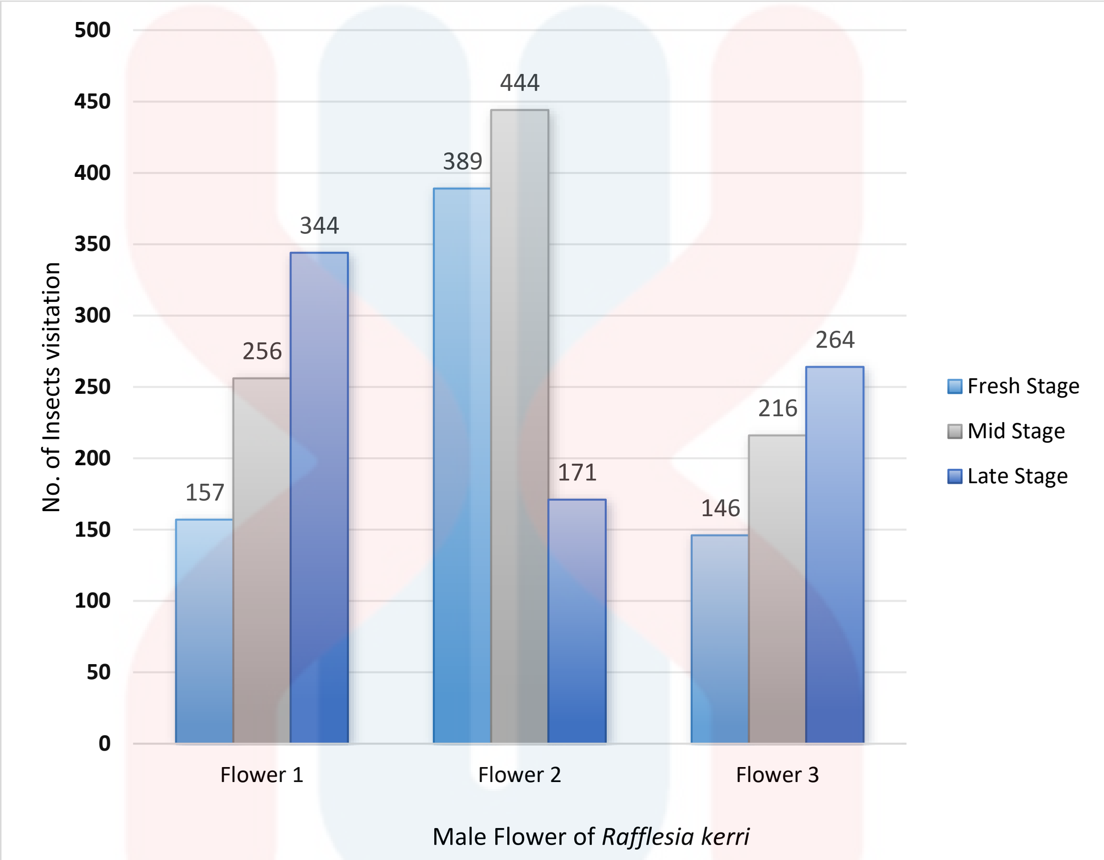
Rafflesia sp. has released a carrion smell to attract an abundance of insects to swarm around wherever the flower is in bloom. Occasionally, these non-pollinators are attracted by the various lures without obtaining any substance from the flower. Simuliidae and Sarcophaginae were assumed to be misled by fake odors released by the flower on imitation of carrion or other decomposition animal matter. Meanwhile, Apidae and Polistinae were suspected of stealing the nectar that was part of their diet. Last but not least, Cryptodesmidae and Nymphalidae presume to be visitors to the swarm event.

Figure 4.2c. The pollinators of *Rafflesia kerri* activities during the observation. A. *Chyrsomya* sp. rests on the top of the flower diaphragm. B. *Chyrsomya* sp. rest on the perigone lobe. C. *Lucilia* sp. rest on the ramenta. D. *Lucilia* sp. standstill on the perigone lobe. E. The *Chyrsomya* sp. rests on the leaf near the *Rafflesia* flower. F. *Chyrsomya* sp. breaks on the flower processes.

4.3 The Frequency of Insects Visited Male *Rafflesia kerri* Flower During Blooming Stages

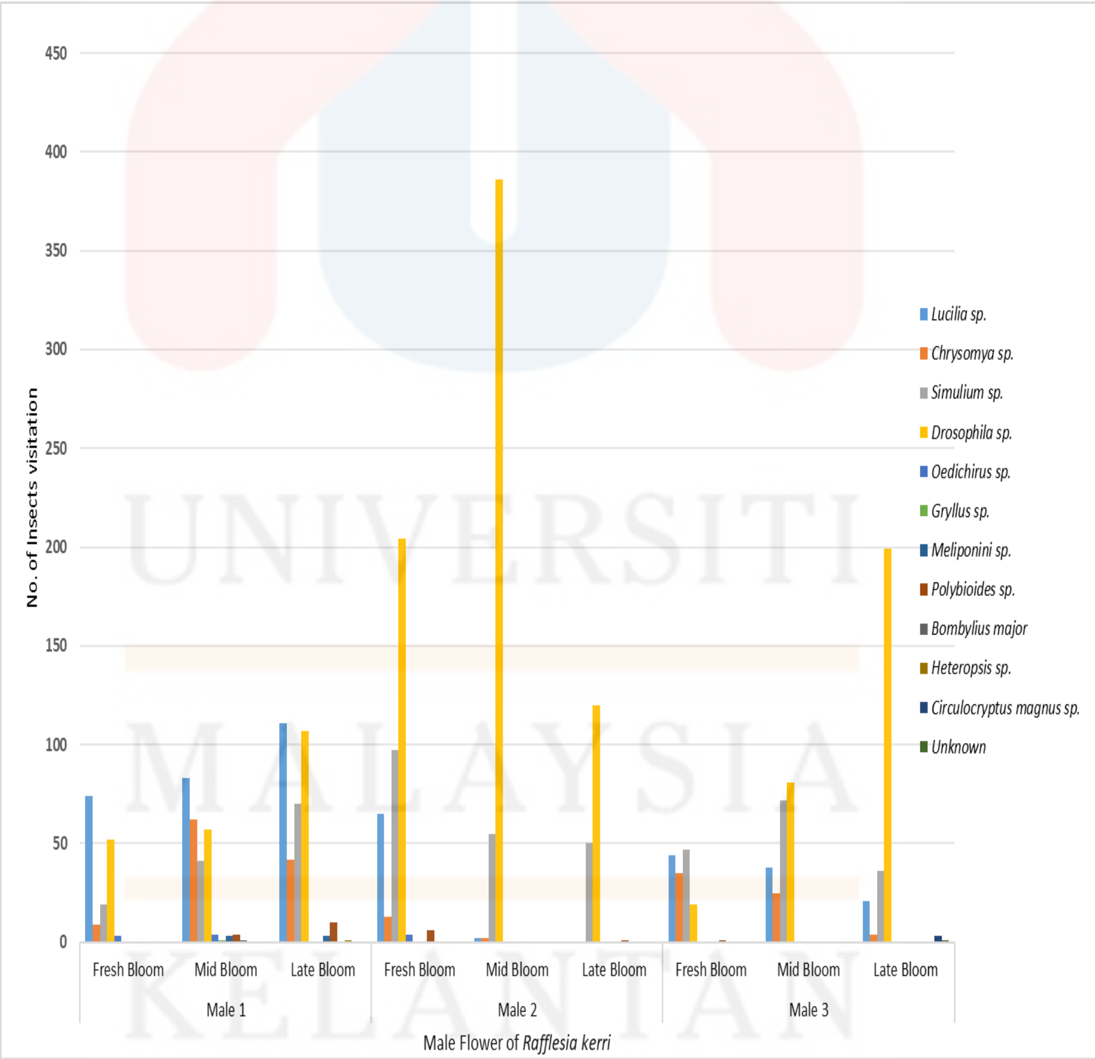
The results show that a total of 2,387 visits by pollinators and visitors to three male flowers of *Rafflesia kerri* were recorded. Overall, *R. kerri* male Flower 2 recorded the highest number of pollinators and visitors, followed by male Flowers 1 and 3, with a total number of 1004, 757 and 626 pollinators and visitors respectively. As shown in Figure 4.3.1, the trend of the pollinators and visitors was increasing across the stage of the male *R. kerri* flower's blooming, except for the male Flower 2. This was due to the condition of the male flower associated with the weather which is in the fresh-bloom and mid-bloom the weather condition is cloudy meanwhile in the late-bloom stage the weather is rainy which makes the flower odor less as described in Table 4.1.

