ASSESSMENT ON THE STATUS OF POST BLOOM STAGES OF *Rafflesia kerri* Meijer IN LOJING HIGHLANDS, KELANTAN, PENINSULAR MALAYSIA

by

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A report submitted in fulfillment of the requirement for degree of Bachelor of Applied Science (Natural Resources Science) with Honors

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DECLARATION

I hereby declare that this thesis entitled 'Assessment on the Status of Post Bloom Stages of *Rafflesia kerri* Meijer in Lojing Highlands, Kelantan, Peninsular Malaysia' is the presentation of my original research work. Wherever contributions of others involved, every effort is made to indicate this clearly, with due reference to the literature and acknowledgement of collaborative research and discussions. I have faithfully and accurately cited all my sources including book, journal articles, books and unpublished manuscripts. The work embodied in this thesis has not been submitted for a higher degree to any other University and Institution.

Name : NURULAIN BT MOHD ZAWAWI

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Date : _____

APPROVAL

"I hereby declare that I/ we have read this thesis and in our opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Applied Science (Natural Resources) with Honors"

Signature : _____

Name of Supervisor I : _____

Date : _____

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LIST OF SYMBOLS

D	Density
N	Number of Population
A	Area
ha	Hectar
m^2	Metre square
˚C	Degree Celcius
˚	Degree for Latitude and Longitude
%	Percentage

LIST OF ABBREVIATION

Sp.	Species
UMK	Universiti Malaysia Kelantan
GPS	Global Positioning System
NGO	Non-Government Organization

Assessment on the Status of Post- bloom Stages of *Rafflesia kerri* Meijer in Lojing Highlands, Kelantan, Peninsular Malaysia

ABSTRACT

The existence of *Rafflesia* flower in Kelantan had initiated a lot of association of both non-government and government organization to take a step forward in conserving this unique species. However, no reinforcement had been taken for a while. *Rafflesia kerri* Meijer contribute into a lot of changes in terms of economic and development especially towards the local community of indigenous people in Lojing Highlands. This changes indicate the importance of conserving this unique plant. An observation on the assessment on the status of *Rafflesia kerri* Meijer in its post- bloom stages were investigated within the three ha plot in order to find out its population density. The method used is plot less sampling and the observation was conducted at Kg Jedip which the highest point of *Rafflesia* population. The ecological data were collected based on the observation on site. The elevation and coordinates of all flower (on post-bloom stages) were recorded as raw material for reference. Based on the number of flowers found, the population density of *R. kerri* flower in post- bloom stages within three ha plot can be estimated. The status of *Rafflesia kerri* Meijer in Lojing with its mortality rates can be identified. The longevity life cycle of *Rafflesia* can be guarantee well if its life cycle not disturbed in order to develop a perfect mature fruit seed for next germination. *R. kerri* life cycle did not end after its blooming phase.

Penilaian mengenai Status Tahap Pasca mekar *Rafflesia kerri* Meijer di Lojing Highlands, Kelantan, Semenanjung Malaysia

ABSTRAK

Kewujudan bunga R*afflesia* di Kelantan telah memulakan banyak persatuan daripada kedua-dua organisasi bukan kerajaan dan kerajaan untuk mengambil langkah maju dalam memelihara spesies unik ini. Walau bagaimanapun, tiada penguatkuasaan semula telah diambil untuk seketika. *Rafflesia kerri* Meijer menyumbang kepada banyak perubahan dari segi ekonomi dan pembangunan terutamanya ke arah masyarakat tempatan orang asli di Lojing Highlands. Perubahan ini menunjukkan kepentingan memelihara populasi tumbuhan unik ini. Pemerhatian mengenai penilaian *Rafflesia kerri* Meijer dalam peringkat pasca mekar telah diselidiki dalam plot tiga hektar untuk mengetahui kepadatan populasinya. Kaedah yang digunakan adalah plot kurang pensampelan dan pemerhatian dijalankan di Kg Jedip yang merupakan titik tertinggi penduduk Rafflesia. Data ekologi dikumpulkan berdasarkan pemerhatian di tapak. Ketinggian dan koordinat semua bunga (pada peringkat pasca mekar) telah direkodkan sebagai data untuk rujukan. Berdasarkan jumlah bunga yang didapati, kepadatan bilangan bunga *R. kerri* dalam peringkat pasca mekar dalam plot tiga ha boleh dianggarkan. Status *Rafflesia kerri* Meijer di Lojing dengan kadar kematiannya dapat dikenalpasti. Kepanjangan hidup jangka hayat *Rafflesia* dapat dijamin dengan baik jika kitar hayatnya tidak terganggu untuk menghasilkan benih buah matang yang sempurna untuk percambahan seterusnya. Kitar hidup *R. kerri* tidak berakhir selepas fasa mekarnya.

CHAPTER 1

1.0 INTRODUCTION

1.1 General Background of the Study

Malaysia is one of the country along with Thailand and Indonesia that is known to have or rich with variety of biodiversity in its tropical rainforest of Southeast East. Malaysia also committed to the sustainable management and its biological diversity (Anonymous, 2013a). That also include the wildlife and wild plants population at which this uniqueness had attract a lot of tourists and nature lovers from within the country and also abroad to experience the nature. Nowadays, *Rafflesia*, one of the rare species worldwide can also be found in Kota Kinabalu, Sabah. This gigantic flower (*Rafflesia*) being the main talk in community after first discovered in 1818 by Sir Stamford during his first journey (Brown, 1821).

Besides that, along with Sabah and Sarawak, a few states in Peninsular Malaysia are also included as one of the location whereas this species germinate. *Rafflesia* has the title of 'The Greatest Prodigy in Vegetable World', that produces the largest flower in angiosperms (Nikolov and Davis, 2017). There are seven species of *Rafflesia* that was found in Peninsular Malaysia alone (Farah *et al.*, 2018). These are *Rafflesia kerri, Rafflesia tengku-adlini, Rafflesia azlanii, Rafflesia sharifah-hapsahiae, R. parvimaculata, R. cantleyi* and *R. sumeiae*.

The distribution of *Rafflesia* only endemic to tropical rainforest in Southern Asia and Malaysia is one the blessed country with variety of biodiversity and rare

species (Azilah, Noraini and Jumaat, 2018). All *Rafflesia* species has several characteristics in common except the distribution of the warts that was completely differ from each other (Aalto *et al.,* 2002).

The present of *Rafflesia* in Borneo and Peninsular Malaysia initiate Malaysia to take a step forward on looking a big closure into conservation of the natural resources. Hence, for gaining or develop more knowledge and information on this unique species. *Rafflesia* is the best attraction for ecotourism in Malaysia (Tan *et al.,* 2010).

The issues regarding conservation of *R. kerri* should not be taken lightly. The bud need to survive in order to sustain the population of blooming flower along with the fruit seed as most of the premature buds of *R. kerri* was destroyed due to human activities. For example, trampling by the tourist who come to see the species or being cut off either for studies or used by indigenous people who populating in Lojing Highland. Then, overlapping, overweight, termites and unhealthy host are also the main reasons. The unhealthy host was caused by a lot of factors such as sedimentation, sensitivity to even small disturbance and others.

1.2 Problem Statement

R. kerri can be found in Lojing Highland, Peninsular Malaysia. This species has not met extinction yet but there was a population decline in some of other species of *Rafflesia*. Based on the observation on site, the population of *Rafflesia* has the potential to have a lot of fruit seed. Those area can be sealed as the buffer zone in order to protect the fruit seed from any physical damage that was not caused by nature behaviour. For example, human behaviour.

Hidayati (2016) state that *Rafflesia* population was decline were sometimes due or related to habitat disturbance and some of its causes were still unknown. There were also lack of information about its life cycle, biological or ecological information of *Rafflesia* since most of it comes from observations on the area selected and not from any experimental evidence. It is important to protect the *Rafflesia kerri* Meijer in order to sustain it for a long period of time and for future generation.

The survival of *Rafflesia* is getting more challenging in sustaining this population each year due to uncontrollable human movement into the Lojing without proper permission. Nowadays, Lojing Highland has a lot of development and some of it give affects to the environment nearby. As the first step towards Lojing as *Rafflesia* Conservation Area (RCA), one of the experts in *Rafflesia* from Universiti Malaysia Kelantan, Zulhazman Hamzah had proposed the idea to the Government of Kelantan of conserving this species under a joint venture with Universiti Malaysia Kelantan as main research. It will be under management of District Council of Gua Musang. However, there were no further enforcement was taken. This situation can lead into a very drastic decline of *Rafflesia* in future, especially in Lojing. The government may clarify the conservation areas at the Lojing as the 'buffer zone' in order to protect the

species. One of the best way was to keep it in the in situ conservation without disturbing its nature behaviour.

In general, Lojing forest has the potential to give hazard to human. It can cause a severe landslide due to agricultural activities. Most of the place are covered with the white canopies whereas the agricultural activities take place. The authority needs to do something on this area because this place will lose the potential to conserve the *Rafflesia* if no proper action was taken.

1.3 Objective of the Study

The objectives of this study are:

i. To determine the population density and the status of *Rafflesia kerri* Meijer in post bloom stages

ii. To study the post bloom stages of *Rafflesia kerri* Meijer

1.4 Scope of the Study

This research was conducted in Legup Cebur, Kg. Jedip in Lojing Highland and there were several limitation or scope that may be considered.

Significantly, the success in pollination will produce the mature fruit seed. It will undergoes a few stages from the cupule stage, bract stage, perigone stage, mature bud stage, pre-blooming stage, deterioration stage and lastly the mature fruit stage. The observation will take place for deterioration stage until mature fruit seed development whereas it start to decay after *R. kerri* blooming phase ended.

Furthermore, there were a few important parameters that might need to be considered. For example, the prime time of the blooming flower period. Depending on the situation, the plant (*Rafflesia kerri* Meijer) might not be blooming or rarely blooms since there were no clear schedule of their blooming time. Apart from its blooming period, the deterioration stage can be predicted as the blooming phase will show sign of rotting early in five days. It also depends on the weather condition either it is good or bad. During rainy season, it might be hard for the observation as the routes might be slippery and the fruit seed species (*Rafflesia kerri* Meijer) might be hard to be seen.

1.5 Significance of the Study

Rafflesia kerri Meijer has a unique structure as the biggest flower worldwide and its life cycle still being the 'secret' of nature of how it breeds. Thus, it gain a lot attention and many people try to research on this species. *Rafflesia* population displays a moderate genetic biodiversity as it do not show any evidence of pronounce breeding and appear to have low gene flow (Pelser *et al*, 2017).

This species germinates according to its natural behaviour and tissue culture was considered to be one of the method to sustain the population of *R. kerri* by the ex-situ conservation. Indonesia has proposed this method on *Rafflesia arnoldii* by Research Centre for Biology of Indonesian Institute of Science but it met failure when the explants stop to produce callus after two weeks of development (Sukamto and Mujiono, 2010).

The conservation of in-situ was the only way that can ensure the longevity of this species so that the flow of *Rafflesia* life cycle was not disturbed. The density of the abundance of *Rafflesia* flowers that are in deterioration stage and mature fruit seed stage (post blooming process) was calculated. It is important to make mature fruit seed will be formed according to its estimated time.

It was compulsory to ensure that this population keep on germinating once blooming until deterioration stage and forming the mature fruit seeds on the last stage in order to complete one life cycle. If this species can be conserved, there might not be any worries or conflict on the destruction of the bud and *Rafflesia* flower. Hence, *R. kerri* will always bloom without considering its limitations and it will give benefit both to country's economic, outside of the world and the research community.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 *Rafflesia kerri* Meijer

There were 10 species of *Rafflesia* discovered in Malaysia (Zulhazman, 2015). This unique flower is only available at 4 countries and only in Asian which are Malaysia, Indonesia, Philipines with Thailand and Thailand's country has one and only species which is *Rafflesia kerrii* Meijer unlike others that has more one than one species. It was found in the Southern of Thailand which its Thai local name is Bua Phut. Bua Phut is Thailand's largest flower with 70 cm in diameter.

R. kerri is the member of genus *Rafflesiaceae* and has the undistributed small warts that can be seen on its petals. It is a family of holoparasite flowering plant for being one of the world's largest flower after *Rafflesia arnoldii* which its diameter is in the range between 50cm to 90cm. The smallest *Rafflesia,* in average, among its genus is *Rafflesia verrucosa* that was found in Philipines (Balete *et al.*, 2010) It lives as a holoparasite plant depending entirely on a host plant known as Liana due to lack of root, stem and leaf (Rinrampai *et al.,* 2014). This species is still under strict conservation within the gazetted area and there are a lot of efforts that have been done in order to protect this species from being completely destroyed.

