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**EVALUATING THE COLONY DEVELOPMENT  
OF STINGLESS BEE (*HETEROTRIGONA ITAMA*)  
USING MORY TECHNIQUE**

by

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## DECLARATION

I declare that this thesis entitled “EVALUATING THE COLONY DEVELOPMENT OF STINGLESS BEE (*HETEROTRIGONA ITAMA*) USING MORY TECHNIQUE” 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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## Evaluating the Colony Development of Stingless Bee (*Heterotrigona itama*) using MORY Technique

### ABSTRACT

*Heterotrigona itama* is the common species of the stingless bee that has been propagated. The MUSTAFA and UTOB hive techniques are focused on the hive design only. These do not include the queen in their care for the colony's development. This study reports the effectiveness of an innovative technique in propagating the *H. itama* colonies. The MORY technique focuses on the hive and the queen in the propagation process. This study used nine colonies of *H. itama* and the period of this study is 3 months. This approach ensures 100% survival for *H. itama* species. This is reinforced with the t-test and one-way ANOVA. There were no significant changes in light intensity between the nine colonies' locations [ $t(13) = -.861, p = .202$ ]. Then, the daily mean of temperature results demonstrate substantial differences across the nine colonies [ $t(13) = 21.35, p < 0.001$ ]. The study found significant differences in daily mean of relative humidity among the nine colonies ( $t(13) = 9.96, p < 0.001$ ). Moreover, the effect of colony growth was significant, according to an analysis of variance, [ $F(109.92, 41.08) = 8, p < .001$ ]. Post hoc analyses using the Tukey HSD were done in this study to define the significance between the logs.

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## Menilai Perkembangan Koloni Lebah Tanpa Sengat (*Heterotrigona itama*) Menggunakan Teknik MORY

### ABSTRAK

*Heterotrigona itama* adalah spesies biasa lebah tanpa sengat yang telah dibiakkan. Teknik sarang MUSTAFA dan UTOB tertumpu kepada reka bentuk sarang sahaja. Ini tidak termasuk ratu dalam penjagaan mereka untuk pembangunan tanah jajahan. Kajian ini melaporkan keberkesanan teknik inovatif dalam membiak koloni *H. itama*. Teknik MORY memfokuskan pada sarang dan ratu dalam proses pembiakan. Kajian ini menggunakan sembilan koloni *H. itama* dan tempoh kajian ini adalah selama 3 bulan. Pendekatan ini memastikan 100% kemandirian untuk spesies *H. itama*. Ini diperkukuh dengan ujian-t dan ANOVA sehalu. Tiada perubahan ketara dalam keamatan cahaya antara lokasi sembilan koloni [ $t(13) = -.861, p = .202$ ]. Kemudian, purata keputusan suhu harian menunjukkan perbezaan yang ketara merentasi sembilan koloni [ $t(13) = 21.35, p < 0.001$ ]. Kajian mendapati perbezaan ketara dalam purata harian kelembapan relatif di antara sembilan koloni ( $t(13) = 9.96, p < 0.001$ ). Selain itu, kesan pertumbuhan koloni adalah ketara, menurut analisis varians, [ $F(109.92, 41.08) = 8, p = < .001$ ]. Analisis post hoc menggunakan Tukey HSD telah dilakukan dalam kajian ini untuk menentukan kepentingan antara log.

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## LIST OF ABBREVIATIONS

MORY	Mohd Rosli Yaakub
ANOVA	Analysis of Variance
MUSTAFA	Meliponiculture Using a Split-able Throne within Air-jacketed palace For Amplification
UTOB	Utrecht University – Tobago
MET Malaysia	Malaysian Meteorological Department
SPSS	Statistical Package for Social Science Version 29.0.2.0

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## CHAPTER 1

### INTRODUCTION

#### 1.1 Background of Study

Bees without stingers belong to the Apidae family. It denotes that honeybees, euglossine, and bumble bees are all members of the same family as stingless bees. Stingless bees derive their name from the fact that they lack a traditional sting. However, their primary defense mechanism lies in their mandibles, which they deploy to bite when threatened, as noted by Voeller et al. (2023). The name "stingless" is somewhat misleading, as these bees can resort to biting, especially when feeling threatened, often flying into the faces of intruding animals and humans. They also bite eyelids very aggressively and get inside the nose and the ears. They cling on while vibrating their wings and are highly annoying. However, stingless bees are important in our pollination.

*Heterotrigona itama* displays a uniform black color across its entire body. Its wings are transparent and shining. *H. bakeri*, *H. erythrogastra* and *H. itama* represent the three species forming this genus. Both *H. itama* and *H. bakeri* have fairly similar physical traits, except for *H. itama*'s coarse thorax and hairy scutellum. In contrast, the thorax of *H. bakeri* is smooth and polished, lacking such characteristics. The nest entrance is a standard downward-pointing tube (Shamsul Bahri Abd Razak & Mokhtar Ishak, 2017).