Figure 4.3.1 A Total Number of Pollinators and Visitors of Three Male Flowers of *Rafflesia kerri*



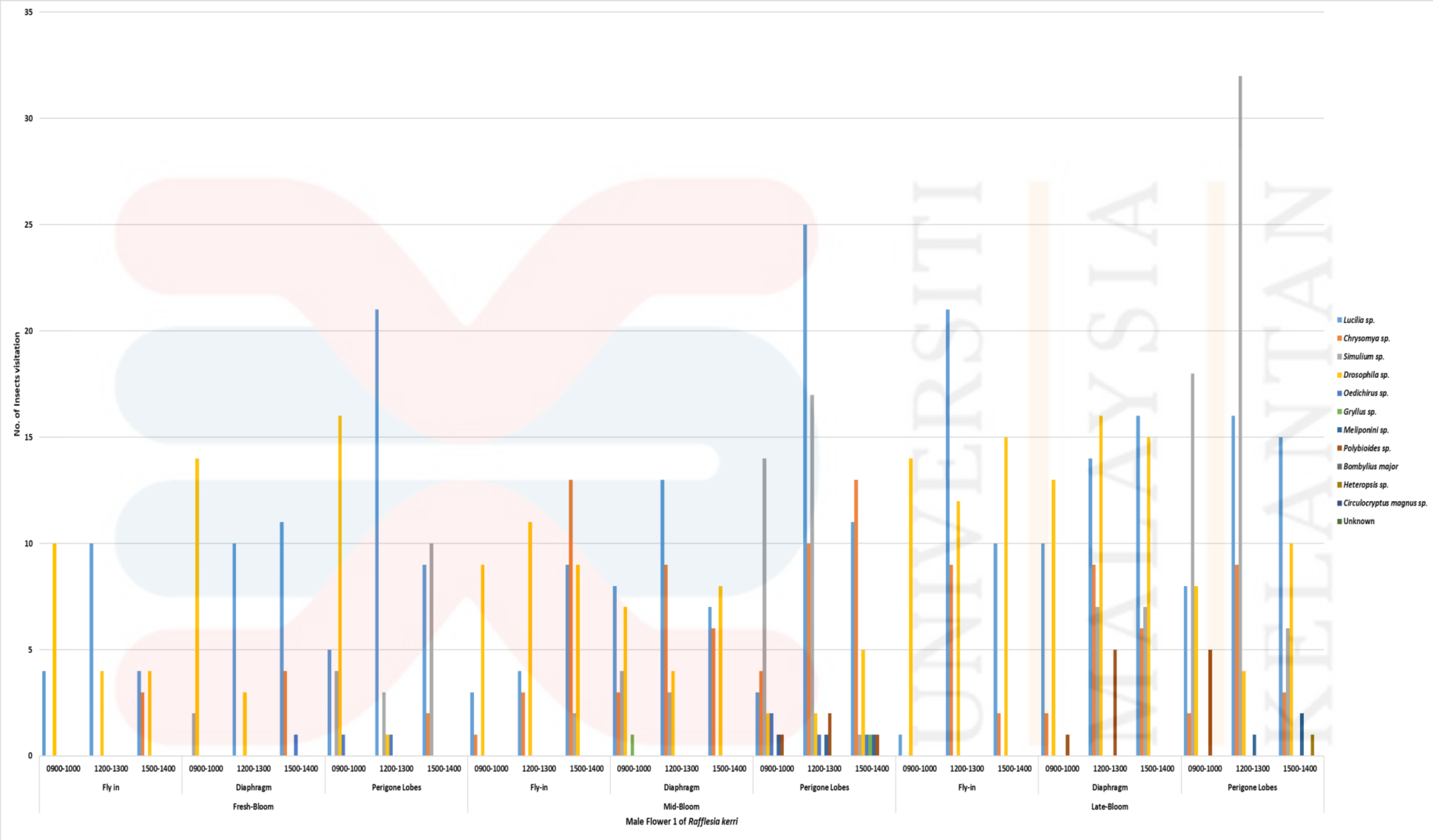
The result also shows that *Drosophila* sp. was the most frequent visitor, accounting for 51.30% of all visits, followed by *Lucilia* sp. (22.53%) and *Simulium* sp. (20.39%). However, for pollinators, *Lucilia* sp. and *Chrysomya* sp. were recorded at 22.53% and 8.04% respectively. As shown in Figure 4.3.2, *Lucilia* sp. is the dominant visitor for male Flower 1. Meanwhile, *Drosophila* sp. is the most dominant visitor for both male Flowers 2 and 3.

Figure 4.3.2 Total Number of Pollinators and Visitors of Three Male Flowers of *Rafflesia kerri*.