According to indigenous people, they believed that the decoction of flower buds from high boiling point is one of the traditional medicine that can be used to cure the female uterus after giving birth and for strengthening the inner energy for male.

The survival of *R. kerri* was threatened due to over-collection by the local people including its habitat destruction (Meijer and Elliott, 1990). Some of the indigenous people sold it since most of them still believes that *R. kerri* has medicinal value and till now the bud can be seen to be sold at a very cheap price to the locals itself at the market.

Hence, young flower buds and the flower of *Rafflesia hasseltii* Suringar, *Rafflesia kerri* Meijer and *Rafflesia cantleyi* Solms-Laubach used by the local in Malaysia and also in Indonesia for medicinal purposes as the traditional ethno medicine as wound healing agents (Wicaksono, Mursidawati and Sukamto *et al.*, 2016). Nevertheless, this statement is strongly against by one of the researchers at the National University of Malaysia under the department of Biosciences and Biotechnology, Dr. Nazlina Ibrahim.

This experiment was conducted on the female mice by using *Rafflesia azlanii*. Khairunnadwa, the master student under her supervision state that the liver of female mice was able to detoxify the ingredients from the bud of *Rafflesia azlanii* but this process will force the liver to shrink from its original size which can cause harm towards human body (Star Online, 2010). However, according to (Mahmood *et al*, 2009), by using another species which is *Rafflesia hasselti*, this genus was proved to be able increase the rate of wound healing process. It can be assumed that different species make different assumptions.

'Corpse' or 'bloody' flower (Figure 2.1) was one of the common name and famous among indigenous people due to its bad smell. 'Corpse' was also a common name for another stinking corpse lily, *Amorphophallus* sp. or known as titan arum. It also emits bad odour worse than *Rafflesia*. Hence, it also described as one of the

biggest species in the world recorded along with *Rafflesia* species and generally larger than *Rafflesia* but lighter and less dense (Rodgers, 2017). The smell emitted by *Rafflesia* attracts the flies to fly near the flower and crawling everywhere inside the chamber. The smell, colour, and the temperature of the flowers were meant to attract the pollinators and to ensure the continuation of the species (Bradfod, 2017). Based on observation, there were also other 'visitors' along with flies surrounding the flower such as mosquitoes. Mosquitoes can be seen near the chamber of the flower but it is not identified as the transfer agent but only as visitors.

Figure 2.1: 'Blood' from rotten flower of *Rafflesia kerri* Meijer

Image: ©Nurulain

2.2 The development of *Rafflesia kerri* Meijer

The *Rafflesia* is discovered by Raffles and Arnold in 1820 near Sumatra showing a remarkable diversity of about 10-12 species in the whole area of Malaysia including Sabah and Sarawak, by which one is still hidden in the forests of Kelantan (Meijer, 1991).

The success in pollination was not when the flower of *R. kerri* was blooming but when it reach the mature fruit seed stage which take a longer time. Small buds appear along the trunk and roots of the host (*R. kerri*) which was after between eight until nine months formed. Then, the petals will bloom one by one and produce the 'cracking' sound while opening before turning into the 'giant' flower. However, it will only last from 7 to 12 days before it dies. The emergence of flower bud can occur at any possible places include slope, hill or stone and any host of *Tetrastigma* sp. in forest. It will undergoes a few stages of development for flower budding until it reaches the mature bud (perigone stage).

Like other common species of flowers, the flower of *Rafflesia* is unisexual. The germination of the *Rafflesia* is still questionable but there were a lot of studies that had been carried out before in order for *Rafflesia* to have an effective reproduction. The flies were known for the role of transfer agent. It will transfer the pollen from male flower into the female flower.

The pollinators (flies) are very active during the daytime especially around 12.00 pm- 15.00 pm. Besides flies, there are also a high number of non-pollinators (mosquitoes or butterflies) that also attracted to *Rafflesia* due to its strong smell released from the perigone lobes. However, the non-pollinators do not perform any pollen transferring activity (Hor, 2015). Large flies are more effective in picking up the pollen from male flower as it has big surface area since the pollen is sticky and hard to attach on something (Reed, Pamla and John, 1988).

The distance between both male and female flower was estimated to be close and near to each other. It is blooming and widely opened at the same time. However, when or how both male and female flower blooming is still under observation since

there is no fixed evidence and suitable method to prove it. The pollen can be found under the disk at which the processes (spikes on central disk in *R. kerri* chamber) can be seen. Male flower has around 40 anthers with bristle on the lower part of the crest of the disk (Meijer, 1984). The space under the disk was really narrow and it was difficult to get the pollen with bare hands.

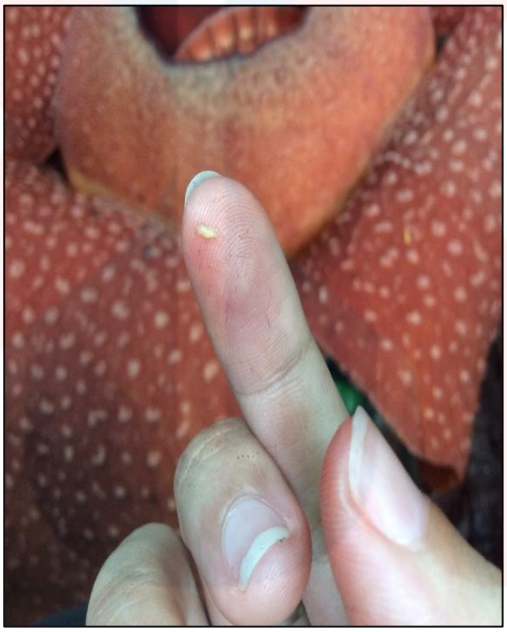


Figure 2.2: Pollen obtained from the anther of male flower

Image: ©Nurulain

After forming the mature fruit seed, the mammals such as squirrel or rat will act as pollinating agents of seed dispersal. The seed that they eat might be stuck on its fingers. The seed will be spread out as they move around and that is the reason on why *Rafflesia kerri* Meijer can be seen grown in between or middle of tree shrunk. Since the external layer is very hard, the trampling by big animals such as elephant can break it down and the seed will be dispersed while the animals walk around. The genus of the *Rafflesiaceae* has a diversity both of its ovules and seeds (Bouman and Meijer, 1994).

Depending on the season, *R. kerri*'s flower can be found blooming seasonally due to a few factors such as bad weather. *R. kerri* can be found more during dry season between January until March compared to wet season (Anonymous, 2017b). For example, from July until December, blooming flower of *R. kerri* is hard to be found and the number of bud population also decreases as it dies before reaching its mature bract stage. Hence, it will be hard to enter the Lojing during rainy season due to a few factors such as the slippery route, landslide, heavy rains, blocked routes and others that was dangerous.

Other flowers were small in size, produce nice smell, easy to be found, comes in many different shades of colours and its life cycle do not required a lot of time, However, *Rafflesia* was completely contrary. The reason on why *Rafflesia* was identified as flower is because of its five petals which was the only visible part of it that identical to other ordinary flower that also have petals. Hence, it was discovered as a plant like. It also can weigh up until 10kg and its diameter of one petal can reach to 20cm-30cm. Unlike other common flowering plants, it does not have any green leaves and roots (Suphuntee and Sangtongpraow, 2000).

The petals (perigone lobes) of female blooming flower will rot completely except in the middle of the flower that contain processes only which then turned into the fruit seed. The male flower will rot completely and that is how the male and female flower can be differentiated aside from its size. The flower that is big in size in considered as the female flower and the smaller flower is considered as the male. However, the shape and the size of *Rafflesia* does not vary significantly between male and female flower (Nikolov *et al.*, 2014). Then, it will develop into mature fruit seed that take times longer than two years in duration.

R. kerri is known as parasitic flowering plant and depending on its host as the roots. It is *Tetrastigma* sp. and it does not cause any damage to trees because *Rafflesia* takes a very long time as it required more than three years in order to complete one life cycle compared to its decay process which takes only seven to ten days for the flower to completely decay before forming mature fruit seed. It grows very slowly no matter how big the flower will be and sometimes this species will die before reaching the blooming stage. *Rafflesia kerri* Meijer being classified as endangered species under the IUCN (International Union for Conservation of Nature and Natural Resources) Red List of Threatened Plant in 1997(Anonymous, 2014c).

2.2.1 Life Cycle of *Rafflesia*

Figure 2.3 below shows the life cycle of *Rafflesia*. Meanwhile Figures 2.4 and 2.5 shows the development of buds and development of *Rafflesia*.

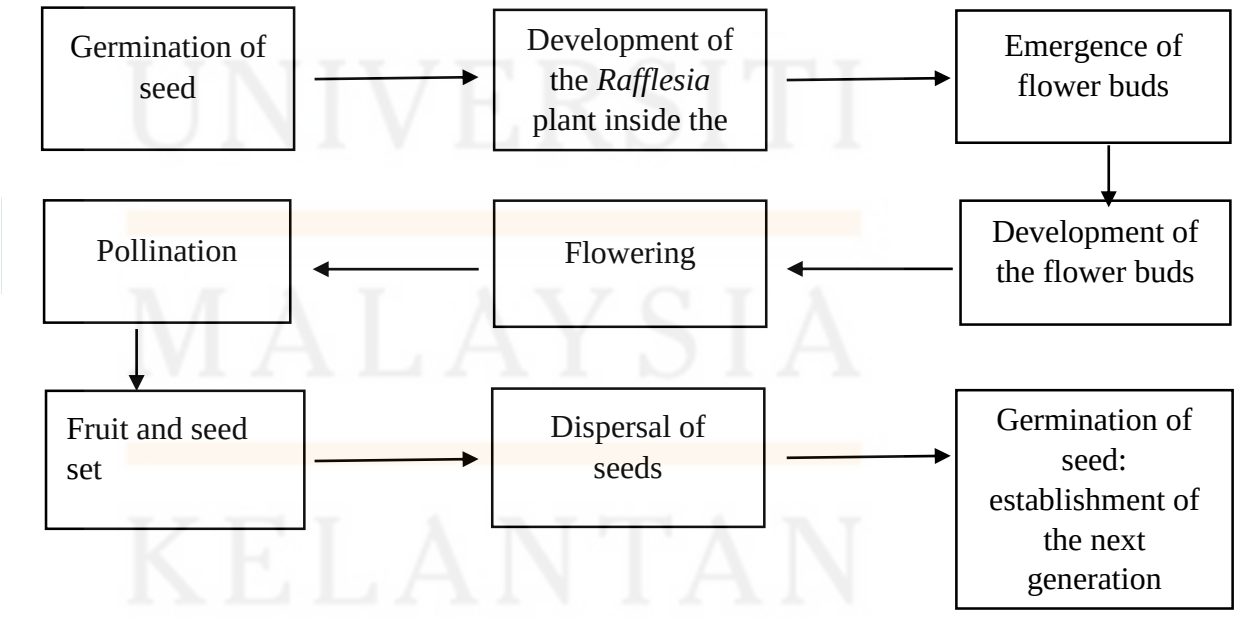


Figure 2.3: Life Cycle of *Rafflesia* (Jamili, 2001)

The existence of blooming flower indicates the formation of fruit seed when it start to rot during deterioration phase of post bloom stages. A complete life cycle of *R. kerri* is from the formation of mature fruit seed and undergoes the seed dispersal by mammals and seed germination. Once dispersed, the emergence of flower bud can be seen on its host (*Tetrastigma* sp.). The development of flower bud takes a few months to reach a mature bud as big as a big bowl in orange reddish black colour. Then, one by one petals (perigone lobes) will open up that only needs one night to completely open and the anthesis of *Rafflesia* can be observed.