The management and breeding of stingless bees is known as meliponiculture. The stingless bees such as *Geniotrigona thoracica*, *H. itama*, *Lepidotrigona terminata*, *Tetragonula fuscobalteata* and *T. leviceps* play important roles in meliponiculture

(Kelly et al., 2014, as cited in Norhidayah Che Soh et al., 2021). This study focuses on the *Heterotrigona* genus, specifically *H. itama*. *H. itama* is among the highly recommended species for commercial honey production in Malaysia, as indicated by Arthur et al. (2020). This preference is attributed to the fact that *H. itama* is the most commonly cultivated species by stingless beekeepers, as claimed by Sharina Shamsudin et al. (2019). The split method is used by stingless beekeepers in meliponiculture to propagate the colony of stingless bees (Shamsul Bahri Abd Razak et al., 2023). The split technique requires brood and queen from the original log to become the new colony. It should be transferred into a new box. This method can help the stingless beekeepers to increase their colonies in produce a lot of yield and can sell it in both domestic and international markets.

## 1.2 Problem Statement

The MORY technique represents an innovative approach to cultivating stingless bees. The term "MORY" is an abbreviation for "Mohd Rosli Yaakub" and was introduced by Cikgu Mohd Rosli Yaakub, drawing upon his five years of expertise in stingless bee cultivation. This technique was specifically designed to enhance yield compared to existing methods.

Although the MORY approach has various potential advantages for beekeepers, its precise effect on *H. itama* colony expansion is not well understood. The lack of sufficient research on the MORY technique's application to this specific species of bee makes a thorough evaluation of its effectiveness in fostering colony growth and sustainability impossible.

Evaluating the impact of the MORY approach on *H. itama* colony growth is the driving force behind this investigation. The scope of this technique's potential contributions to sustainable beekeeping practices is limited due to the absence of

comprehensive insights into how it interacts with the distinctive traits and behaviors of *H. itama*.

As a result, the challenge highlights the importance of studying the impacts of the MORY technique, especially on the colony development of *H. itama*. Addressing this knowledge gap is critical for furthering our understanding of sustainable beekeeping techniques and optimizing the management of this specific bee. This technique also was conducted using scientific method and it will provide as guideline for further research study. Then, it can help to gather new knowledge and improve existing information about stingless bees.

### **1.3 Objectives**

The objectives of the study are as follows:

- i. To document the MORY technique in transplanting queen *Heterotrigona itama*.
- ii. To examine the environmental parameters such as temperature, humidity and light intensity influencing *Heterotrigona itama*.
- iii. To assess the growth of colony and yield of newly propagated colony of *Heterotrigona itama*.

### **1.4 Scope of Study**

The study was carried out in Kg. Paloh, Tendong, Pasir Mas, Kelantan. The MORY approach was applied and assessed in this study. This study seeks to evaluate the potential benefits, limitations and overall impact of applying the MORY technique in stimulating the development of *H. itama* colonies through a complete study. The colony size and volume of yield of new colony for *H. itama* species demonstrate the efficiency of the MORY approach. Temperature, humidity and light intensity are the three environmental parameters measured in this study. A lux meter is equipment used

to measure environmental factors. The environmental parameters for this study were collected weekly for the duration of three months. Nine colonies of *H. itama* were employed in the study.

### 1.5 Significant of Study

The significance of a study are as follows:

i. Beekeeping practices

Some stingless beekeepers keep stingless bees such as *H. itama* for honey and other products like bee pollen and propolis. Colony development research can help guide better beekeeping practices, which could contribute to increased economic rewards for stingless beekeepers. This is due to the high demand for stingless bee products in the local market and international markets. They also can improve the quality of the production to fulfill the demand.

ii. Agricultural impact

The Apidae family, which includes *H. itama*, is an essential pollinator of many crops. A better understanding of their colony development may have an impact on agriculture by increasing crop yields and food production. Then, the agricultural industry has the potential to boost the Gross Domestic Product (GDP). The stingless bees help in transferring the pollen grains onto stigmas that result in the process of pollination and lead to fertilization. This ultimately results in the development of fruit and seeds.

iii. Conservation of native bees

A species of stingless bee indigenous to Southeast Asia is called *H. itama*. The study of its colony development could be important for the protection of native bee

species, which play an important role in pollination and biodiversity. This action also can help to protect all of ecosystem from destroyed because of human activities like illegal logging, deforestation, and urbanization.

iv. Educational value

The findings of this study can be used to educate people about the importance of stingless bees and the distinctive traits of *H. itama*. Education can help the next generation to know the strategies to protect this pollinator from extinct in our ecosystems.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Biology of Stingless Bees

In tropical and subtropical regions of the world, stingless bees are one of the most significant pollinators of native plants and commercial crops. It has been documented that 60 stingless bee species are used commercially throughout Asia. The use of pollination and the production of honey and propolis are the primary focuses of meliponiculture in Southeast Asia at the moment (Rattanawanee, 2019). In Peninsular Malaysia, an analysis of 145 specimens from the Malaysian Agricultural Research and Development Institute (MARDI), the Malaysian Genome Institute (MGI), and samples collected from various stingless bee farms led to the examination and revision of 19 species of stingless bees across eight genera, as detailed in Table 2.1 (Siti Fatimah Samsudin et al., 2018). Since stingless bees are eusocial, they coexist in hives and generate honey. Stingless bee nests are frequently discovered in hollow objects like tree trunks and even inside walls. Stingless bees used as pets are frequently housed in wooden boxes by their keepers. Stingless bees forage for materials like tree resin to construct their nests.