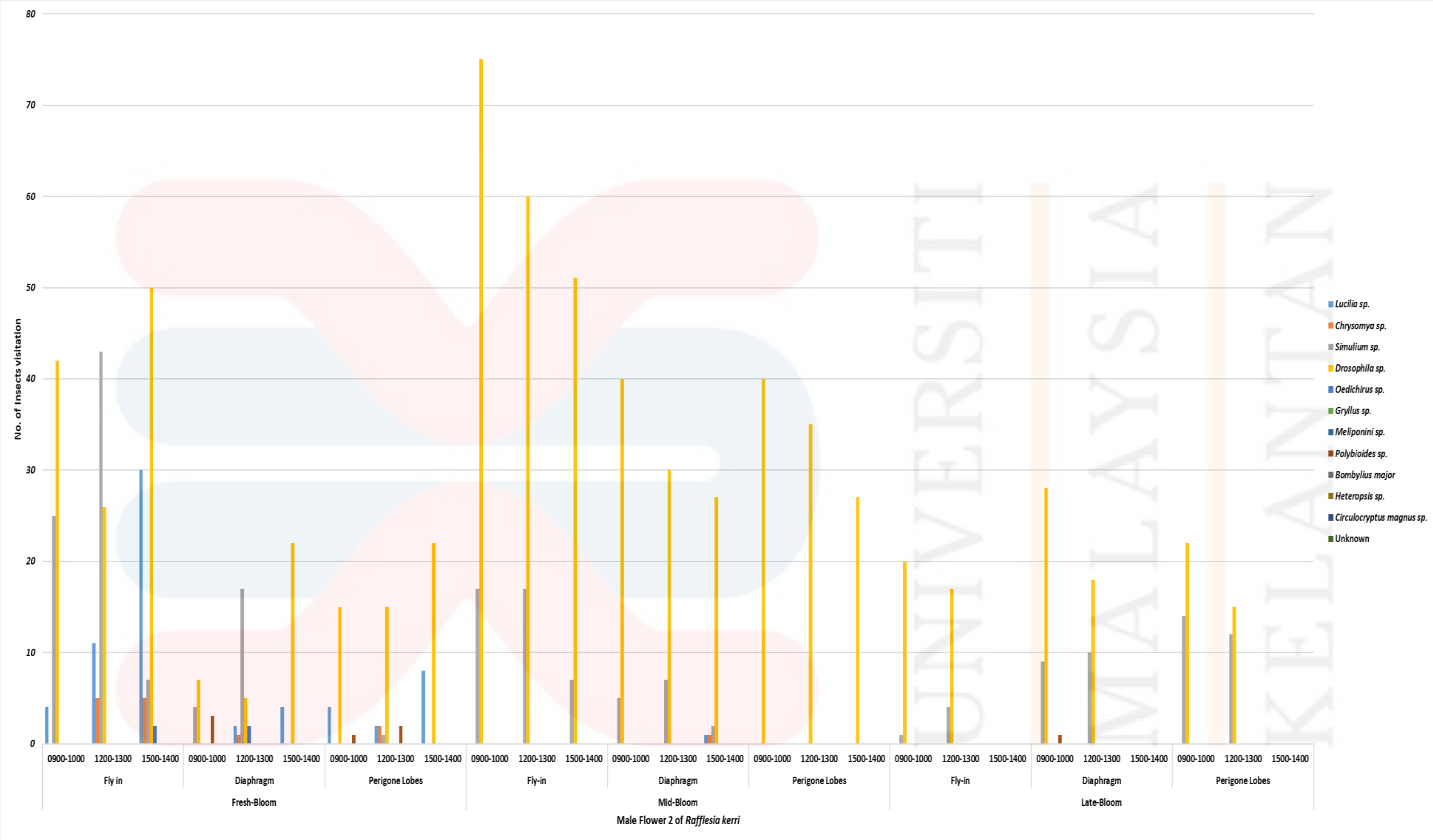
The abundance of pollinators and visitors is varied for each male flower. In male Flower 1, pollinators and visitors were highly observed during the late-bloom stage, this is because, in the late-bloom stage, the flower was infected by the fungus which is spotted at the end of the perigone lobe. This condition can attract visitors such as the *Drosophila* sp. that act as decomposing agents, followed by the mid-bloom and fresh-bloom stages with, a total number of 345, 256 and 157 pollinators and visitors respectively. Precisely, the perigone lobes were the area with a high number of pollinators and visitors recorded for the overall blooming stages. A total of 268 and 113 visits were recorded for both pollinators, *Lucilia* sp. and *Chrysomya* sp. throughout the blooming stages of the male flower 1 of *R. kerri* as illustrated in Figure 4.3.3. For the visitor's category, *Drosophila* sp. shows the highest frequency because *Drosophila* sp. is attracted by the flower odor and visiting the male flower 1, followed by *Simulium* sp. with a total number of 216 and 130 respectively.

Figure 4.3.3 Total Number of Pollinators and Visitors of Male Flower 1 of *Rafflesia kerri* Throughout Its Blooming Stage



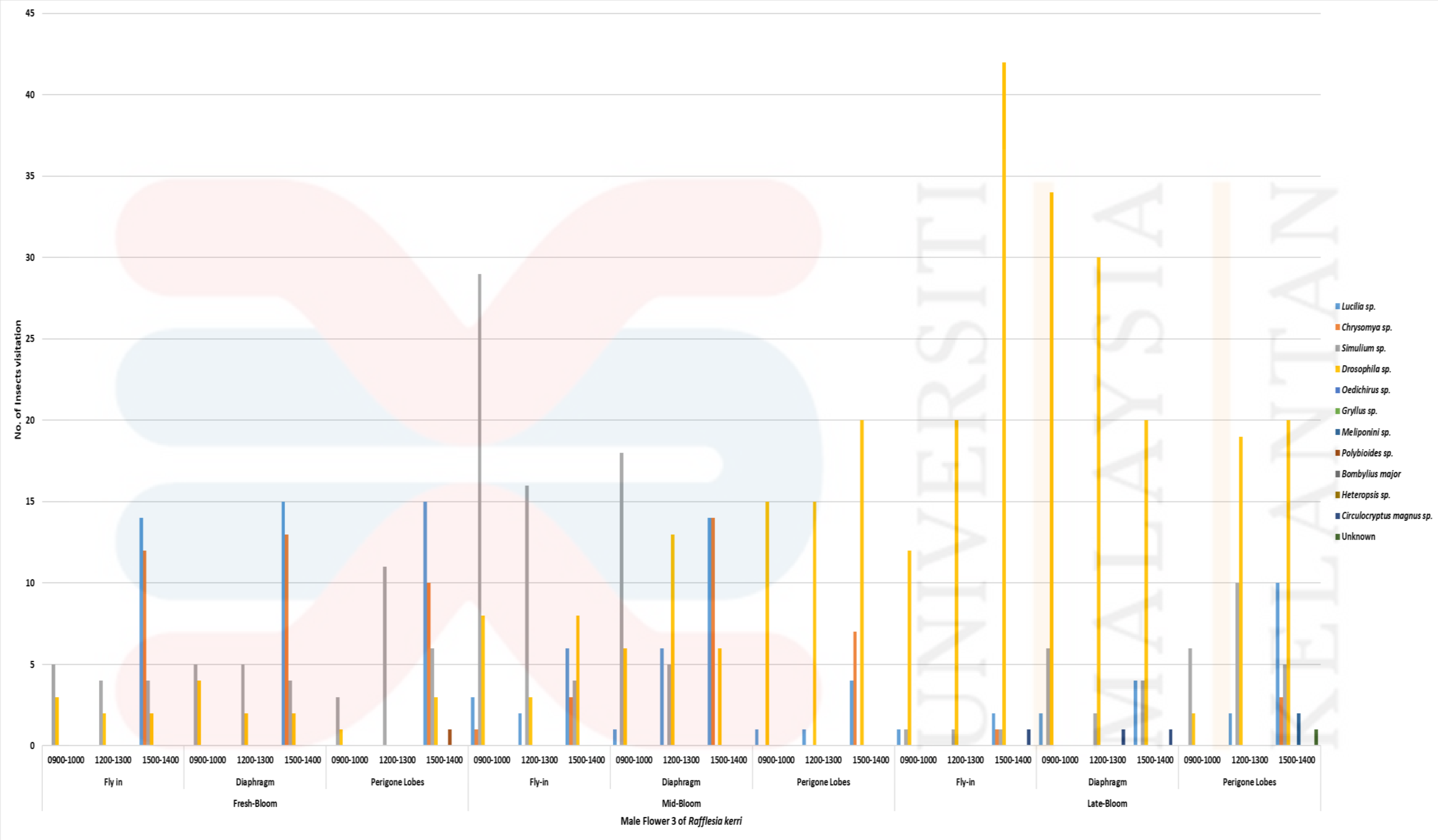
From the study, the Male Flower 2 of *R. kerri* shows an abundance of pollinators and visitors during the mid-blooming stage (442 visits), followed by fresh-bloom (389 visits) and late-bloom (171 visits) as indicated in Figure 4.3.4. This is because Flower 2 is affected by the fungus while in bud condition until the blooming period and the decaying process is started. The highest number of pollinators and visitors was recorded flying into the flower, followed by landing and crawling on the diaphragm and exploring the surrounding perigone lobes. In detail, both pollinators, *Lucilia* sp. and *Chrysomya* sp. recorded a total number of 66 and 14 individuals counted respectively. Meanwhile, *Drosophila* sp. shows the highest visiting frequency to the male flower 2, followed by *Simulium* sp. with a total number of 709 and 202 individuals counted respectively.