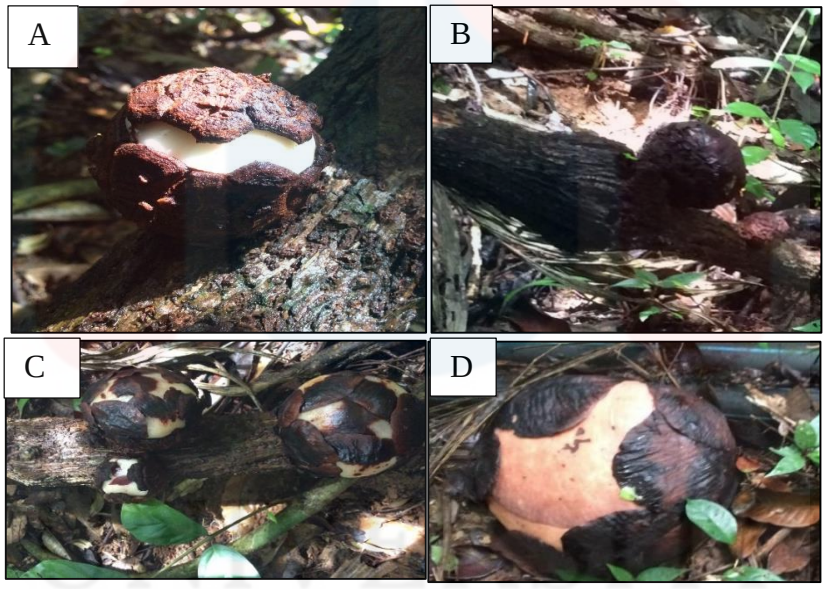


Figure 2.4: Development of bud

Image: ©Nurulain

Figure 2.4 shows the Image A, Image B, Image C and Image D (bud growth). Image A was known as Cupule Stage (Phase I) whereas the swelling of host due to seed emergence (germination occur) and the growth rate was very slow. It develops by cracking the hard external surface while Image B was the Bract Stage after entering the Phase II. The appearance of wannabe perigone lobes was visible in black colour.

Both buds (Cupule and Bract Stage) are small in size. Hence, the development of perigone lobes can be see clearly during the Perigone Stage (Image C) in milky white black colour. The size was differ from previous stage and bigger. Image D was Mature Bud stage. Image D was a mature bud that will bloom on a few days ahead. The colour described is reddish brown orange and black which the black colour figure represents the perigone tube and the other colour was the perigone lobes.

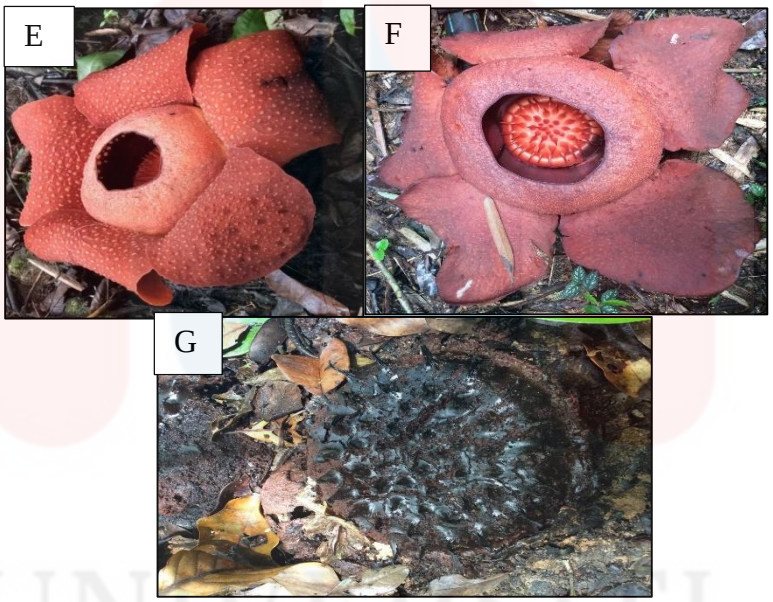


Figure 2.5: Development of *Rafflesia*

Image: ©Nurulain

Image E, Image F and Image G in Figure 2.5 are the Blooming Flower at third day, Blooming Flower at seventh day and Deterioration stage respectively. The Image E and Image F are different male flowers. The size was smaller and blooming at two different locations. Image F was estimated in seventh day of blooming due to its colour that slowly turning into dark brown or black which was the colour of rotten flower that

decay. Once decay, it will take a few months to develop a mature fruit seed and dispersed. The flower of *Rafflesia* are notoriously rare but the information on its seed after a few phase of life cycle is also lacking (Banziger, 2004).

2.3 *Tetrastigma sp.* as the host for *Rafflesia kerri* Meijer

Figure 2.6: *Tetrastigma* sp.

Image: ©Nurulain

Tetrastigma sp. was known as the host for all *Rafflesia* species include *Rafflesia kerrii* Meijer. The most common *Tetrastigma* species for *Rafflesia* in Malaysia are *T. rafflesiae* for *Rafflesia pricei* in Borneo Sabah and *T. hookeri* for *Rafflesia kerrii* Meijer in Lojing Highlands, Kelantan. In Borneo, *Tetrastigma rafflesiae* (Miq.) Planch. (Vitaceae) also the host plant for *Rafflesia tuan-mudae* (Fatiha *et al*, 2016).

Rafflesia cantleyi and *Rafflesia azlanii* are parasite to its host of *Tetrastigma rafflesiae* (Miq.) Planch while *Rafflesia kerri* Meijer and *Rafflesia sumeiae* are parasite to *Tetrastigma hookeri* (Laws.) Planch (Nasihah *et al*, 2016). Its genus is known as the

best host plant of *Rafflesia* and this species is widely distributed throughout subtropical and tropical Asian with around 95 species known worldwide (Chen, Chen and Wen, 2011). Interestingly, according to indigenous people, the flower of the parasite (*Rafflesia*) would begin its development after the host had lost its fruit (Veldkamp, 2009).

Both *Rafflesia* and *Tetrastigma* were linked together as *Tetrastigma* serve itself as the nonvisible roots for *Rafflesia* that absorb all the foods needed for *Rafflesia* through an unseen structure called 'haustarium' or threadlike-root inside the tissue of the plant vine (Anonymous, 2018e). *Rafflesia* is known for not having any stem, leaves and any vegetative structure. Furthermore, it is also described as large vines as its stem is thick, long and woody and its trailing stem may be found in draping trees and shrubs, forest edge and river bank along the road that mostly can be seen in higher altitudes (Latiff, 1984). It absorbs all the nutrients and minerals needed from its host plant.

Hence, the chemical compound in both *Rafflesia* and its host has not been on any research yet till today despite the fact that *Rafflesia* is a parasite that depending its whole life cycle on its host (Sofiyanti *et al.*, 2008). If there was any stress on *Tetrastigma*, it will also affects the growth of bud during its cupule stage to not swollen (develop) well when it may die before forming mature fruit seed.

Figure 2.7: The bud at early bract stage grow on *Tetrastigma* sp.

Image: ©Nurulain

In Figure 2.7, the bud can be seen grow on high tree trunk was due to seed dispersal agent that eat the mature fruit seed and crawls around the tree and seed was dispersed. For example, mammals like squirrel.

2.4 The determination of post blooming status of *Rafflesia kerri* Meijer

The diversity of *Rafflesia* can be determined by plot less sampling or distance based techniques whereas the sampling do not require any quadrants or transects that was needed for other sampling of plants in rainforest. This was due to population of *Rafflesia* that is not fixed and unevenly distributed. The plot less sampling is advantageous compared to common sampling as it does not required any quadrants by which it will not take a longer time and faster. Hence, in terms of time, it also does not require a lot of materials and also the adjustment for quadrant size.

CHAPTER 3

3.0 MATERIALS AND METHOD

3.1 Description of the Study Area

This study was conducted in Lojing Highlands at Kampung Jedip in Legup Cebur area. This area is inhabited by Temiar people which Temiar people were a Senoic original people living in Malaysia including Kelantan (Hackson, 2005). This area is situated at the Southern part of the Kelantan State, Peninsular Malaysia.

It is located between latitude 4˚32' to 4˚47'N and longitude 101˚20' to 101˚34' E in the District of Gua Musang, Kelantan and situated at the Cameron Highlands footstep which is the Lojing Highlands. It lies at 1000 m above sea level with its highest peak, Gunung Warpu (1864 m) and the area is covered with hill dipterocarp and montane forests (Nasihah *et al*, 2013). The logging trails are the first to access into Lojing. Sungai Belatop, Sungai Denkong, Sungai Brooke and Sungai Jedip are the rivers found in Lojing. Sungai Denkong provides the clean water for Lojing's local people, Temiar (Star Property, 2014). However, according to indigenous people, Sungai Jedip and Sungai Denkong are already polluted by soil erosion (Star Online, 2016).

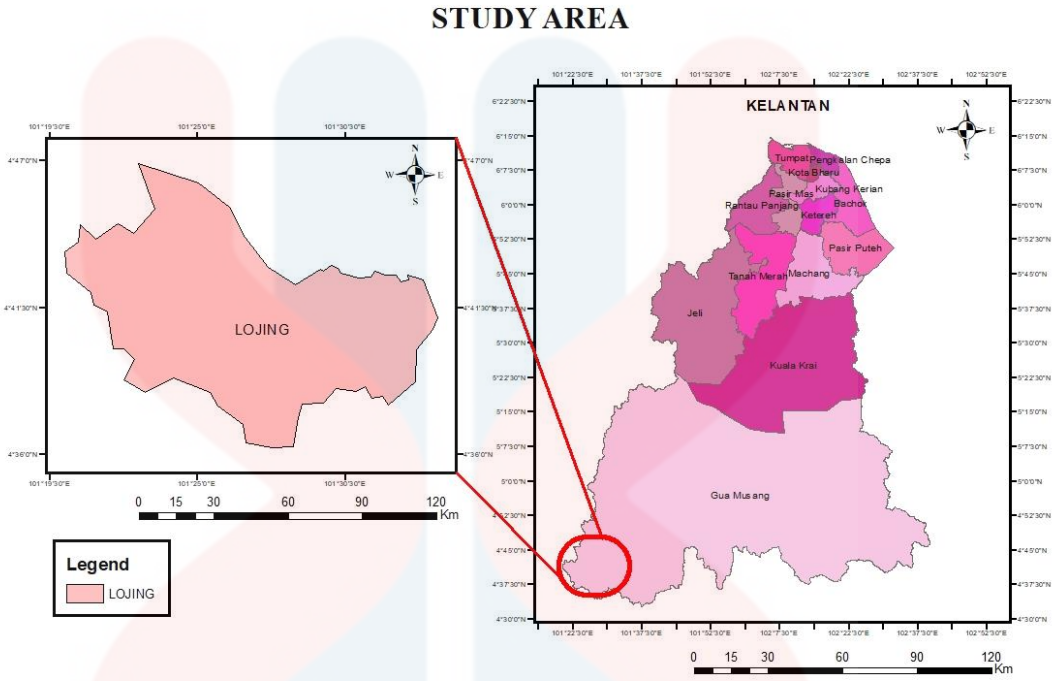


Figure 3.1: Study Area at Lojing Highlands, Gua Musang

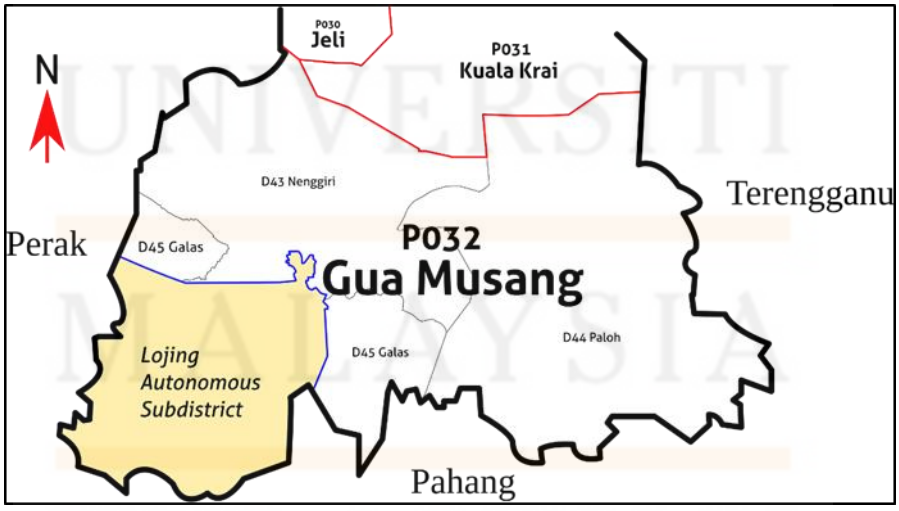


Figure 3.2: Zoom in of Lojing Area

Technically, this study area in Figure 3.1 is a mountainous area that comprising mountain valleys and mountain ridges. Lojing Highland which is located in the south west of Kelantan state is neighbouring to Pahang state which is at Gua Musang. It is the continuation of Cameron Highlands (one of tourist attractions within both Malaysia and abroad for sight viewing and its low temperature) with an altitude above sea level of 610-1500m. Cameron Highlands and Lojing are lower in temperature due to high elevation of the highlands, higher relative humidity and lower solar radiation (Anonymous, 2002d). It is 404 hectare in area which is located within *Rafflesia kerri* Meijer conservation area of the gazetted area. Lojing Highlands is famous for its *Rafflesia*.