**Table 2.1:** List of species of stingless bees in Peninsular Malaysia

No.	Species
1	<i>Geniotrigona thoracica</i> (Smith, 1857)
2	<i>Heterotrigona erythrogastra</i> (Cameron, 1902)
3	<i>Heterotrigona itama</i> (Cockerell, 1918)
4	<i>Homotrigona fimbriata</i> (Smith, 1857)
5	<i>Lepidotrigona doipaensis</i> (Schwarz, 1939)
6	<i>Lepidotrigona nitidiventris</i> (Smith, 1857)
7	<i>Lepidotrigona terminata</i> (Smith, 1857)
8	<i>Lophotrigona canifrons</i> (Smith, 1857)
9	<i>Tetragonilla collina</i> (Smith, 1857)
10	<i>Tetragonilla fuscibasis</i> (Cockerell, 1920)
11	<i>Tetragonula drescheri</i> (Schwarz, 1939)
12	<i>Tetragonula fuscobalteata</i> (Cameron, 1908)
13	<i>Tetragonula geissleri</i> (Cockerell, 1918)
14	<i>Tetragonula laeviceps</i> (Smith, 1857)
15	<i>Tetragonula minangkabau</i> (Sakagami & Inoue, 1985)
16	<i>Tetragonula testaceitarsis</i> (Cameron, 1902)
17	<i>Tetrigona apicalis</i> (Smith, 1857)
18	<i>Tetrigona binghami</i> (Schwarz, 1937)
19	<i>Tetrigona melanoleuca</i> (Cockerell, 1929)

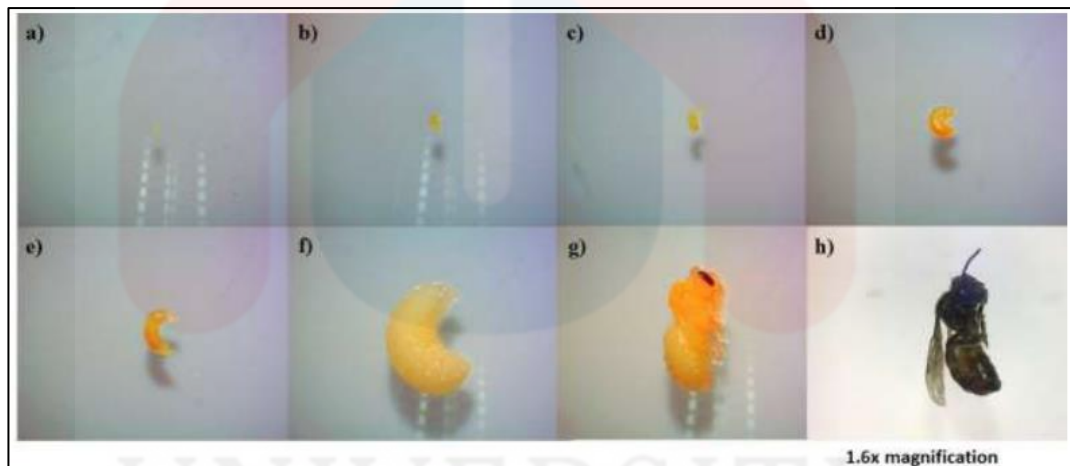
(Source: Siti Fatimah Samsudin et al., 2018)

## 2.2 Life Cycle of Stingless Bees

The life cycle of stingless bees, encompassing egg, larva, pupal and adult stages, are discussed further in the sub-topics below.

### 2.2.1 Egg, Larva and Pupal Stages of Stingless Bees

The queen of stingless bees lays a single egg in honey and pollen-filled brood cells. This is because this pollinator stores pollen and nectar in pot-like structures near the nest's outside edge. The workers then immediately seal the cell. Based on the Figure 2.2, it shows stages of *Heterotrigona itama* in egg, larva and pupal. The transition from the egg stage to the larva stage takes about 1 - 2 days. The larva stages obtain enough food because the workers do the work. It takes 35 days for the larva to mature into an immature larva. It takes 14 days from the immature larva to the pupal stage (Wahizatul et al., 2022).



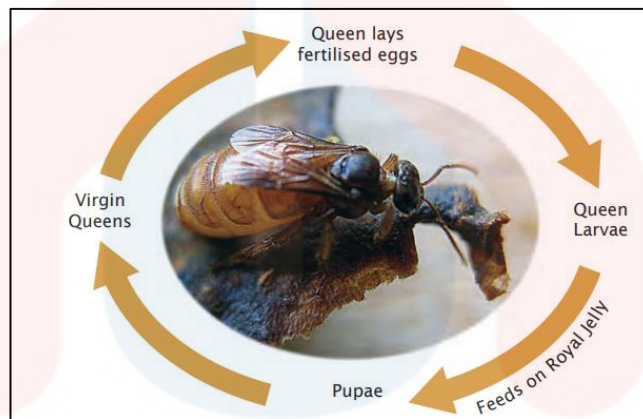
(Source: Wahizatul et al., 2022)

**Figure 2.2:** Life cycle of *in-vitro* queen of *Heterotrigona itama*. a) An egg; b) 1-3 days old larvae; c) 5 days old larvae; d) 5-6 days old larvae; e) 6-7 days old larvae; f) 35 days old larvae; g) 56 days old pupae; and h) *in-vitro* of *Heterotrigona itama*