Figure 4.3.4 Total Number of Pollinators and Visitors of Male Flower 2 of *Rafflesia kerri* Throughout Its Blooming Stage



Likewise, the pollinators and visitors were vastly observed during the late-blooming stage of male Flower 3, ahead of its mid-bloom and fresh-bloom, with a total number of 266, 229 and 146 pollinators and visitors respectively. As illustrated in Figure 4.3.5, pollinators and visitors dominantly visited the diaphragm, followed by counted pollinators and visitors flying in and exploring the perigone lobes, with a total number of 237, 211 and 193 pollinators and visitors respectively. Thoroughly, *Lucilia* sp. and *Chrysomya* sp. contributed a total of 103 and 64 pollinators counted. *Drosophila* sp. was recorded as the highest number of visitors for the male Flower 3 with 312 total visitors, followed by *Simulium* sp. which recorded a total number of 155 visitors individually. Overall, *Drosophila* sp. was the dominant visitor for the male Flower 3 of *R. kerri*.

Figure 4.3.5 Total Number of Pollinators and Visitors of Male Flower 3 of *Rafflesia kerri* Throughout Its Blooming Stage



During observed visits, pollinators were observed engaging in sapromyophily syndrome behavior, suggesting a commensalism relationship between *R. kerri* and its pollinators, since its pollinators find no reward during exploration of the flower, whilst the pollen from male *R. kerri* could be transported by pollinators as the pollen stick on the upper thorax of the pollinator during exploration of the flower. The results also revealed the variation in visitation behavior between pollinators and visitors. Despite the presence of the pollen on the insects as the distinction sign between pollinators and visitors, visitation duration was varied between pollinators and visitors. *Lucilia* sp. and *Chrysomya* sp. exhibited longer visit duration as compared to other visitor species. This study finding aligns with previous studies on *R. kerri* pollination by Hor et al. (2021), highlighting the importance of *Lucilia* sp. and *Chrysomya* sp. as the main pollinators.

Understanding the frequency and behavior of pollinators and visitors of the *R. kerri* is crucial for conservation efforts aimed at protecting *Rafflesia kerri* populations and their associated ecosystems at *Rafflesia* Conservation Park, Lojing Highlands of Kelantan, Peninsular Malaysia. The study also emphasized the importance of maintaining habitat quality and preserving pollinator diversity to ensure the long-term survival of *Rafflesia* species.

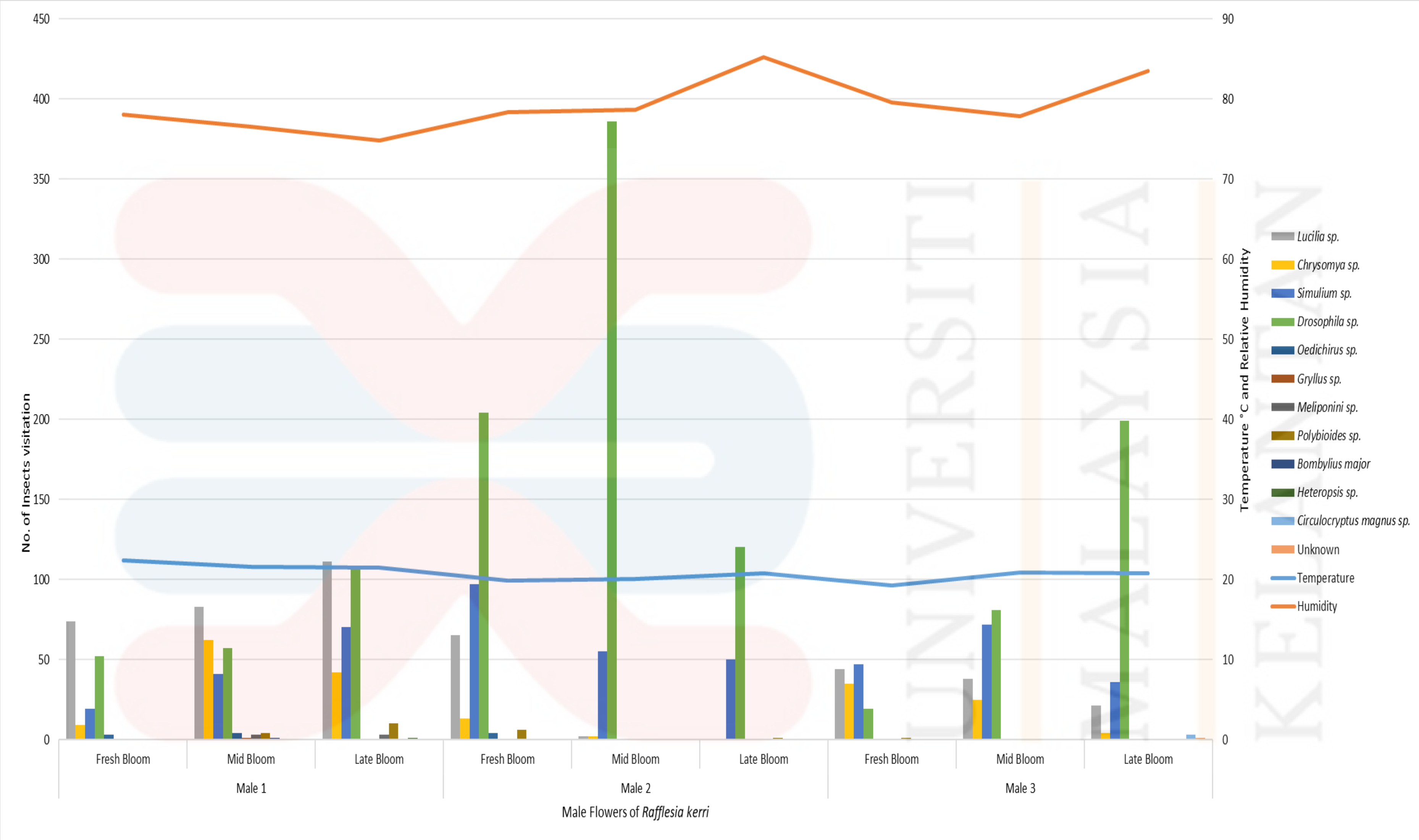
4.4 The Impacts of Humidity and Temperature on Pollinators and Visitors Activities of *Rafflesia kerri*

Humidity and temperature play a significant impact on the activities of pollinators and visitors of the *R. kerri* male flower. High relative humidity will affect the activities of the pollinators and visitors, due to high water vapors on the air surrounding environment. In this study, the relative humidity of more than above 80% will impact the frequency of pollinators and visitors to male flowers shown in Figure 4.4. High relative humidity during the late-bloom of the male Flower 2 and late-bloom male Flower 3 with relative humidity 85.23% and 83.53%, attracted a total number of 171 and 264 pollinators and visitors respectively. Despite the altitude factor, weather such as rain could also affect the relative humidity of the area. In this case, the weather during the late bloom of the male Flower 3, was rainy. This condition affects the abundance of pollinators and visitors to the male Flower 3. Some insects may exhibit behavioral adaptations in response to humidity. As illustrated in Figure 4.4, *Drosophila* sp. and *Simulium* sp. show its presence although the humidity is high during the late-bloom male Flower 3.