R. kerri had attracted a lot of tourist and also researcher as it was really famous due to its morphology characteristics which rarely can be found on other common flowers species worldwide. Lojing Highland is known for its icon which was *R. kerri* that already becomes main attractions in Kelantan (Nazaruddin *et al.*, 2014). However, there are a few species from same genus (*Rafflesia*) that still not gained acceptance due to lack source of information, data and similar or synonyms to other species that has been discovered and described (Sofiyanti, Kamaruddin, Khairil *et al.*, 2016).

The Lojing Highlands (refer Figure 3.1) is not the same as before since the surrounding have been affected by human development such as clearing of hills, soil erosion, intensive and excessively agricultural development. The degradation of tropical ecosystem are threatening numerous species including *Rafflesia* with extinction and driving biodiversity crisis with worst consequences (Posa *et al.*, 2008).

A sizeable of area in Lojing was converted to agricultural farm such as tomato. The effort in maintaining and restoring all the species would require a lot of money

and investment since the probability to make this effort a success was estimated very low due to probability destruction of wild animals that populating the selected area. Lacking in food sources might lead them to eat all the *Rafflesia* bud or destroy it. Contrary to Sabah, conservation of *R. kerri* in Lojing was taken lightly and lack of efficiency and awareness as the area is under threat from rampant land clearing (Malaysian Times, 2013). Preserving the habitat, sign board, and reintroduction of the host vine are important in order the habitat (Yulian *et al.*, 2002). Conservation can be described as the ethical use of sources, allocation along with protection while maintaining the tranquillity and health of the earth (Ibrahim, 2010).

3.2 Materials

The materials used in this study to identify the density population of *Rafflesia kerri* Meijer during its post-bloom were measuring tape, Global Positioning System (GPS), marker and tag number.

3.3 Method

The three-ha area was established in one of the highest population density of *Rafflesia kerri* Meijer in Lojing Highland, Kelantan. This was under study area at Kampung Jedip and this area was known as Legup Cebur by the local community and a survey was conducted throughout this area in order to count all the available flower of *Rafflesia kerri* Meijer in post-blooming stages in those selected area.

3.3.1 Plot Setting

Three ha equals to 30 000 m² which means that the area that covered was big. The plot was set up along the three ha within the range by using the plot less sampling which the sampling plotted without the use of quadrants or transects. There were a few advantages when using this method in this study which were the sample plot do not need to be established, save a lot of time and enhance the chances of elimination of subjective error associated with the sample plot boundaries (Fidelibus and Aller, 1993).

Plot less sampling was used in order to plot the population of *R. kerri* within the selected area and this method was the best to use compared to plot sampling. Due to lack of efficiency and not accurate, plot sampling was not suitable for this study for a few factors.

For example, based on observation on site, each plant species was linked to each other as it is competing in order to get the sunlight as their source of energy and food. The disruptions from other plants may make the measurement inaccurate. Hence, the distribution of the *Rafflesia* flower was in clump (tends to be close to each other) at any area and also the geographical condition of Lojing. In addition, Lojing has high possibility of having landslide caused by agricultural activities.

3.3.2 Data Collection

The fieldwork of monitoring and observing was carried out on 10th and 11th October 2018 and the site (Kg. Jedip) was visited.

There was only one type of collection that has been used in this study, photography collection. Photography collection can be described as the species specimen (*R. kerri*) that found or left in observation site in order the conserve its

population by in-situ conservation that was used as the references in the results and discussions of writing. The morphological characteristics or rotten flower was observed and photographed.

3.3.3 Parameter Measurements

In this study, a few parameters were measured in order to access *R. kerri* during its post-bloom phase (deterioration stage).

Table 3.1: Parameter measurements and its descriptions

Parameter Measurements	Descriptions
a) Colour	Based on Literature Review, the real colour of *Rafflesia kerri* Meijer is orange reddish dark colour. However, the colour change as soon as it reaches the deterioration stage. The colour observed changed from beautiful orange reddish colour into dark colour of dark brown and black. It took more than seven days to start changing colour.
b) Morphological Characteristics of *R. kerri*	The morphological characteristics of dead *Rafflesia* were completely different during deterioration stage. The colours change. Perigone lobes (petals), spiky processes, ramenta, window, disk and other parts of *Rafflesia* will rot and decay completely. However, the morphology

	characteristics in each plot was different due to different time, stage and phase of blooming.
c) Mortality Causes of *R. kerri*	There are a few factors that lead into *Rafflesia* mortality rates. For example, trampling, termites, overweight and limited space. Based on observations, termites can be found in every rotten flower along with the visitors. In general, it can be concluded that termites is the biggest contributor into *Rafflesia kerri* Meijer mortality rates.
d) Sex (Gender)	The gender of *Rafflesia* was easy to be identified. In addition, the flower was on deterioration stage. During rotting phase, the male flower do not leave any trace of morphology characteristics of *Rafflesia* while female flower will leave the central disk visible whereas the development the seeds will occurred. Hence, female flower of any *Rafflesia* was bigger in size compared to male flower.

e) Coordinates and Elevation	The coordinates and elevation of each plot were recorded and measured. It was measured using the Global Positioning System (GPS). The data was recorded.
f) Tagging	Each population was plotted as M1P1 (first male flower at first plot) and F1P2 (female flower at second plot) and labelled.

3.3.4 Data Analysis

a) Determination of Density / population density

$$D_p = \frac{N}{A}$$

D_p = Population density

A = Specified area (three hectare)

N = Number of rotten flower of *Rafflesia kerrii* Meijer in post bloom status

The units of A must be in Hectare

CHAPTER 4

4.0 RESULTS AND DISCUSSION

4.1 Density population and the status of *Rafflesia kerri* Meijer in three ha plot

A total of 28 flowers were found within three ha during site observation. There were 28 flowers which the male flowers that was found were 16 and female flowers were 12 in total. Each flowers have different morphology characteristics and all of it were rotten. It was decay after the blooming phase at the different time.

Table 4.1 and Table 4.2 shows the results derived from the post-bloom stages that derived from Lojing Highlands, Kelantan.

Table 4.1: Stage of Post- Bloom and the number of flowers

Stage of Post-Bloom	No. of Flower
Deterioration Stage	25
Mature Fruit Seed Stage	3

Table 4.2: The number of flower according to its sex

Sex	No. of Flower
Male	16
Female	12

From the Table 4.1 and Table 4.2, it shows that 25 *Rafflesia* flower that was found were in deterioration stage. The flowers showed the state of condition on deterioration stage after blooming phase of seven days. Hence, the mature fruit seed that were found only three from three ha plot (area). The distribution of male flower was a bit higher than female flower which was 16 and the female flower was 12 only. Not all the 12 rotten female flower will be developed into mature fruit seed. This contribute to low percentage and chances of new germination to occur.

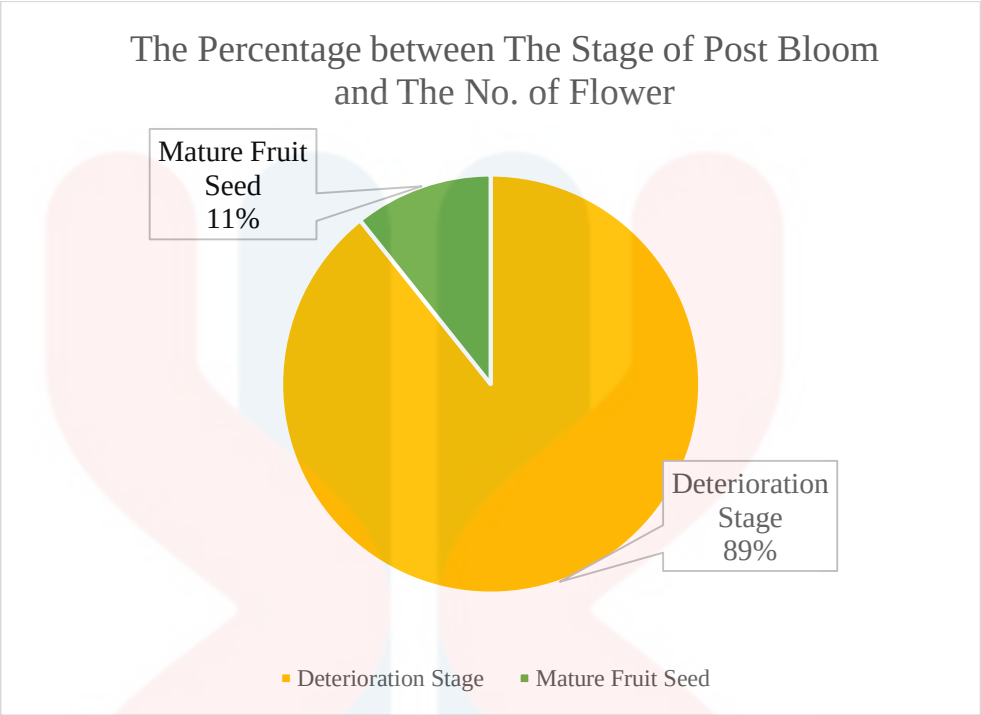


Figure 4.1: Pie Chart of the Percentage between Post Bloom Stages and the No. of Flower

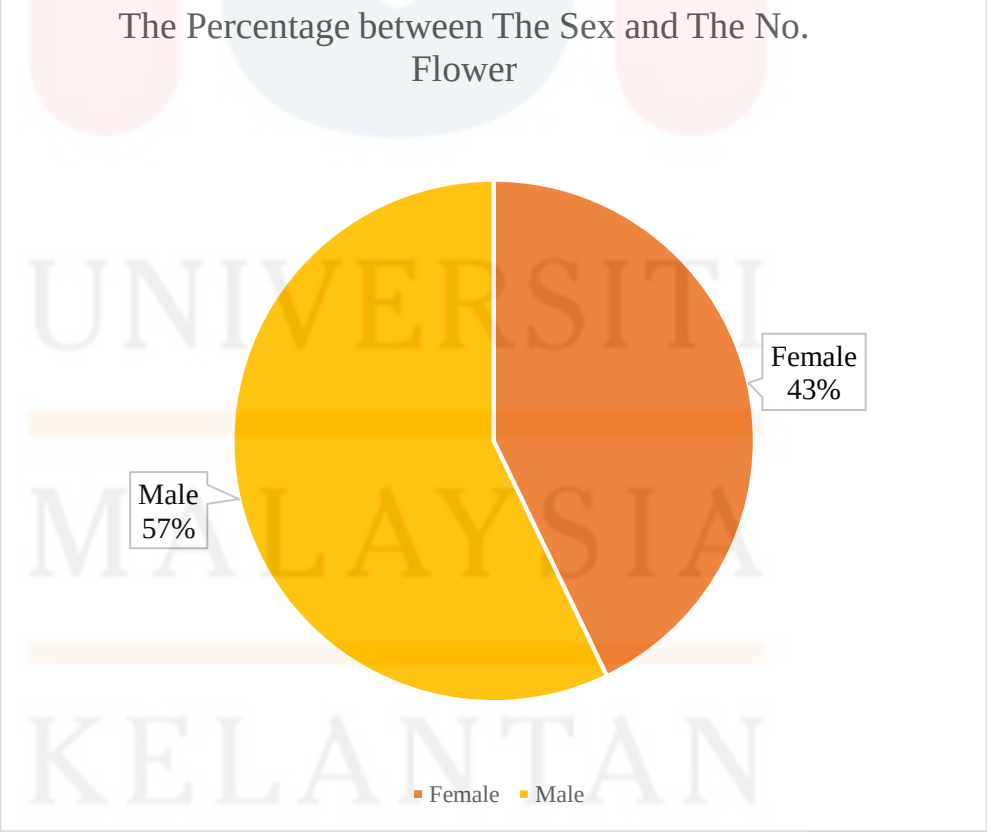


Figure 4.2: Pie Chart of the Percentage between the Sex and the No. of Flower

4.1.1 Equation and calculation for population density

Formula used: Eq. (4.1)

$$D_p = \frac{N}{A}$$

= Number of population ÷ area (hectare)

Three ha plot

Insert this formula: $D_p = \frac{N}{A}$

$$= \frac{28}{30000}$$

= 9 flowers per hectare

By using the equation (Eq. 4.1), the population density of *Rafflesia kerri* Meijer during post bloom stages in Lojing Highlands, Kelantan for three ha plot can be calculated. Its density population was 0.00093333 flowers per metre square. From this calculation, the population of rotten flower in its post blooming stages was low. According to (Shruhan, 2017), the disproportionate number between both male and female flowers in ratio had caused the decreasing pollination rate of *Rafflesia*.