### 2.2.2 Adult Stages of Stingless Bees

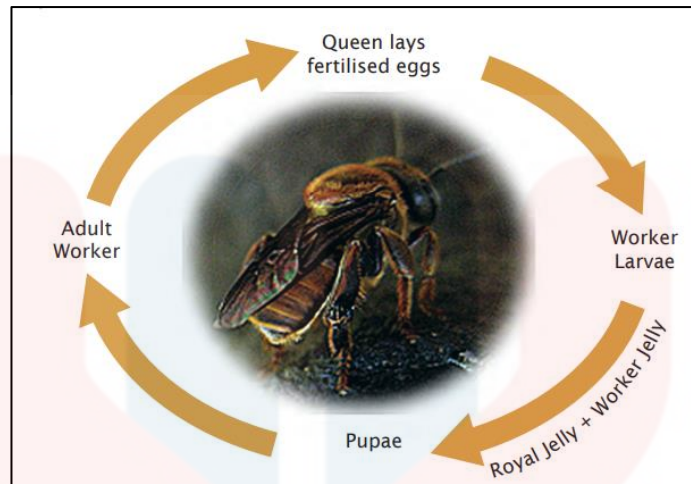
Adult stages include the queen, worker and drone. Swarming is the method used by stingless bees to reproduce their colonies. The queen, workers and drones of stingless bees are present. Figures 2.3, 2.4 and 2.5 show the life cycle of queen, worker

and drone respectively. Laying eggs is the queen's primary task. One drone from a different colony forms a mating pair with the queen. The drones are the male components of the colony and play a crucial role in colony reproduction, whereas the workers' stingless bees are the female components of a colony aside from the queen (Kwapong et al., 2010). Most of the nest's operations, including foraging, housekeeping, defense and larval feeding, are carried out by the adults as they emerge as workers.



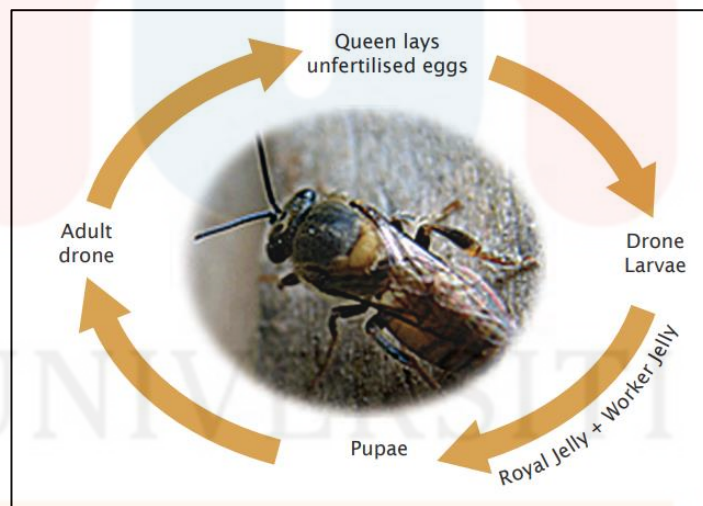
(Source: Kwapong et al., 2010)

**Figure 2.3:** Life cycle of the stingless bee queen



(Source: Kwapong et al., 2010)

**Figure 2.4:** Life cycle of the worker stingless bee



(Source: Kwapong et al., 2010)

**Figure 2.5:** Life cycle of the drone stingless bee

### 2.3 Value Products of Stingless Bees

Propolis and honey, two stingless bee products, have considerable commercial value. For instance, it was predicted that the worldwide propolis market will reach 610

million USD in 2020 and increase at a projected annual net growth rate of 5.48% from 2021 to 2026 (Goh et al., 2023). Locally known as "*Kelulut*" this sector of the economy, which generated RM33.6 million in revenue in 2020, has the potential to increase to RM3.03 billion in yearly sales if promoted (Lee, 2021).

#### **2.4 Medical Properties of Stingless Bees' Products**

Honey from stingless bees and the propolis they produce have antioxidant, anti-inflammatory, anti-cancer, and antibacterial properties. As a result, the honey of stingless bees contains anti-obesity properties. Then, the ability of stingless bee cerumen extracts to block the enzymes that catalyze the action of pro-inflammatory mediators gives them the potential to be anti-inflammatory agents.

Although less inhibitory than honeybee propolis in this investigation, cerumen extracts were comparable to that of the positive control, Trolox (an antioxidant similar to vitamin E). Additionally, stingless bee cerumen extracts have been utilized to potentially treat cancer in the human breast, lung, liver, stomach and colon cancer cell lines by causing high cytotoxicity and apoptotic-like cell morphology. Extracts from stingless bee pollen show anti-inflammatory properties by lowering mouse footpad edema and diminishing signs of pain (antinociceptive) response after acetic acid treatment (Al - Hatamleh, et al., 2020).

#### **2.5 Yield Collection**

Table 2.2 shows the previous study, which used yield collection at different meliponiculture locations. The previous study does the researched on the *H. itama* species. The time frame for this study is one year, from June 2019 to June 2020.