Temperature, on the other hand also influences the metabolic rates of pollinators and visitors, affecting their activity levels. Moderate temperatures within the preferred range can stimulate foraging behavior, leading to increased visitation rates to *Rafflesia* flowers (Banziger, 1991). In this study, the temperature range 19.00°C to 22.35°C shows optimal foraging conditions for pollinators and visitors of *R. kerri*. Moreover, the temperature can impact the physiology of the *Rafflesia* flower (Banziger, 1991). Optimal temperatures may enhance the release of volatile compounds responsible for attracting pollinators and visitors, making flowers more enticing to potential visitors. Strong odoriferous items help slow down pollinators and visitors to leave the flower (Banziger, 1991).

Consequently, visitation rates were positively correlated with humidity and temperature, with peak activity observed on warmer days as illustrated in the case of the male Flower 1 as shown in Figure 4.4. Hor et al. (2021) stated that high temperature was believed to be the factor in the volatile compound of the flower was expressed and released to the surrounding atmosphere to attract pollinators and visitors. Meanwhile, rainfall events were associated with a temporary decrease in pollinator and visitor activity, indicating a potential impact of weather conditions on visitation patterns. Rainfall events increase the humidity level, which makes the movements of pollinators and visitors challenging. Moreover, temperatures with high humidity during rainfall events were decreased, which slowed down the process of releasing a volatile compound from the flower to the atmosphere. Additionally, released volatile compounds were trapped in the water vapor during the rainfall and fell along with the rain.

Figure 4.4 Effect of Humidity and Temperature on Abundance of Pollinators and Visitors of The Three Male Flowers of *Rafflesia kerri*



4.5 The Impact of the Time Period on the Abundance of Pollinators and Visitors of *Rafflesia kerri*

Other than relative humidity and temperature, the abundance of pollinators and visitors is also influenced by the period of time. In this study, the frequency of pollinators and visitors was observed for three periods of time; 0900 - 1000, 1200 – 1300 and 1500 - 1600. Overall pollinators and visitors' activity varied throughout the day, with peak visitation observed during the late morning and early afternoon for male Flower 1, late morning and late afternoon for the male Flower 2 and late afternoon for the male Flower 3. The observation throughout the study was varied due to location and influenced by the condition of the flower itself. Among the visitors, *Drosophila* sp. accounted for the majority of visits, comprising 51.3% of total visitation, followed by *Lucilia* sp. and *Simulium* sp. with 22.53% and 20.39% of visitation respectively.

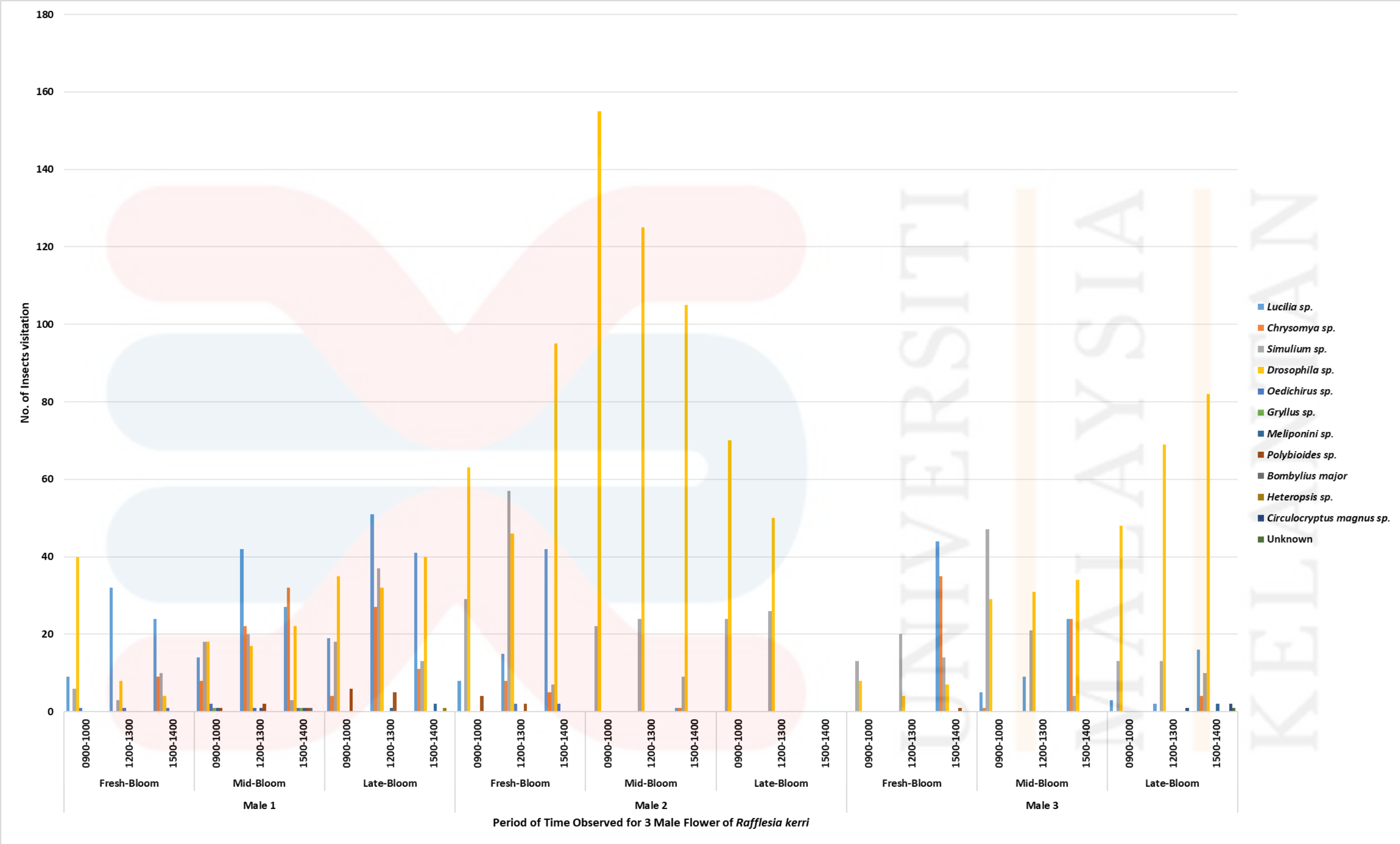
From the observation of the male Flower 1, during the fresh-bloom stage flower, the peak visitation was observed during late morning (0900 - 1000), with a total of 56 pollinators and visitors. However, during the mid-blooming and late-blooming stages, the peak visitation was observed during the early afternoon (1200 - 1300) with a total of 105 and 153 pollinators and visitors. Among the observed visitation along the blooming stage, pollinator, *Lucilia* sp. shows an increasing in trend, with peak visitation in the early afternoon. Meanwhile, *Chrysomya* sp. shows an uneven visitation trend, where during fresh-bloom, it was only present during the late afternoon, while the increased number of visitations from morning to late afternoon during mid-bloom, but during the late-bloom stage, the peak visitation was observed in the early afternoon.

The male Flower 2 of *R. kerri* recorded peak visitation in the late afternoon during fresh-bloom stages but changed its visitation trend to late morning for both mid-blooming and late-blooming stages. These changes were observed during the early phase of mid-blooming of the male Flower 2. The rapture that occurs to the male Flower 2 during the early mid-blooming stage causes the data observed to be uneven. The rapture also caused the male Flower 2 disable to bloom perfectly as shown in Figure 4.1. Rains and high humidity during mid-blooming and late-blooming significantly affect the data collection and pollinator's and visitor's visitation activities. Among pollinators, *Lucilia* sp. shows an increased visitation trend in the fresh-blooming stage from morning to late afternoon as illustrated in Figure 4.5.