Density was important in order to determine the current status of population, as prediction in future. Moreover, the species that were low in its population density might have trouble in mating (mortality causes) compared to high population density (Khan Academy, 2018). It was assumed that the status of post blooming status of *R. kerri* were poor. There were a few factors that lead to a low number of rotten flower (during deterioration stage). For example, too dry or too wet condition of soil that will

affect the soil fertility. Furthermore, the increasing and decreasing value of population in ecosystem caused by the changes in the factors that restrict growth (Edwards and Edwards, 2011).

Since the observation was conducted in October 2018 by which rainy season takes place and the weather might be one of the causes. Annually, there were a lot *R. kerri* that always blooms but not all of it can finish its whole life cycle. The duration for the *R. kerri* to form its bud formation from bract stage to mature bract stage and the pre-blooming stage (in bud form) until flower begin to blooming took around 8 or more months. Its deterioration stage during rotting need one to two years to have a complete mature fruit seed compared to its blooming phase that take place less than a week before died (Sharpe, 2017). The population density of *R. kerri* was very low despite the large area of 3 ha or 30 000 m² was covered.

Plot less sampling method was used in this study. Plot less sampling often used for surveys of forest vegetation when where rapid inventory was needed (Oxford, 2018). It was the most efficient way to identify the location of rotten flower of *R. kerri* (in post bloom stages) due to geographical structure of Lojing that was undistributed well. Lojing Highlands is one of the area within Kelantan that facing soil erosion (Yasmin, 2012). Hence, there were a lot of neighbouring plants linked to each other that limit the movement. Lojing was also one of the fragile ecosystems of other tropical highlands in Malaysia (Izzudin, 2015). The presence of many neighbouring plant species disturb the quadrants or plot as the measurement would be less efficienct and will not be accurate.

4.2 Post-bloom stages of *Rafflesia kerii* Meijer

After reaching its blooming stage when the real visual of *R. kerri* can be seen, its life cycle do not end there. It turned witter but this species was not dead (MySabah, 2012). It will start to decay in less than 10-12 days. It was called the deterioration stage before reaching the mature fruit seed stage.

Blooming *Rafflesia* has a reddish or dark brown bright colour with its colour really attracting and beautiful with small undistributed warts (Anonymous, 2018f). However, upon reachinf to its deterioration stage, the colour turned into dark colour. For example, dark brown or black colour. It was hard to be seen during its decay process since the colour was almost the same with its surrounding soil.

Figure 4.3: Rotten Female Flower on *Tetrastigma* sp.

Image: ©Nurulain

In Figure 4.3, a rotten female flower that already dead can be seen growing on its host which is the *Tetrastigma* sp. that also acts as their root since *Rafflesia* is known to not have any vegetative features including the roots. It was discovered as the female flower as the central disk is not rotting and its size that is bigger compared to other

flowers. It was located in between the branch of *Tetrastigama* sp. that was linked to each other and act as their host. The flower was covered by dried leaves that lead to difficulty while looking for this species. The factors that lead to this flower mortality was due to limited space and high competition with other species in order to get the nutrients from host. Furthermore, the weather is one of the factors that encourage flower blooming during the rainy season on October 2018.

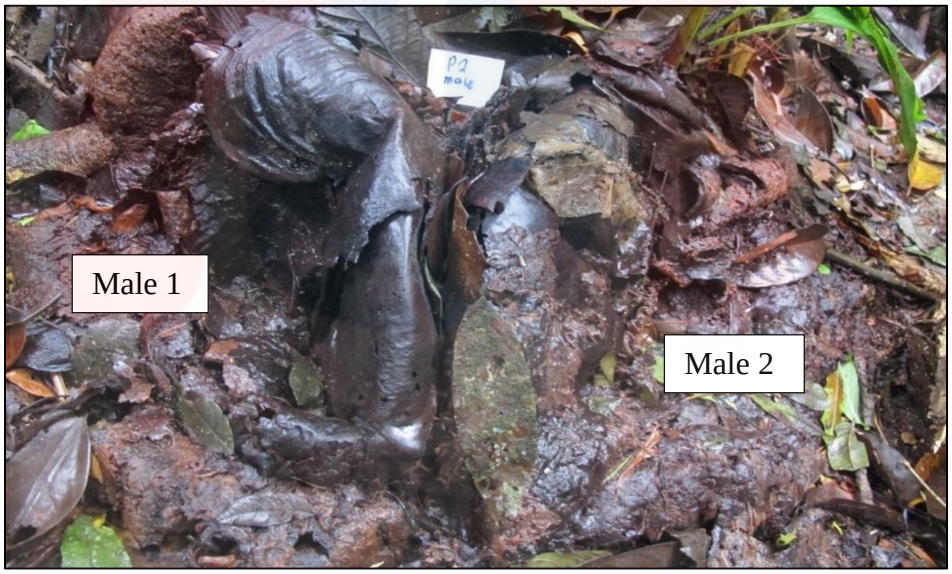


Figure 4.4: Two rotting male flowers

Image: ©Nurulain

From Figure 4.4, it was hard to see the features of *Rafflesia kerri* Meijer as it begins to completely decay. It grows proximately close to each other and the perigone lobes (petals) tend to curve inside instead of being straight like any other blooming flowers. It can be assumed that the distance between flowers during bud bract stage were too close that lead into the curving perigone lobes.

Figure 4.5: Hanging rotten female flower at cliff

Image: ©Nurulain

For Figure 4.5, the second rotten female flower was found and it was hanging on the cliff. Its perigone lobes that still visible shows that the flower was blooming in estimated time of two weeks earlier.

Figure 4.6: Three rotten male flowers near young ginger plant

Image: ©Nurulain

In Figure 4.6, it was a male flower. There were three male flowers that was almost completely rot and grow close to each other. The male flowers grown near to or around of a young ginger plant. It was discovered as a ginger plant due to its morphological characteristics with many fibrous roots, aerial shoots (pseudo stem) with leaves, herbs smell-like, the number of veins and the shape of the leaves. It was assumed as *etlingera* sp. due to its common genus to all gingers species because Lojing is also inhabited by the population of ginger plant. The ginger was still young and it was difficult to identify as there were no presence of the flower. Besides that, all the ginger species can only be identified from its flower. However, the flowers grow at the base of the plants which make it hard to notice (Kohl, 2018).

Figure 4.7: Mature died fruit seed

Image: ©Nurulain

Figure 4.7 shows the mature fruit seed that was found during observation on site. Unfortunately, it was dead and there were possible mortality causes of fruit seed

such as trampling, termites or stress on its host *(Tetrastigma* sp.). Based on Figure 4.7, the middle part of *R. kerri* was present but it was rotten both on surface and its inside. Those significant figures prove that the mortality causes of mature dead fruit seed in this figure was not caused by trampling by wild animals or human but its nature behaviour. For example, termites.

Figure 4.8: The biggest rotten female flower found during its deterioration stage

Image: ©Nurulain

It was the female flowers (Figure 4.8) that rotten and the biggest flower that was found during observation which was blooming around 10-12 days before developing into this state since all the features especially its big perigone lobes were still visible.

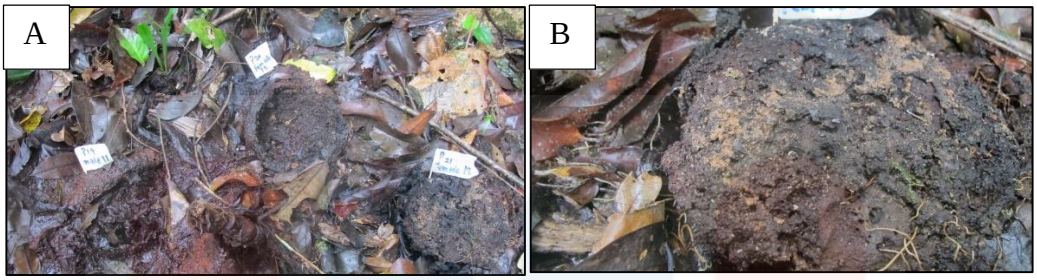


Figure 4.9: Mature fruit seed that dispersed and become rotten respectively

Image: ©Nurulain

The image shown in Figure 4.9 was both the mature fruit seeds. Image A was the mature fruit seed that already dispersed by dispersal agent (mammals) such as squirrel and elephant. It contributes to the way to the dispersal of plants (Vigni and Melati, 2013). The seed was assumed to be eaten by squirrels. Pollination by elephant was called Elephophily. The pollen grains of *Rafflesia* flower get attached to the feet of the elephant and was carried out to the stigma of another booming female flower of *Rafflesia*. It leave only the outer external and the seeds were assumed eaten by mammals and dispersed and Image B was a rotten fruit seed that almost reaching its mature state.

Especially the male flower, once it decay, it will decaying completely include the perigone lobes and the disk that has the processes. Meanwhile, for female flower, the visible parts of *R. kerri* which was the petals rotted leaving the disk that contained the processes visible in dark colour. The centre part of this species (*Rafflesia kerri* Meijer) was the one that will be forming the mature fruit seed with many tiny coasted seeds (Earlham College, 2003).

The pollination will occur on the female flower which was the reason on why the female flower do not rot completely unlike the male flower. Due to its dark colour, trampling on female flower may occur and the wannabe fruit seed will be destroyed.

Rafflesia bloom close approximately to each other and the rotten flower was close to bloom *Rafflesia* flower. Hence, the tourists will trample on the rotten female flower while took a closer look on blooming flower (Sharifah, 2017).

For *Rafflesia* mortality rates, termites can be found on the decay flower. It is very small in physical and similar in size to ants. During decaying process of *Rafflesia* at the observation site, the termites can be seen flying around this species which this conclude that termites might act as a catalyst that increase the rate of decay process of *Rafflesia.*

It was also concluded that termites contribute to one of the highest to mortality rates. However, that is still not proven that termites is the main contributor into *Rafflesia* mortality rates as the stress from its roots (*Tetrastigma*) might be the main reason or factor for its mortality rates. For example, at Gunung Gading National Park under the Department of Sarawak Forestry, an effort had been conducted whereas a few locations of *Rafflesia* germination had been restricted from any visitors and the result was that the site with no visitors produce more *Rafflesia* and buds compared to other area that was not restricted to visitors.

Hence, the visitors or tourists can enjoy the flowers habitat without walking on the ground. It was called laid plank walk (Sarawak Forestry, 2018). But, this assumptions was still cannot be proven and under research because there were no article or paper were published yet.

The current status of post-bloom stages of *Rafflesia kerri* Meijer at Lojing Highland was that there were three rotten flowers that found which were in different conditions such as mature dead fruit seed and also mature fruit seed that already forming but dispersed by mammals leaving the hard external.

Hence, the male flower population was found is higher in number compared to female flower. This numbers indicates that the population of *R. kerri* may meet decline in future. More male flowers were produced compared to female flowers. However, the weather factor should be taken since this study was conducted during rainy season by observation on the site.

CHAPTER 5

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The status assessment of *Rafflesia kerri* Meijer in this study was conducted in Lojing Highlands, Kelantan. The study of *Rafflesia* populations in 3 ha plot has provided a data for references in future. A total of 28 flowers of *R. kerri* was found. It shows that the result and analysis of *R. kerri* provided based on research on observation site.

Several conclusions can be derived from this study, as follows:

a) A total of 28 flowers of *Rafflesia* were identified in three ha plot and there were 16 male and 12 female flowers.

b) The density population of *R. kerri* in post bloom stages within three 3 ha were 9 flowers per hectare and it was categorized as poor due to disproportionate number between male and female flowers that lead to decrease rate of pollination of *R. kerri* even in its highest point of population area (Kg Jedip).

c) Generally, the status of post bloom stages of *R. kerri* during deterioration stage was 25 flowers. Meanwhile, the status for noted mature fruit seed was only three.

5.2 Recommendations

In order to maintain the sustainability of this species in future, it is recommended of proposing the ex- situ conservation of *R. kerri* by tissue culture

method. The seed and pollen can be used as explants. Other than that, further study on the life span of *R. kerri* pollen and the viability of *R. kerri* seed by using germination test. It is important to test the viability first before proceeding into tissue culture mothos as not all the explants will germinate. Hence, further research on the mortality rates of *Rafflesia kerri* Meijer caused by the stress on *Tetrastigma* sp. as *Rafflesia* host plant. Both unhealthy host and termites contribute to the highest mortality rates of *Rafflesia kerri* Meijer. The lab observation can be done for more accurate information on this research compared to observation on site that depending on the environment and surrounding for more information gathered.