**Table 2.2:** Honey production in dry and rainy seasons

Meliponi-culture location	Sum of hives	Honey production at rainy season			Honey production at dry season			Honey prod. hives <sup>-1</sup> year <sup>-1</sup>	Honey prod. all hives (L)
		All hives (Lmonth <sup>-1</sup> )	Per hive (L)	For 5 months (L)	All hives (Lmonth <sup>-1</sup> )	Per hive (L)	For 5 months (L)		
Fahrudin <sup>a</sup>	252	30	0.12	0.60	50	0.20	0.99	1.59	400
Warhamni <sup>b</sup>	121	20	0.17	0.83	30	0.25	1.24	2.07	250
Yusuf <sup>b</sup>	107	15	0.14	0.70	20	0.19	0.93	1.64	175
Suriyani <sup>c</sup>	96	15	0.16	0.78	20	0.21	1.04	1.82	175
Ibnu Kasir <sup>c</sup>	100	25	0.25	1.25	35	0.35	1.75	3.00	300
Average	135.2	21	<b>0.17</b>	0.83	31	<b>0.24</b>	1.19	<b>2.02</b>	260

<sup>a</sup> Land coverage by combination forest and garden (type 1).  
<sup>b</sup> Land coverage by combination settlement, shrub, and paddy fields (type 2).  
<sup>c</sup> Land coverage by combination settlement, plantation, and shrubs (type 3).

(Source: Wahyuningtyas et al., 2021)

According to Seprido & Nariman Hadi (2024), they conducted research on duration within 6 months and specified using the *H. itama* species with 10 colonies. The technique they employ involves covering the hive with a 2-inch-thick board that measures 30 cm in length, 35 cm in width, and 7 cm in height to cultivate the colonies. Table 2.3 displays the findings of this research, and the total volume of honey per pot is 41 ml.

**Table 2.3:** *Heterotrigona itama* colonies in adapted nature

No	Colony	Plants of Colonial Origin	Acceptance Time (Days)	Time to Make Honey Pots (days)	Number of honey pots (fruit)	Volume of honey per pot (ml)
1	1	Rambutan	83	102	22	3
2	2	Rambutan	85	93	28	4
3	3	Rambutan	95	86	18	3.5
4	4	Rambutan	74	93	25	3
5	5	Rubber	65	92	21	4
6	6	Rubber	88	84	20	5.5
7	7	Rubber	91	76	26	5
8	8	Rubber	86	112	27	4
9	9	Rubber	81	98	25	5
10	10	Duku	75	100	16	4
Total			823	936	228	41
Average			82.3	93.6	22.8	4.1

(Source: Seprido & Nariman Hadi, 2024)

## **2.6 Current Beekeeping Practices**

Stingless beekeepers come out with a lot of beekeeping practices to propagate the new colony.

### **2.6.1 Hive Designs**

The stingless beekeepers employ a variety of hives built of various materials. Log hives and wooden box hives were the most common hives split. In terms of colony propagation, the log hive is the mother. A wooden box hive is a common type of man-made stingless bee hive. As the entrance, they construct a little hole. The wooden box hive will use two techniques which are a clear plastic sheet between the lid and the hive to allow for scouting and other systems will use two chambers within the wooden box.

Moreover, bamboo hives, coconut hives and PVC hives are also suitable for stingless bees. The bamboo hive is the most basic. It does this by splitting a bamboo chamber lengthwise and drying a small hole in one of the sides. The coconut hives are then used for the entire coconut. This design has a side effect of needing the destruction of the majority of the hive to get the honey. Finally, a farm in Kerala, India, promoted PVC hives for the propagation of stingless bees. This design can be mounted in a variety of positions to assist in protecting the hive from predators (Fisher, 2021).

### **2.6.2 Methods in Propagate the New Colony of Stingless Bees**

There are several methods for propagating stingless bees. First, the stingless bees are propagated through splitting or division. Tim Heard, an early adopter of the splitting approach. The failure to re-queen is a result of the splitting, and it can affect the colony's activity. Second, the propagation method is education or budding. It was

the original Australian approach, devised by John Klumpp. The disadvantages of this strategy are that it requires more management and takes a longer time than the splitting method.

Aside from that, the brood transfer procedure is used in Brazil to propagate stingless bees. It takes a piece of brood from a healthy colony and places it in an empty box to create a new colony of stingless bees. Allan Beil and Robert Luttrell were early adopters of this strategy. The drawback of the brood transfer approach is that the new colonies can be poor sometimes and require extra administration. The queen transmits and broods by mail, which is how stingless bees reproduce. The queen transfers method requires the addition of sugar water to boost success rates. Brood by mail is appropriate for queenless hives or to begin education processes (Haley, 2018).