On the other hand, peak visitation was observed during the late afternoon for all three blooming stages of the male Flower 3, with a total of 101, 86 and 117 visitations respectively. Among the observed pollinators and visitors, *Drosophila* sp. was evaluated for the most visits, comprising 48.67% of visitation, followed by *Simulium* sp., *Lucilia* sp. and *Chrysomya* sp. with 24.18%, 16.07 and 9.08% of total visitation of male Flower 3. Both pollinators; *Lucilia* sp. and *Chrysomya* sp. show ascending visiting trends alongside the blooming stages and period of time of the male Flower 3.

During daylight, temperature and penetration of light were optimized. High temperatures allow male flowers to release their volatile compound that attracts pollinators and visitors. The strong odor was released as the primary attractant presumably offering food as a reward to the insects (Beaman 1988). Furthermore, pollinators and visitor's activity exhibited diurnal fluctuations, which increased visitation rates observed during daylight hours. From the observation also, this study can conclude that visitation rates were highest during the mid-blooming flower, where the pattern gradually increased from the fresh-blooming, peak visitation during the mid-blooming stage and constantly declined as the flowering period progressed (late-blooming stages).

Figure 4.5 The Total Number of Pollinators and Visitors of Three Male Flowers of *Rafflesia kerri* Based on Time Period of Observation



CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The important findings that have been found from the study that has been conducted are concluded as shown below:

(i) Three male flowers of *R. kerri* were observed throughout their blooming stages. The first flower was located near a rock and a small stream, the second near a tree's buttress root and infected by fungus, and the third on a slope. Observations included flower diameter, color, odor, and insect activities, highlighting the variation in conditions and challenges faced by each flower

(ii) A total of 13 insect species visited the flowers, with *Lucilia* sp. and *Chrysomya* sp. identified as potential pollinators due to the presence of pollen on their bodies. The other visitors included such as *Simulium*, *Drosophila* sp., *Copestylum* sp., *Oedichirus* sp., *Gryllus* sp., *Meliponini* sp., *Polybiodes*, *Bombylius* sp., *Heteropsis* sp. and *Ciculocryptus magnus* sp. This diversity underscores the complex interactions between the flower and various insect species.

(iii) The study recorded 2,387 visits by pollinators and visitors to the three male flowers. Flower 2 had the highest number of visits, likely due to its mid-blooming stage being the most attractive. *Drosophila* sp. was the most frequent visitor, while *Lucilia* sp. and *Chrysomya* sp. were the main pollinators. The observations showed a correlation between blooming stages and visitation frequency, with environmental conditions playing a crucial role.

(iv) The abundance of pollinators and visitors was influenced by the relative humidity and temperature significantly impacted pollinator and visitor activities towards the three male flowers blooming of *R. kerri*. High humidity levels were found to reduce pollinator activity, while optimal temperatures (19°C to 22.35°C) facilitated increased visitation rates. This finding is critical for understanding the ecological requirements for effective pollination and conservation efforts.

(v) The average time of active pollinators and visitor activity was from 1200 to 1300. The distribution of frequency of pollinators and visitors was increased gradually in line with the blooming stages of the male flower of *R. kerri*. The time of day also influenced the abundance of pollinators and visitors. Peak visitation times varied, with late morning and early afternoon being the most active periods. This temporal pattern highlights the need for targeted conservation efforts during these critical times to ensure effective pollination.

5.2 Recommendation

The study of pollinators and their activity concerning *Rafflesia kerri* Meijer is critical for guiding future research efforts and conservation strategies aimed at preserving both plant and pollinator communities. Despite the existing research, several aspects still require further attention to develop a more comprehensive understanding of this unique species. Future works recommended for this study are as shown below:

(i) Extending the duration of studies on *R. kerri* and its pollinators is essential for collecting comprehensive data over multiple seasons and varying environmental conditions. This long-term approach provides a deeper understanding of pollinator behavior, plant-pollinator interactions, and ecological dynamics. To implement this, researchers should increase the duration of field surveys and monitoring programs to cover multiple flowering seasons. Longitudinal studies should be conducted to observe changes in pollinator activity and plant health over time. Continuous data collection will help capture variations in pollinator presence and activity patterns, providing valuable insights for conservation efforts.

(ii) High-quality images and videos are crucial for accurately identifying pollinators and understanding their interactions with *R. kerri* flowers. Utilizing macro cameras can provide detailed visual data that is essential for taxonomic and behavioral studies. Researchers should employ high-resolution macro cameras to capture detailed images and videos of pollinators in action. Automated camera traps can be set up at strategic locations to continuously monitor pollinator activity. The visual data obtained can be used for species identification, behavior analysis, and documentation of pollination events, thereby enhancing the accuracy and depth of the study

(iii) Weather conditions have a significant impact on pollinator activity and plant-pollinator interactions. Monitoring and recording weather data can help correlate environmental factors with pollinator behavior and flower blooming periods. Researchers should install weather monitoring equipment at study sites to record temperature, humidity, rainfall, and wind patterns. Analyzing the impact of these weather conditions on the timing and success of pollination events will provide valuable insights. Additionally, field study schedules and methodologies can be adjusted based on weather forecasts to optimize data collection and ensure the accuracy of the study.

(iv) Effective observation and capture techniques are crucial for studying pollinators. Accurate data on pollinator species, abundance, and behavior can be obtained through systematic and humane capture methods. Researchers should use a combination of direct observation, netting, and trapping techniques to capture pollinators. Gentle and non-lethal capture methods, such as malaise traps should be employed to minimize harm to pollinators. Observational tools, such as binoculars and video recording equipment, can be used to document pollinator behavior without disturbing their natural activities.

REFERENCES

Abdul Wahab, N. A., Talip, N. and Adam, J. H. (2018). American Inst. of Physics 1940 020044.

Adam, J. H., Aizat-Juhari, M. A., Ariff, N. N.-F. N., Khamis, S., Yasin, M. H. M., and Wan, K.-L. (2022). *Rafflesia tunku-azizahiae* (Rafflesiaceae), a New Species from Pahang, Malaysia. *Sains Malaysiana*, 51(11), 3843–3855.

Ahmad Puad, A. S., Wan Zakaria, W. N. F., Geri, C. Zainudin, R. and Latiff, A. 2020. Notes on *Rafflesia hasseltii* Suring. (Rafflesiaceae), a new record for Sarawak, Malaysia. Malayan Nature Journal 72(1): 19-25.

Akhriadi P, HA. Kiswanto, A. Taufiq, D. Alfajri and R. Kadirman (2021). Assessment of Conservation Status of *Rafflesia* in West Sumatra, Indonesia. Padang: *Rafflesia* Monitoring Team [RMT] Padang.

Asfarina, I., Siti-Munirah, M. Y., Susatya, A., Norhazlini, M. Z., and Zulhazman, H. (2022). Examining the Anatomical Characteristics of *Rafflesia kerri* in Lojing Highlands, Peninsular Malaysia. IOP Conference Series: Earth and Environmental Science, 1102(1).

Banzinger, H. (1991). Stench and fragrance: unique pollination lure of Thailand's largest flower, *Rafflesia kerri Meijer*. Natural History Bulletin of Siam Society 39: 19-52.

Banzinger, H. (2004). Studies on hitherto unknown fruits and seeds of some Rafflesiaceae, and a method to manually pollinate their flowers for research and conservation. Linzer Biology Beitr. 36(2): 1175-1198.