REFERENCES

Anonymous. (2012a). No Action, Talk Only. Rubber Forest, Documenting the Rape and Plunder of Kelantan's Rainforests. Retrieved November 25, 2018 from https://rubberforests.wordpress.com/tag/kelantan/.

Anonymous. (2017b). World of Flowering Plants. Retrived November 25, 2018 from https://worldoffloweringplants.com/rafflesia-kerrii/.

Anonymous. (2014c). Mortality Rates of Rafflesia. Retrieved November 22, 2018 from http://www.rafflesiaflower.com/Rafflesia-Threats.html.

Anonymous. (2002d). Study for The Sustainable Development of The Highlands of Peninsular Malaysia. Economic Planning Unit. Draft Final Report. Executive Summary.

Anonymous. (2018e). Retrived December 8, 2018 from http://www.khaosokdiscovery.com/khaosok-national-park-thailand/rafflesia-kerrii-flower/.

Anonymous. (2018f). Rafflesia (*Rafflesia kerrii*). Retrieved December 8, from https://www.arkive.org/rafflesia/rafflesia-kerrii/.

Balete, D. S., Pelser, P. B., Nickrent, D. L., Barcelone, J. F. (2010). *Rafflesia verrucosa* (Rafflesiaceae), A New Species of Small-Flowered Rafflesia from Eastern Mindanao, Philippines, 49- 57.

Banziger, H. (2004). Deterioration Stage of Rafflesia. Thailand: Department of Entomology Faculty of Agriculture Chiang Mai University.

Bouman, F., and Meijer, W. (1994). Rafflesia. Comparative Structure of Ovules and Seeds in Rafflesiaceae, 187-212.

Bradford, A. (2017). Corpse Flower: Facts About The Smelly Plant. Retrived December 1, 2018 from https://www.livescience.com/51947-corpse-flower-facts-about-the-smelly-plant.html.

Brown, R. (2009). Rafflesia. XV. An Account of A New Genus of Plants, named Rafflesia., 201-234.

Chen, P., Chen, L., and Wen, J. (2011). *Tetrastigma Rafflesia* and *Hookeri*. The first Phylogenetic Analysis of *Tetrastigma (*Miq.) Planch., The host of *Rafflesiaceae*, 499-512.

Compton, M. E. (2011). Elements Of In-Vitro Research. In Robert, N. T., and Dennis, J. G. United State Of America: Taylor and Francis Group.

Earlham College. (2003). Biological Diversity 2003. Reproduction. Retrived December 9, 2018 from http://legacy.earlham.edu/~givenbe/Rafflesia/rafflesia/biodiv2.htm.

Edwards, W. J., and Edwards, C. T. (2011). Population Limiting Factors. Nature Education Knowledge 3(10):1.

Farah, K. K., Zulhazman, H., Nur Sayzwani, S., Siti Hajar, Y., Nur Kyariatul Syafinie, A. M., Nasihah, M., and Siti Fatimah, A. (2018). Distribution of Rafflesia in Malaysia. Distribution and Ecology of Rafflesia in Royal belum, 292-296.

Fidelibus, M. W., and Mac, A. R. T. F. (1993). Plot less Sampling. Methods for Plot less Sampling.

Hackson, A. (2005). The Temiars. Retrived December 2, 2018 from http://www.temiar.com/temiar.html.

Hidayati, S. N., and Walck, J. L. (2016). Biology Of Rafflesia. A Review Of The Biology Of Rafflesia: What Do We Know And What's Next?, 67-68.

Ibrahim, O. (2010). Conservation of The Lojing Highlands: The Role of Education and Research. In Ibrahim, O., Zulhazman, H. (2010). Conserving Lojing Highlands for Sustainable Development.

Izzudin, W. (2015). Saving Lojing. About Lojing Highlands. Yayasan Bina Lestari Malaysia. Retrieved December 9, 2018 from https://wanderingwanizz.wordpress.com/2015/06/20/saving-lojing/.

Jamili, N. (2001). Rafflesia of the World. Life Cycle and Flower Bud Development. The Life Cycle of Rafflesia, 33.

Khan Academy. (2018). Demography: Describing Populations and How They Change. Population Size, Density, & Dispersal. What an Ecological Population Is. How Scientists Define and Measure Population Size, Density, and Distribution in Space. Retrieved December 9, 2018 from https://www.khanacademy.org/science/high-school-biology/hs-ecology/hs-population-ecology/a/population-size-density-and-dispersal.

Kohl, A. (2018). How To Identify Ginger Plant. Retrieved December 9, 2018 from https://www.hunker.com/12407070/how-to-identify-ginger-plants.

Latiff, A. (1984). *Tetrastigma Rafflesia* and *Hookeri*. Studies In Malesian Vitaceae VII. The genus *Tetrastigma* in The Malay Peninsula , 214.

Lun, H. P. (2015). Pollinators and Visitors of Rafflesia. A study of Interaction between *Rafflesia kerri* Meijer and Pollinators in Lojing Highlands, Kelantan, Malaysia.

Mahmood, A. A., Khaled, A. A., Hapipah, M. A., Suzita, M. N. and Salmah, I. (2009). Wound Healing Activities of *Rafflesia Hasseltii* Extract in Rats, 304-308.

Meijer, W. and Elliott, S. (1990). Rafflesia Taxonomy, Ecology and Conservation of *Rafflesia kerri* Meijer in Southern Thailand, 117-133.

Meijer, W. (1984). Rafflesia. New species of Rafflesia (Rafflesiaceae), 209-215.

Meijer, W. (1991). Species Diversity of Rafflesia in Malaysia. Species Diversity and The Conservation Status of Rafflessia in Malesia.

MySabah.com. (2012). Blooming Rafflesia, Biggest Flower in The World!. Retrieved December 9, 2018 from http://www.mysabah.com/wordpress/blooming-rafflesia/.

Nazaruddin, D. A., Nur Syazwani, M. F., Zulfarahin, Z., Sharifah Aisyah, S. O., and Mohamad Khidzir, M. I. (2014). *Rafflesia kerri* Meijer. Geological Studies to

Support The Tourism Site: A Case Study In The *Rafflesia* Trail Near Kmapung Jedip, Lojing Highlands, Kelantan, Malaysia, 835-851.

Nikolov, L. A., Staedler, Y. M., Manickam, S., Schönenberger, J., Endress, P. K., Kramer, E. M., and Davis, C. C. (2014). Pollinators and Visitors of *Rafflesia*. Floral Structure and Development in Rafflesiaceae with Emphasis on Their Exceptional Gynoecia.

Nuur Fatiha, W. Z., Aida Shafreena, A. P., Geri, C., Ramlah, Z., and Latiff, A. (2016). Distribution of Rafflesia in Malaysia. T*etrastigma diepenhorstii* (Miq.) Latiff (Vitaceae), a New Host of *Rafflesia tuan-mudae* Becc. (Rafflesiaceae) in Borneo.

Nasihah, M., Zulhazman, H., Siti Munirah, M.Y., Razak, W., Fatimah, K. and Qayyum Nadia W. A. (2013). Soil Nutrient Dynamic At Three Defined Elevation in Relation To Bud Population Of *Rafflesia kerri* In The Lojing Highland Of Kelantan, Malaysia, Lojing Highlands.

Nasihah, M., Zulhazman, H., Siti Munirah, M.Y., Qayyum Nadia, W. A. and A. Latiff. (2016). *Tetrastigma Rafflesia* and *Hookeri*. *Tetrastigma hookeri* (Laws.) Planch.(Vitaceae), A Host Plant for *Rafflesia kerri*, 33-39.

Nikolov, L. A., and Davis, C. C. (2017). The Big, The Bad, and The Beautiful: Biology of The World's Largest Flowers. Retrieved November 30, 2018 from https://onlinelibrary.wiley.com/doi/full/10.1111/jse.12260.

Oxford Reference. (2018). Plot less Sampling. Oxford Reference. Retrieved December 9, 2018 from http://www.oxfordreference.com/view/10.1093/oi/authority.20110803100332609.

Nor Azilah, A. W., Noraini, T., and Jumaat, A. (2018). Rotten Male Flower of Rafflesia. Distribution and Taxonomy of *Rafflesia* R. Br. (Rafflesiaceae) in Peninsular Malaysia.

Patiño, S., Aalto T., Edwards, A. A., and Grace, J. (2002). Is Rafflesia An Endothermic Flower?, 429-437.

Pelser, Pieter, B., Nickrent, Daniel, L., Gemmill, Chrissen, E. C., Barcelona, Julie, F. (2017). Genetic Diversity and Structure in the Philippine *Rafflesia lagascae* Complex (Rafflesiaceae) Inform its Taxonomic Delimitation and Conservation. Systematic Botany, Volume 42, Number 3, pp. 543-553.

Posa, M. R. C., Diesmos, A. C., Sodhi, N. S., Brooks, T. M. (2008). Hope for Threatened Tropical Biodiversity: Lessons From The Philippines. BioScience, Volume 58, Issue 3, 1 March 2008, 231–240.

Puttipan, R., and Okonogi, S. (2014). *Rafflesia kerri* Meijer. Antioxidant Activity Of *Rafflesia kerri* Flower Extract, 18-24.

Pullaiah, T., and Subba Rao, M. V. (2009). Plant Tissue Culture Theory and Practicals. India: Tanay Sharma Scientific Publishers.

Reed, S. B., Pamla, J. D., and John, H. . (1988). Pollinators and Visitors of Rafflesia. Pollination of Rafflesia (Rafflesiaceae), 1148-1162.

Refaei, J., Jones, E. B. G., Sakayaroj, J. and Santhanam, J. (2011*). Rafflesia cantleyi*. Endophytic Fungi from *Rafflesia cantleyi:* Species Diversity and Antimicrobial, 430.

Rodgers, G. (2017). An Introduction To Rafflesia Flower. Southeast Asia Is Home To One of The World's Heaviest and Rarest Flowers.

Sarawak Forestry. (2018). National Park and Nature Reserve. Retrieved December 9, 2018 from https://www.sarawakforestry.com/parks-and-reserves/gunung-gading-national-park/.

Sharpe, K. (2017). The Life Cycle of a Rafflesia Plant. Retrieved December 8, 2018 from https://www.gardenguides.com/126189-life-cycle-rafflesia-plant.html.

Sharifah, M., A. (2017). Trampling Tourist A Threat To Iconic Bloom. Tourist Step On Buds and Host Plants When Visiting *Rafflesia* Sites. News Straits Times.

Shruhan, K. (2016). Rafflesia. Plant of Death. Retrieved December 8, 2018 from https://pages.stolaf.edu/writ211-shruhan/2016/04/11/test/.

Smith, R. H. (2013). Plant Tissue Culture Techniques and Experiments. USA: Academic Press.

Sofiyanti, N., Mat Salleh, K., Mahmud, K., Nor Zuhailah, M., Mohd Ros, A. B. H., and David, F. R. P. B. (2016). Bud Emergence Of Rafflesia. *Rafflesia parvimaculata* (Rafflesiaceae), A New Species of Rafflesia from Peninsular, 207-213.

Sofiyanti, N., Ninik Nihayatul, W., Purwanto, D., Shahputra, E. and Mat Salleh, K. (2008). Alkaloid and Phenolic Compounds of *Rafflesia hasseltii* Suringar and its host *Tetrastigma leucostaphylum* (Dennst.) Alston ex Mabb. in Bukit Tigapuluh National Park, Riau: A Preliminary Study . *Tetrastigma Rafflesia* and *Hookeri*, 17-20.

Star Property. (2014). Letter: Soil erosion at Lojing Highlands. Retrieved December 7, 2018 from http://www.starproperty.my/index.php/articles/property-news/letter-soil-erosion-at-lojing-highlands/.

Sukamto, L. A., and Mujiono. (2010). In-Vitro Culture. In-Vitro Culture of Holoparasite *Rafflesia arnoldii* Brown, R., 81.

Suphuntee, N., and Santongpraow, S. (2000). Morphology and Anatomy of Bua Pud (*Rafflesia kerri* Meijer) in Thailand. Food and Agricultural Organization of The United Unions. Retrieved November 21, 2018 from http://thaiagris.lib.ku.ac.th/eng/.