## **2.7 Agriculture Implication of Stingless Bees**

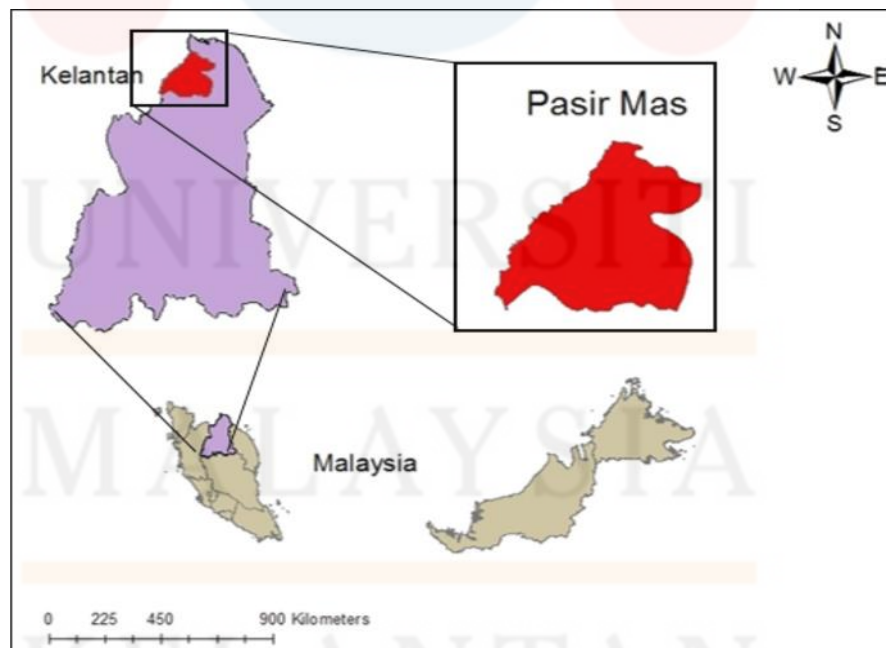
The pollinators especially stingless bees is can help in pollination process. This is due to their ability to transmit pollen from one flower to another. Stingless bees can pollinate the flowers in the greenhouse as well. The greenhouse is a structure designed to control the temperature and humidity of the inside environment. According to the findings of Wahizatul et al. (2017), cucumbers pollinated by stingless bees produced heavier, longer, and larger cucumbers than those pollinated by non-stingless bees. This has the potential to boost food production.

## CHAPTER 3

### MATERIAL AND METHOD

#### 3.1 Description of the Study Area

The study was carried out in Kg. Paloh, Tendong, Pasir Mas, Kelantan, as illustrated in Figure 3.1. Positioned at approximately 6° 04' 11.8"N latitude and 102° 12' 38.9"E longitude, this location was selected due to its abundance of plants facilitating significant interactions between *Heterotrigona itama* species and the environment. Kg. Paloh is characterized by diverse plant species, including the bridal veil tree, lime tree, and areca palm. Notably, this lowland area provides conducive conditions for robust plant growth.



(Source: Nur Aniza Mohamd Hanan et al., 2020)

**Figure 3.1:** The location of study area

### 3.2 Materials

Table 3.1 shows the equipment used in this study.

**Table 3.1:** Equipments and functions

No.	Equipments	Functions
1.	Lux meter	A lux meter was used for assessing the intensity of light in the environment where the <i>H. itama</i> colonies are located. This assists in assuring to illumination conditions for the colony's growth and well-being.
2.	Meteorology data	Monitoring and understanding humidity levels is important since they have a big impact on the health of the colony. The data that were bought are the daily mean of relative humidity and daily mean of temperature from Metrology Station Kota Bharu.
3.	Camera	Camera useful to capture the growth of the new colony. By, capturing the growth, it can tell whether the colonies become stronger or not.
4.	Topping	Topping is used for split the new colony of <i>Heterotrigona itama</i> species. This topping can be hive for <i>H. itama</i> .
5.	Tree trunk	Tree trunk serves as their entrance for the new colony by using the MORY technique.
6.	Chisel	Chisel aims to properly modify the tree trunk. It carefully creates openings and entrances through its actions.
7.	Torch fire gun	Propolis, which bees utilize to seal hive holes, may need to be melted to access the colony structure, which is why the torch fire gun is employed.
8.	Transparent plastic cover	Transparent plastic cover provides a clear view for observing the activities and growth of the <i>H. itama</i> colonies.
9.	Nail	Structures are held in place using nails,

		for example when the topping is fastened to the tree trunk.
10.	Hammer	Hammer is used to secure equipment and make modifications to the tree trunk.
11.	Notebook and pencil	Notebook and pencil is used to write the data collection. It helps to do the analysis and understanding of the study.
12.	Image J	The application, Image J, calculated the area of brood, pollen, and honey pots. This aided in gathering reliable data on it.
13.	Digital scale (SF 400)	Yield from new colony was measured by weighing it on a digital scale.
14.	Stingless bee honey pump	Honey was absorbed using the honey pump.
15.	Plastic strainer	After the honey was absorbed, it was filtered using a strainer. This method is to filter honey from any substances when the suction process.
16.	Plastic jug	Then, honey was placed in the plastic jug.

### 3.3 Methods

The methods utilized in this study are being developed to align with the project's objectives as detailed in this section. Figure 3.2 illustrates a flow diagram of the study.