Barcelona, J.F.; P.B Pelser; D.S. Balete; L.L. Co (October 2009). "Taxonomy, ecology, and conservation status of Philippine *Rafflesia* (Rafflesiaceae)". Blumea. 54: 77–94

Beaman R. S., Decker P. J., and Beaman J.H., (1988). *American J. of Botany*. 75:1148-1162.

Blume CL. (1991). Bijdragen tot de flora van Nederlandsch Indie: Batavia: Ter Lands Drukkerij,1825-1826.; 1825

Britannica, T. Editors of Encyclopaedia (2017). Rafflesiaceae. Encyclopedia Britannica. https://www.britannica.com/plant/Rafflesiaceae

Davis, C. C., Endress, P. K., and Baum, D. A. (2008). The evolution of floral gigantism. In Current Opinion in Plant Biology 11(1):49–57

Fauzan, M. et al., (2021). Managing and protecting endangered *Rafflesia* species in Kelantan, Peninsular Malaysia. IOP Conference Series: Earth and Environmental Science, 842(1).

Hor P. L., Norhazlini M. Z., Suhaimi O., and Zulhazman H., (2021). Diurnal insect pollinators of *Rafflesia kerri* Meijer at Lojing Highlands, Kelantan, Peninsular Malaysia. Malaysian Forester 84: 7-15 8.

Hsuan K. (1978). Orders and Families of Malayan Seed Plants (revised ed.). Singapore: Singapore University Press (originally published by University of Malaya Press 1969). p.106.

Jubil M. (1984) Kajian ekologi dan taksonomi *Rafflesia* di Sabah [Unpublished undergraduate thesis], Jabatan Biologi, Universiti Kebangsaan Malaysia Kampus Sabah, Kota Kinabalu. 1984

Kedri, F. K, Zulhazman H., Sayzwani Sukri, N., Hajar Yaacob, S., Kyariatul Syafinie Abd Majid, N., Mokhtar, N., and Fatimah Amir, S. (2018). Distribution and ecology of *Rafflesia* in Royal Belum State Park, Perak, Malaysia. In International Journal of Engineering and Technology. 7(2.29): 292-296.

Latiff, A. and Wong, M. (2003). A new species of *Rafflesia* from Peninsular Malaysia. Folia Malaysiana 4(3&4): 135-146

Malabrigo, P., Tobias, A. B., Witono, J., Mursidawati, S., Susatya, A., Siti-Munirah, M. Y., Wicaksono, A., Raihandhany, R., Edwards, S., and Thorogood, C. J. (2023). Most of the world's largest flowers (genus *Rafflesia*) are now on the brink of extinction. Plants People Planet. 2023:1-16.

Mat-Salleh, K. and Latiff, A. (1989). A new species of *Rafflesia* and other species from Trus Madi Range, Sabah (Borneo). Blumea 34: 111-116.

Meijer W., (1997)."Rafflesiaceae".Flora Malesiana. Vol.13. Leiden: Hortus Botanicus Leiden, under auspices of Foundation Flora Malesiana. pp.1–42. ISBN 90-71236-33-1.

Nais J. (2001). *Rafflesia* of the world. First Edition ed. Malaysia: Natural History Publications. 243 pp.

Nais J, Wilcock CC. The *Rafflesia* conservation incentive scheme in Sabah, Malaysia, Borneo. Sabah Parks Nature Journal 1998; 1:9-17.

Norhazlini M. Z., Mailina J., Shalini M., Nor-Azah M. A., and Zulhazman H., (2020) Assessing the floral volatile constituents of male and female *Rafflesia kerri* Meijer from Lojing Highlands, Peninsular Malaysia *IOP Conf. Ser.: Earth Environ. Sci.* 549 012068

Norhazlini. M. Z, Jamil, M., Markandan, S., Mohamad Ali, N. A., and Zulhazman H., (2020). Assessing the Floral Volatile Constituents of Male and Female *Rafflesia Kerri* Meijer from Lojing Highlands, Peninsular Malaysia. IOP Conference Series: Earth and Environmental Science, 549(1).

Norhazlini M.Z., Latiff A., Farah K. K., Nasihah M., Siti-Munirah M.Y., and Zulhazman, H. (2021). A review of species diversity of *Rafflesia* in Malaysia. *Malayan Nature Journal* 2021, 73 (4), 531-552

Nur Hidayati, S., and Walck, J. L. (2016). A Review of The Biology of *Rafflesia*. What Do We Know and What's Next? Review Biologi *Rafflesia*: Apa yang sudah kita ketahui dan bagaimana selanjutnya? Buletin Kebun Raya, 19(2), 67–78.

Patino S., Aalto T., Edwards A. A., and Grace J., (2002). *New Phytologist.* 154: 429-437.

Shaw J. (2017). "Colossal Blossom: Pursuing the peculiar genetics of a parasitic plant". *Harvard Magazine*. https://www.harvardmagazine.com/2017/02/colossal-blossom

Sofiyanti, N., Mat-Salleh, K., Mahmud, K., Mazlan, N.Z., Hasein, M. R. and Burslem, D. F. (2016). *Rafflesia parvimaculata* (Rafflesiaceae), a new species of *Rafflesia* from Peninsular Malaysia. Phytotaxa 253(3): 207-21.

Susatya, A. (2020). The growth of flower buds, life history, and population structure of *Rafflesia arnoldii* (Rafflesiaceae) in Bengkulu, Sumatra, Indonesia. Biodiversitas, 21(2), 792–798.

Wan Zakaria, W. N. F., Ahmad Puad, A. S., Geri, C., Zainudin, R., and Latiff, A. (2016). *Tetrastigma diepenhorstii* (Miq.) Latiff (Vitaceae), a New Host of *Rafflesia tuan-mudae* Becc. (Rafflesiaceae) in Borneo. Journal of Botany, 2016. 3952323: 1-6

Wee, S. L., Tan, S. B., and Jürgens, A. (2018). Pollinator specialization in the enigmatic *Rafflesia cantleyi*: A true carrion flower with species-specific and sex-biased blow fly pollinators. Phytochemistry, 153, 120–128.

Wong M, Latiff A. (1994). *Rafflesia* of Peninsular Malaysia. Nature Malaysian ;19[3]:84-8.

Zulhazman, H., Maryati, M., Cornelius, P. and Mohd-Mahmud, M. 2010. Spatial Distribution and Conservation of *Rafflesia kerri* in Lojing Highlands, Kelantan. In: Ibrahim Che Omar and Zulhazman Hamzah. Conserving Lojing Highlands for Sustainable Development. Penerbit UMK, Pp. 44-54.

Zulhazman, H., Maryati, M., Cornelius, P. and Mohd-Mahmud, M. (2010). Spatial Distribution and Conservation of *Rafflesia kerri* in Lojing Highlands, Kelantan. In: Ibrahim Che Omar and Zulhazman Hamzah. Conserving Lojing Highlands for Sustainable Development. Penerbit UMK, Pp. 44-54.

Zulhazman Hamzah. 2012. Assessing and mapping of *Rafflesia* distribution hotspots for nature conservation in Kelantan, Malaysia. Proceedings of the 3rd International Seminar on Regional Network on Poverty Eradication (RENPER), 15 – 17 Oct. 2012, Universitas Bengkulu, Indonesia. 9p.