Tan, A. L., Lee, C. P, Sarah Aziz, A., G. A., Siti Munirah, M. Y. and Mat Salleh, K. (2010). Distribution of Rafflesia in Malaysia. In H. L., Sim H. C. The Status of *Rafflesia* Populations in Taman Negara, Malaysia. How Well Are They Being Protected?. Malaysia: FRIM, APAFRI and Bioversity International, (p. 76).

The Malaysian Times. (2013). Retrieved January 7, 2019 from http://www.themalaysiantimes.com.my/rafflesia-threatened-at-lojing-highlands/.

The Star Online. (2010). Retrieved December 7, 2018 from https://www.thestar.com.my/news/nation/2010/05/23/ukm-study-finds-rafflesia-can-cause-liver-spleen-failure/.

The Star Online. (2016). The hills of Lojing stripped bare. National Human Right Society HAKAM. Retrieved December 7, 2018 from https://hakam.org.my/wp/2016/10/01/the-hills-of-lojing-stripped-bare/.

Veldkamp, J. H. (2009). Notes on The Names of The *Tetrastigma* (Vitaceae) Host of Rafflesia (Rafflesiaceae), 77.

Vigni, I. L., and Melati, M. R. (2013). Examples of Seed Dispersal by Entomochory. Botany Letters Volume 146, 145-156.

Wicaksono, A., Mursidawati, S., Sukamto, L. A., and Silva, J. A. T. (2016). Bud Emergence of Rafflesia. Rafflesia spp.: Propagation and Conservation.

Yasmin, S. Y. (2012). Application of Geographic Information System in Soil Erosion Prediction. Conference: 33rd Asian Conference on Remote Sensing 2012, ACRS 2012, At Pattaya; Thailand, Volume: Volume 3, 2012, Pages 2694-2700.

Yulian, Hermawan, B., Okuda, N., Fujime, Y. (2002). Studies On Rafflesia Flower In Bengkulu, Indonesia. The Agriculture, Forestry and Fisheries Research Information Technology Center. Retrieved December 6, 2018 from http://www.affrc.go.jp/en/.

Zulhazman, H. (2015). Distribution of Rafflesia in Malaysia. Rafflesia of Kelantan, Peninsular Malaysia, 15-16.

APPENDIX A

Population of post bloom stages of *Rafflesia kerrii* Meijer observed in Lojing

Population	Tag No.	Coordinates	Elevation (m)
1	F1	N 04˚37.937 E 101˚30.272	1038
2	M1M2	N 04˚37.934 E 101˚30.269	1040
3	M3	N 04˚37.922 E 101˚30.285	1048
4	M4	N 04˚37.916 E 101˚30.269	1048
5	M5	N 04˚37.920 E 101˚30.271	1046
6	F2	N 04˚37.914 E 101˚30.269	1045
7	F3	N 04˚37.913 E 101˚30.263	1043
8	F4	N 04˚37.908 E 101˚30.259	1046
9	F5	N 04˚37.909 E 101˚30.257	1048
10	F6	N 04˚37.909 E 101˚30.257	1047
11	F7	N 04˚37.929	1051

		E 101˚30.261	
12	F8	N 04˚37.933 E 101˚30.260	1050
13	M6,7,8	N 04˚37.936 E 101˚30.259	1045
14	M9	N 04˚37.933 E 101˚30.256	1045
15	F9	N 04˚37.945 E 101˚30.245	1040
16	F10	N 04˚37.948 E 101˚30.249	1039
17	F11	N 04˚37. 957 E 101˚30.252	1038
18	M10	N 04˚37.968 E 101˚30.259	1036
19	M11	N 04˚37964 E 101˚30.248	1037
20	F12	N 04˚37.964 E 101˚30.244	1036
21	F13	N 04˚37.966 E 101˚30.240	1036
22	F14	N 04˚38.007 E 101˚30.262	1027
23	M12	N 04˚38.026	1024

		E 101˚30.269	
24	M13	N 04˚38.039 E 101˚30.273	1026
25	F15	N 04˚38.013 E 101˚30.275	1032

There were 25 plots within the three ha and three flowers were found on the same area at 13th plot.

APPENDIX B

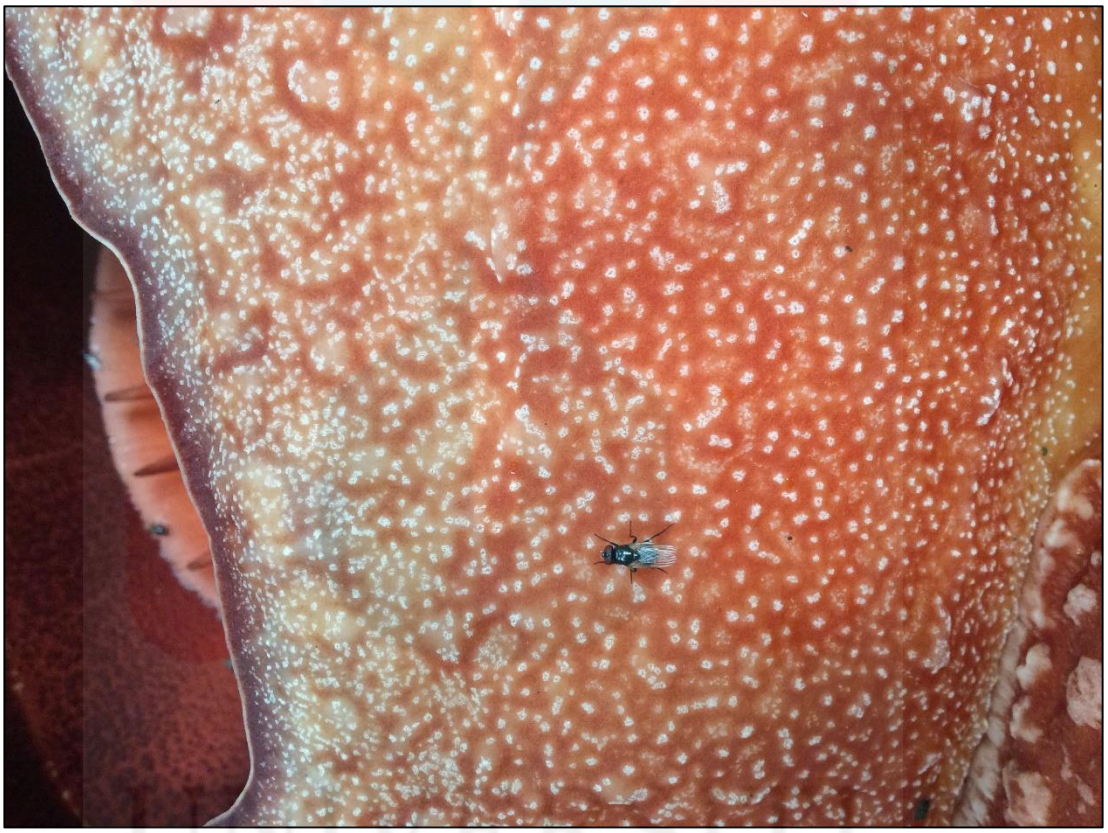
Diameter size of *Rafflesia kerri* Meijer and diameter size of disk of *Rafflesia kerrii* Meijer in each population

Plot	**Tag. No**	**Diameter of *R. kerrii* (cm)**	**Sex**
1	P_1F_1	48	Female
2	$P_2M_1M_2$	30	Male
3	P_3M_3	27	Male
4	P_4M_4	27	Male
5	P_5M_5	37	Male
6	P_6F_2	60	Female
7	P_7F_3	41	Female
8	P_8F_4	40	Female
9	P_9F_5	49	Female
10	$P_{10}F_6$	43	Female
11	$P_{11}F_7$	41	Female
12	$P_{12}F_8$	95	Female
13	$P_{13}M_{6,7,8}$	30	Male
14	$P_{14}M_9$	28	Male
15	$P_{15}F_9$	18	Female
16	$P_{16}F_{10}$	30	Female
17	$P_{17}F_{11}$	82	Female
18	$P_{18}M_{10}$	42	Male
19	$P_{19}M_{11}$	40	Male

20	$P_{20}F_{12}$	17	Female
21	$P_{21}F_{13}$	14	Female
22	$P_{22}F_{14}$	41	Female
23	$P_{23}M_{12}$	32	Male
24	$P_{24}M_{13}$	34	Male
25	$P_{25}F_{15}$	48	Female

APPENDIX C

Image of the pollinators of *Rafflesia kerri* Meijer that was taken in Lojing Highlands, Kelantan

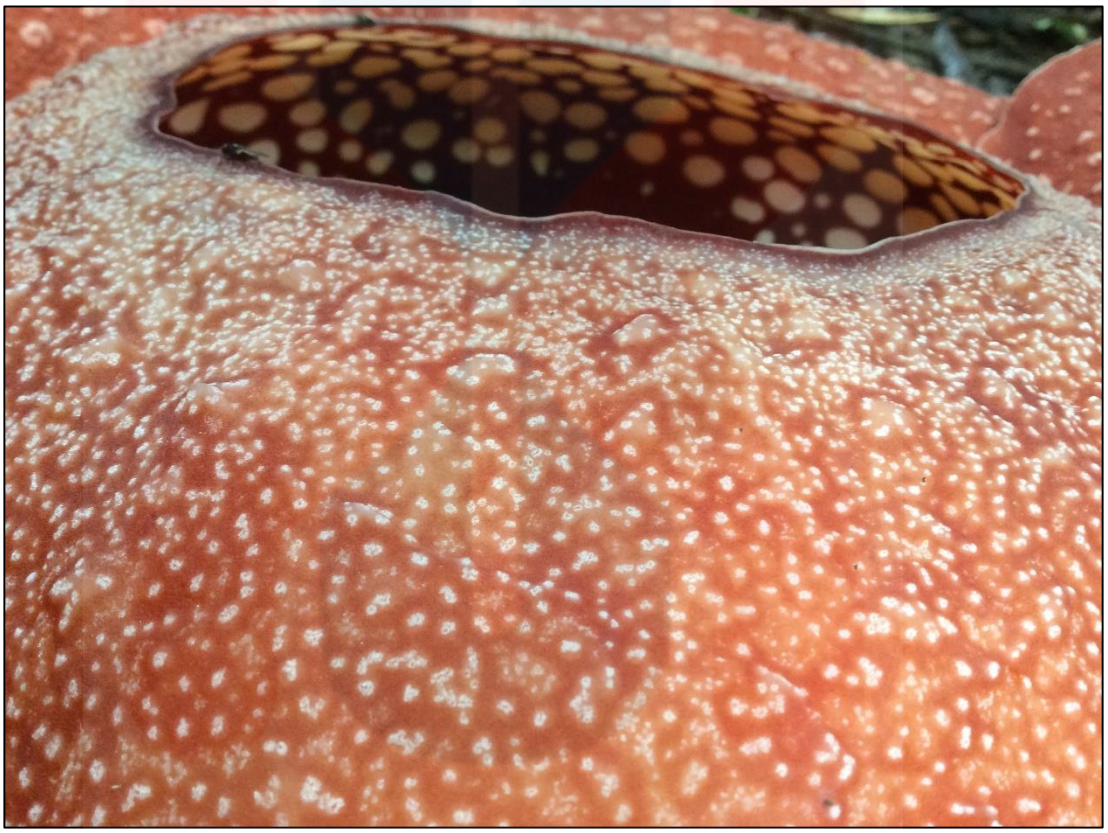


Pollinators (flies) behaviour on *R. kerri*.