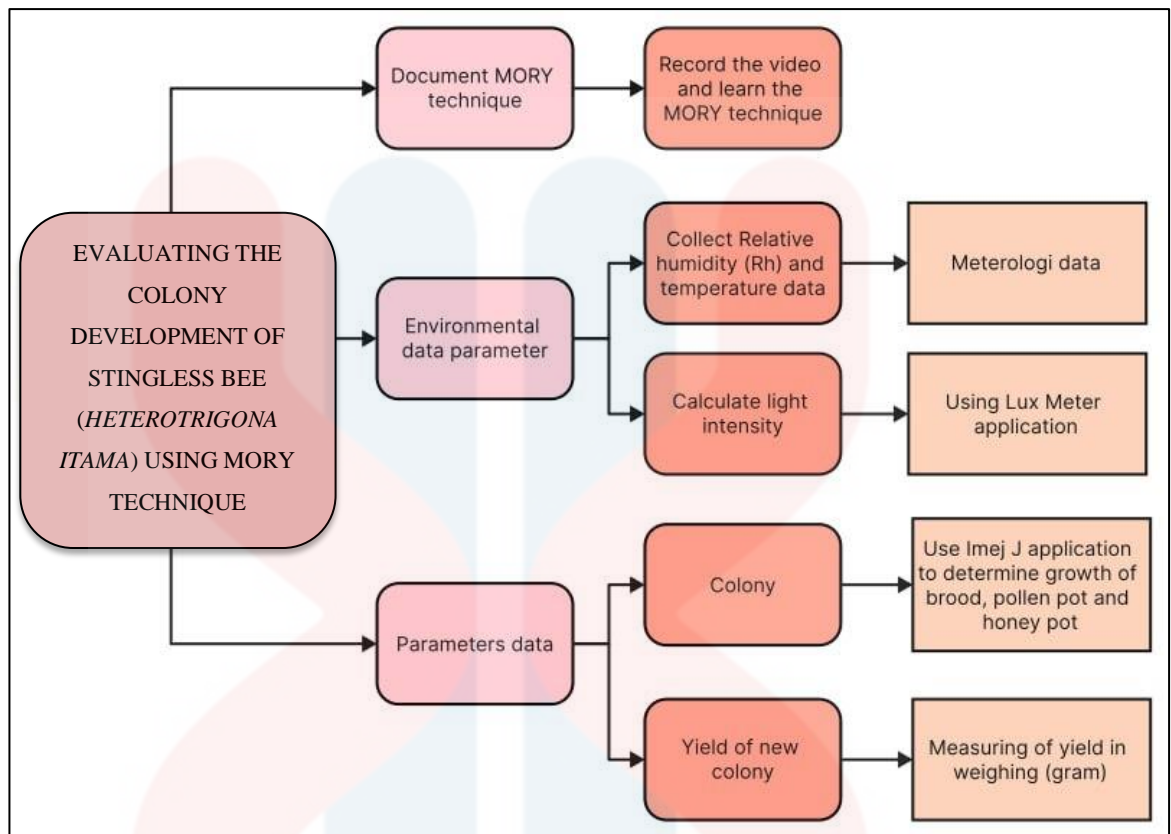


Figure 3.2: Flow diagram of the study

### 3.3.1 Document the MORY Technique in Transplanting Queen *Heterotrigona itama*

The MORY technique uses a log as an entrance for the stingless bees while topping as a split of a new colony.

Construct a log measuring 0.61 meters in length and at its center, create a hole with a diameter of 0.02 meters and a depth of 0.03 meters. Place it at an angle of 0.79 radians from the hole. Subsequently, carve an entrance 0.01 meters in length and 0.01 meters in height from the top of the log, with the entrance measuring 0.02 meters in width. After that, dry the log's surface using the torch gun (Figure 3.3). Then, apply propolis to seal it (Figure 3.4). Figure 3.5 also shows the form of the propolis of *Geniotrigona thoracica*.



**Figure 3.3:** Dry process of log's surface



**Figure 3.4:** Surface of the log layered with propolis



**Figure 3.5:** Propolis from *Geniotrigona thoracica*

Next, procure the topping, which already includes a central hole measuring 0.05 meters in diameter for *H. itama* in Figure 3.6. The topping was available in two sizes which are measuring 0.51 meters in length, 0.51 meters in width and 0.10 meters in height and another measuring 0.36 meters in length, 0.36 meters in width and 0.08 meters in height. This study employed eight and one with topping sizes of 0.51 meters and 0.36 meters respectively. Therefore, secure the log and the topping together using nails. This made up a new hive for the colony of *H. itama* (Figure 3.7). Finally, wrap it with transparent plastic and secure it with propolis.



**Figure 3.6:** Hole at the topping



**Figure 3.7:** A new hive of *Heterotrigona itama*

This study employed two treatments, namely immature queens and queens which are shown in Figures 3.8 and 3.9 respectively. The procedure involved retrieving colony eggs (Figure 3.10), honey pots (Figure 3.11), pollen pots (Figure 3.12) and either immature queen stages or queens from diverse *H. itama* colonies and then placing them within the topping. Colonies 1, 4, 7, 8 and 9 kidnapped the reproductive queen from the strong colony and employed the 0.51 meter topping size. Colonies 2, 3 and 6 are treated with a virgin queen, and the topping measures 0.51 metres. Colony 5 utilized 0.36 meters of topping size and had an immature queen. The treatment of various sizes of topping for *H. itama* has a significant impact on colony development. The topping size of 0.36 meters was inappropriate for *H. itama* species due to their rapid development. This size of topping gets crowded, leaving little room for proper development. Using 0.51 meters of it can help the colony develop properly.