APPENDIX

Raw Data of Pollinators and Visitors of Male *Rafflesia kerri* 1

Pollinator and Visitor Abundance (Male 1 Day 1)- Fresh Bloom Stage										
Species	**Fly-in**			**Diaphragm**			**Petal**			**Total**
	9.00-10.00	**12.00-1.00**	**3.00-4.00**	**9.00-10.00**	**12.00-1.00**	**3.00-4.00**	**9.00-10.00**	**12.00-1.00**	**3.00-4.00**	
Bluebottle fly	**4**	**10**	**4**	**0**	**10**	**11**	**5**	**21**	**9**	**74**
Greenbottle fly	**0**	**0**	**3**	**0**	**0**	**4**	**0**	**0**	**2**	**9**
Black fly	**0**	**0**	**0**	**2**	**0**	**0**	**4**	**3**	**10**	**19**
Red head fly	**10**	**4**	**4**	**14**	**3**	**0**	**16**	**1**	**0**	**52**
Charlie	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**0**	**3**

Pollinator and Visitor Abundance (Male 1 Day 2)- Mid Bloom Stage										
	Fly-in			Diaphragm			Petal			
Species	9.00 - 10.00	12.00-1.00	3.00 - 4.00	9.00 - 10.00	12.00 -1.00	3.00 - 4.00	9.00 - 10.00	12.00 -1.00	3.00 - 4.00	Total
Bluebottle fly	3	4	9	8	13	7	3	25	11	83
Greenbottle fly	1	3	13	3	9	6	4	10	13	62
Black fly	0	0	2	4	3	0	14	17	1	41
Red head fly	9	11	9	7	4	8	2	2	5	57
Cricket	0	0	0	1	0	0	0	0	0	1
Charlie	0	0	0	0	0	0	2	1	1	4
Stingless bee	0	0	0	0	0	0	1	1	1	3
bee	0	0	0	0	0	0	1	2	1	4
Fluffy fly	0	0	0	0	0	0	0	0	1	1

Pollinator and Visitor Abundance (Male 1 Day 3)- Late Bloom Stage										
Species	Fly-in			Diaphragm			Petal			Total
	9.00-10.00	12.00-1.00	3.00-4.00	9.00-10.00	12.00-1.00	3.00-4.00	9.00-10.00	12.00-1.00	3.00-4.00	
Bluebottle fly	1	21	10	10	14	16	8	16	15	111
Greenbottle fly	0	9	2	2	9	6	2	9	3	42
Black fly	0	0	0	0	7	7	18	32	6	70
Red head fly	14	12	15	13	16	15	8	4	10	107
Bee	0	0	0	0	5	0	5	0	0	10
Stingless bee	0	0	0	0	0	0	0	1	2	3
Butterfly	0	0	0	0	0	0	0	0	1	1

Raw Data of Pollinators and Visitors of Male *Rafflesia kerri* 2

Pollinator and Visitor Abundance (Male 2 Day 1)- Fresh Bloom Stage										
Species	**Fly-in**			**Diaphragm**			**Petal**			**Total**
	9.00-10.00	**12.00-1.00**	**3.00-4.00**	**9.00-10.00**	**12.00-1.00**	**3.00-4.00**	**9.00-10.00**	**12.00-1.00**	**3.00-4.00**	
Bluebottle fly	**4**	**11**	**30**	**0**	**2**	**4**	**4**	**2**	**8**	**65**
Greenbottle fly	**0**	**5**	**5**	**0**	**1**	**0**	**0**	**2**	**0**	**13**
Black fly	**25**	**43**	**7**	**4**	**17**	**0**	**0**	**1**	**0**	**97**
Red head fly	**42**	**26**	**50**	**7**	**5**	**22**	**15**	**15**	**22**	**204**
Charlie	**0**	**0**	**2**	**0**	**2**	**0**	**0**	**0**	**0**	**4**
bee	**0**	**0**	**0**	**3**	**0**	**0**	**1**	**2**	**0**	**6**

Pollinator and Visitor Abundance (Male 2 Day 2)- Mid Bloom Stage										
Species	Fly-in			Diaphragm			Petal			Total
	9.00-10.00	12.00-1.00	3.00-4.00	9.00-10.00	12.00-1.00	3.00-4.00	9.00-10.00	12.00-1.00	3.00-4.00	
Bluebottle fly	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**2**
Greenbottle fly	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**2**
Black fly	**17**	**17**	**7**	**5**	**7**	**2**	**0**	**0**	**0**	**55**
Red head fly	**75**	**60**	**51**	**40**	**30**	**27**	**40**	**35**	**27**	**385**

Pollinator and Visitor Abundance (Male 2 Day 3)- Late Bloom Stage										
Species	Fly-in			Diaphragm			Petal			Total
	9.00-10.00	12.00-1.00	3.00-4.00	9.00-10.00	12.00-1.00	3.00-4.00	9.00-10.00	12.00-1.00	3.00-4.00	
Bluebottle fly	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Greenbottle fly	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Black fly	**1**	**4**	**0**	**9**	**10**	**0**	**14**	**12**	**0**	**50**
Red head fly	**20**	**17**	**0**	**28**	**18**	**0**	**22**	**15**	**0**	**120**
bee	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**1**

Raw Data of Pollinators and Visitors of Male *Rafflesia kerri* 3

Pollinator and Visitor Abundance (Male 3 Day 1)- Fresh Bloom Stage										
Species	**Fly-in**			**Diaphragm**			**Petal**			**Total**
	9.00-10.00	**12.00-1.00**	**3.00-4.00**	**9.00-10.00**	**12.00-1.00**	**3.00-4.00**	**9.00-10.00**	**12.00-1.00**	**3.00-4.00**	
Bluebottle fly	**0**	**0**	**14**	**0**	**0**	**15**	**0**	**0**	**15**	**44**
Greenbottle fly	**0**	**0**	**12**	**0**	**0**	**13**	**0**	**0**	**10**	**35**
Black fly	**5**	**4**	**4**	**5**	**5**	**4**	**3**	**11**	**6**	**47**
Red head fly	**3**	**2**	**2**	**4**	**2**	**2**	**1**	**0**	**3**	**19**
bee	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**

Pollinator and Visitor Abundance (Male 3 Day 2)- Mid Bloom Stage										
Species	**Fly-in**			**Diaphragm**			**Petal**			**Total**
	9.00-10.00	**12.00-1.00**	**3.00-4.00**	**9.00-10.00**	**12.00-1.00**	**3.00-4.00**	**9.00-10.00**	**12.00-1.00**	**3.00-4.00**	
Bluebottle fly	**3**	**2**	**6**	**1**	**6**	**14**	**1**	**1**	**4**	**38**
Greenbottle fly	**1**	**0**	**3**	**0**	**0**	**14**	**0**	**0**	**7**	**25**
Black fly	**29**	**16**	**4**	**18**	**5**	**0**	**0**	**0**	**0**	**72**
Red head fly	**8**	**3**	**8**	**6**	**13**	**6**	**2**	**15**	**20**	**81**

Pollinator and Visitor Abundance (Male 3 Day 3)- Late Bloom Stage										
Species	Fly-in			Diaphragm			Petal			Total
	9.00-10.00	12.00-1.00	3.00-4.00	9.00-10.00	12.00-1.00	3.00-4.00	9.00-10.00	12.00-1.00	3.00-4.00	
Bluebottle fly	1	0	2	2	0	4	0	2	10	21
Greenbottle fly	0	0	1	0	0	0	0	0	3	4
Black fly	1	1	1	6	2	4	6	10	5	36
Red head fly	12	20	42	34	30	20	2	19	20	199
unknown	0	0	0	0	0	0	0	0	1	1
ulat gonggok	0	0	1	0	1	1	0	0	0	3