Image: ©Nurulain

APPENDIX D

Undistributed small warts of *Rafflesia kerri* Meijer

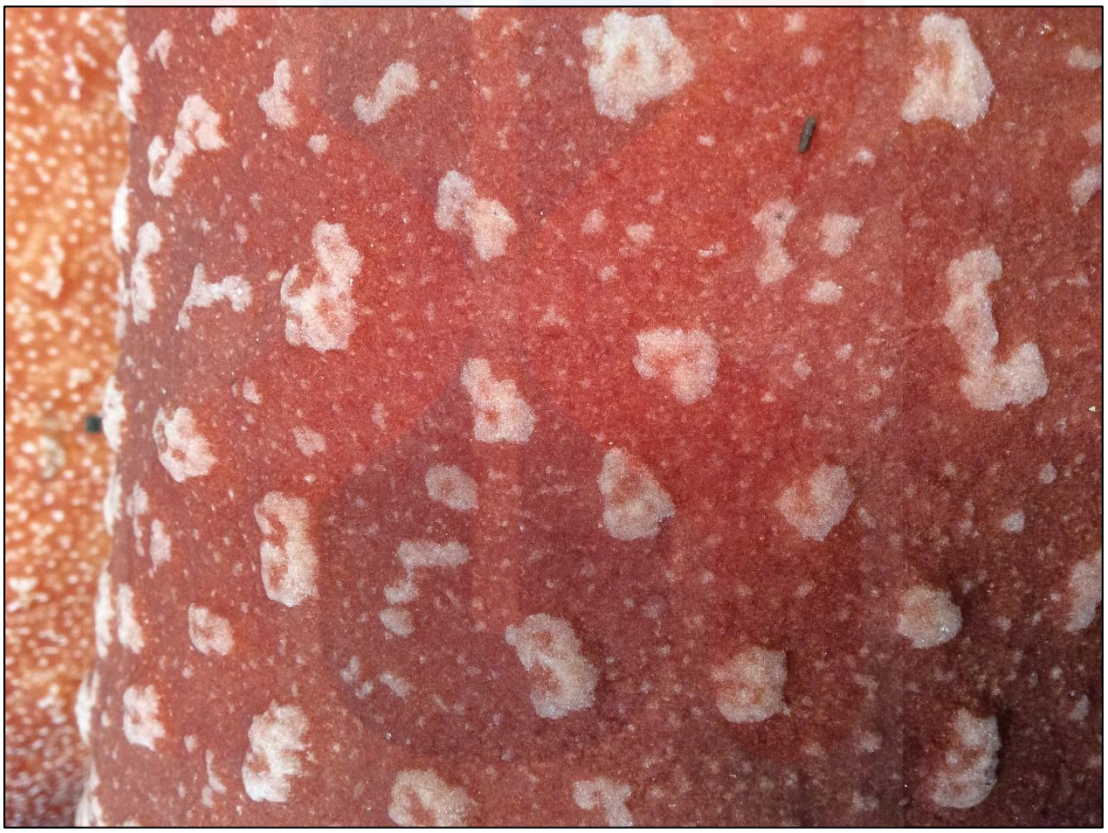


Rafflesia kerri Meijer has small undistributed warts compared to other *Rafflesia* species. This morphology characteristics differentiate *R. kerri* with other species**.**

Image: ©Nurulain

APPENDIX E

Perigone lobes of *R. kerri*



Perigone lobes with numerous and scattered small warts that make *R. kerri* differ from other species of *Rafflesia*.

Image: ©Nurulain

APPENDIX F

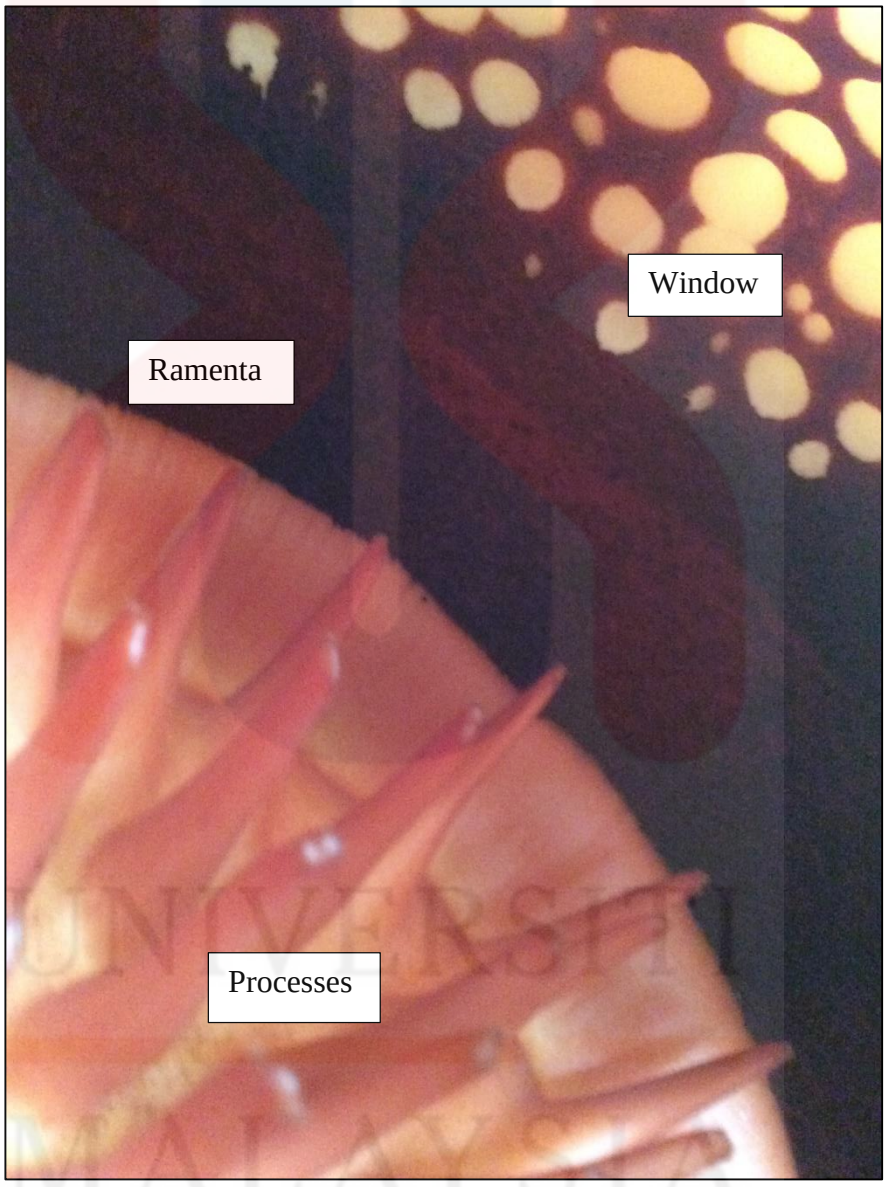
The outer layer of *Rafflesia kerri* Meijer

It is known as bract. The black outer layer protect the bud (perigone lobes) before develop into blooming flower.

Image: ©Nurulain

APPENDIX G

Window, Ramenta and Processes (*R. kerri*. Morphology characteristics)

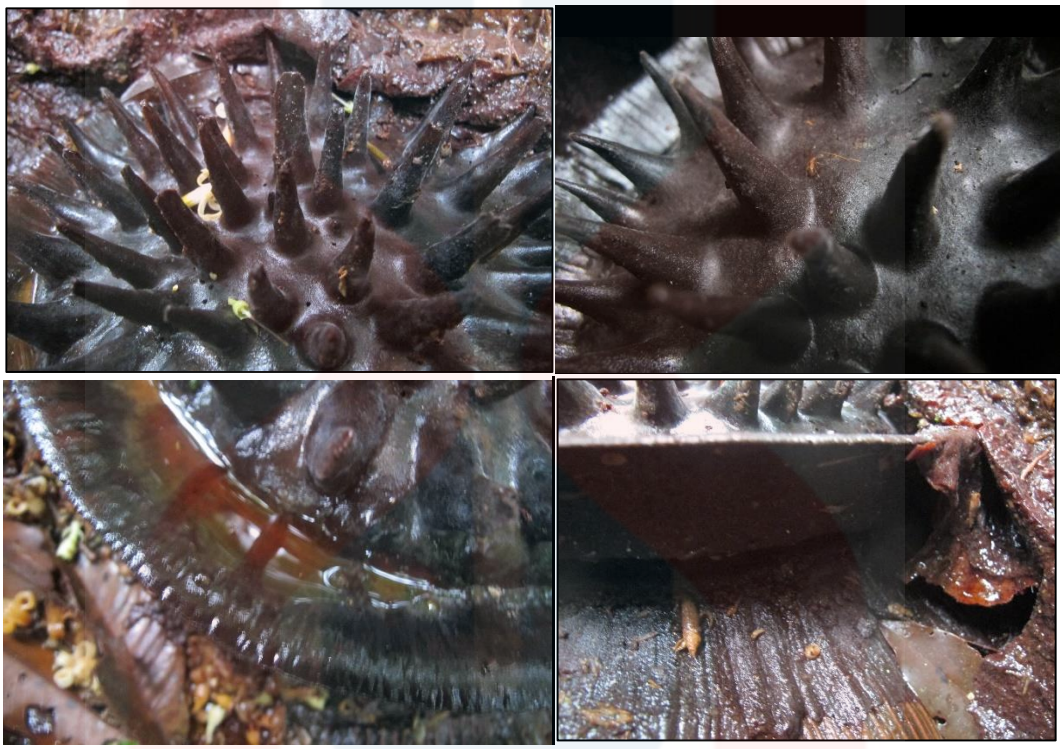


The white spots called Window was located in the lower surface of diaphragm and ramenta has a hairy-like structure that exist under the layer of diaphragm. The processes can be seen on the central disk of diaphragm.

Image: ©Nurulain

APPENDIX H

Compilations of rotten spiky process during deterioration stages

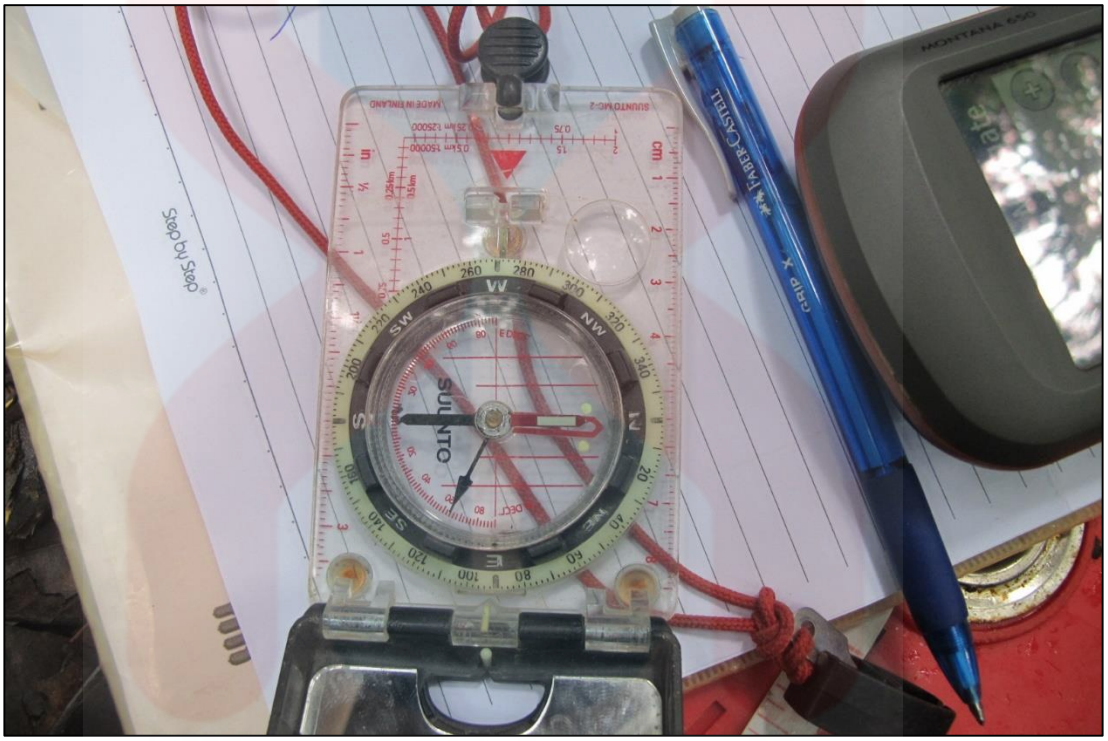


Rafflesia processes took a longer time than its perigone lobes to decay.

Image: ©Nurulain

APPENDIX I

Compass and Global Positioning System (GPS) were used for direction and coordinates.



The elevation and coordinates of each flowers with the centre of plot were recorded.

Image: ©Nurulain

APPENDIX J

Observation on site at Lojing Highlands, Kelantan

Field Work	Descriptions
	A) Observation was conducted on blooming phase of *Rafflesia kerri* Meijer flower at April 26, 2018. No data were recorded.
	B) Observation was conducted on October 11, 2018 for flowers at deterioration stage and mature fruit seed

Image: ©Nurulain

APPENDIX K

FYP Planning

FYP1	
January 2018	Title discussion
February 2018 – March 2018	Proposal writing draft Chapter 1: Introduction Chapter 2: Literature Review Chapter 3: Materials and Method
Early April 2018	Draft submission
April 25, 2018	Proposal Defence
FYP2	
October 10, 2018	Data Collection in Lojing Highlands
October 2018	Analysing data
December 2018	Final Report Draft Submission and Presentation
January 2019	Final Report Submission