**Figure 3.8:** Immature queen of *Heterotrigona itama*



**Figure 3.9:** Queen of *Heterotrigona itama*



**Figure 3.10:** Brood of *Heterotrigona itama*

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**Figure 3.11:** Honey pots of *Heterotrigona itama*



**Figure 3.12:** Pollen pots of *Heterotrigona itama*

The colony eggs were horizontally divided to minimize damage during the splitting process (Figure 3.13). A 0.01 meter section was transferred from a colony's entrance to the entrance of the new nest to effectively attract *H. itama* workers as shown in Figure 3.14. The study was conducted using nine *H. itama* colonies that were

established on different dates. Colonies 1, 2 and 3 were established on 20 October 2023, with Colonies 4 and 5 following on 21 October 2023. Next, Colonies 6 and 7 were set up on 27 October 2023, then Colonies 8 and 9 on 28 October 2023. This is because the strong colonies must be defined before transplanting and setting up the hive for the new colonies takes time. In this study, the total number of colonies was nine colonies that have been decided. This is because *H. itama* is the most common species in stingless bees that have been cultivated by stingless beekeepers.



**Figure 3.13:** Horizontal cutting to brood of *Heterotrigona itama*



**Figure 3.14:** Entrance of new hive for *Heterotrigona itama*

### 3.3.2 Examining the Environmental Parameters

This study recorded environmental data, specifically focusing on three parameters which are relative humidity, temperature and light intensity. This study used meteorological data. Data on the daily mean of relative humidity and temperature were more precise when obtained from the Malaysian Meteorological Department (MET Malaysia). Meteorology data were collected across three months of the research period. These data were bought from the MyMET data website. Temperature and relative humidity measurements come from their surroundings, not the nest itself.

Furthermore, data on light intensity was collected utilizing a lux meter, covering five distinct locations for each log, denoted as A, B, C, D and E as shown in Figure 3.15. This selection was made considering that the light entering the hive produces unique readings at each location, with careful consideration given to depicting diverse areas in the nest where light conditions could vary. This data collection occurred weekly over a three-month period. The utilization of these instruments is crucial for accurately quantifying environmental conditions within the study area, allowing us to develop a comprehensive understanding of how these factors might influence the study variables.



**Figure 3.15:** Five points for measuring the light intensity

### 3.3.3 Assessing the Growth of Colony and Yield of Newly Propagated Colony

This study assesses the development of the colony, pollen pots and honey pots. The colony's growth was quantified by employing an application that incorporated images depicting the progression of each colony. These images were captured from the initiation of the new colony until it evolved into an active colony over the course of three months. This approach provides insights into the growth conditions of *H. itama* colonies, fostering a more comprehensive understanding of the formation of stingless bee colonies and their hive-building processes. It has been done by using the Image J application (Figure 3.16).



**Figure 3.16:** Development of Log 1 using Image J

Hence, yields were gathered after the six months of this study. This decision was made to emphasize the significance of maintaining the quality of honey. The mass serves as a metric for measuring the yield. These data collections were then compared with findings from a prior study, aiming to evaluate the effectiveness of the MORY approach in achieving a high yield.

Figure 3.17 shows the suction process of honey. Thus, the stingless bee honey pump was used to gather the yield (Figure 3.18). It can facilitate the collection process. After that, a plastic strainer was used to filter the honey before it was placed into the plastic jug (Figure 3.19). This technique is used to remove any particles from the honey during the suction process. The filtered honey was weighed using a digital scale (SF 400) (Figure 3.20).



**Figure 3.17:** Honey suction process



**Figure 3.18:** Stingless bee honey pump



**Figure 3.19:** Filtered process



**Figure 3.20:** Digital scale (SF 400)

### 3.4 Data Analysis

The data analysis was done using Statistical Package for Social Science (SPSS) Version 29.0.2.0. One Sample t-test was used in this study's statistical analysis. It presents data for the environmental parameters which are relative humidity, temperature and light intensity that affect the growth of colony for *H. itama* species. These data were used t-test for the statistical analysis. This can help to conclude that these three data play an important role in the growth of the colony, especially *H. itama*.

Moreover, the growth of the brood, honey and pollen pots was analyzed using one-way ANOVA. The one-way ANOVA can demonstrate the relevance of the brood, honey and pollen pots of different colonies for *H. itama*. Then, the Tukey test also was used in this study to identify the significance between the nine logs. The effectiveness of the MORY technique can be proven by using ANOVA analysis.

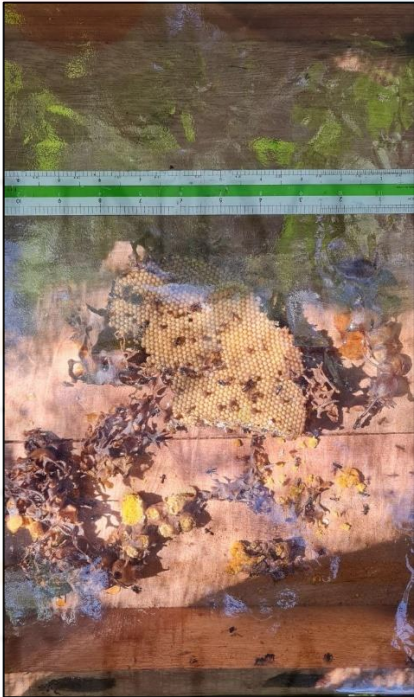

## CHAPTER 4

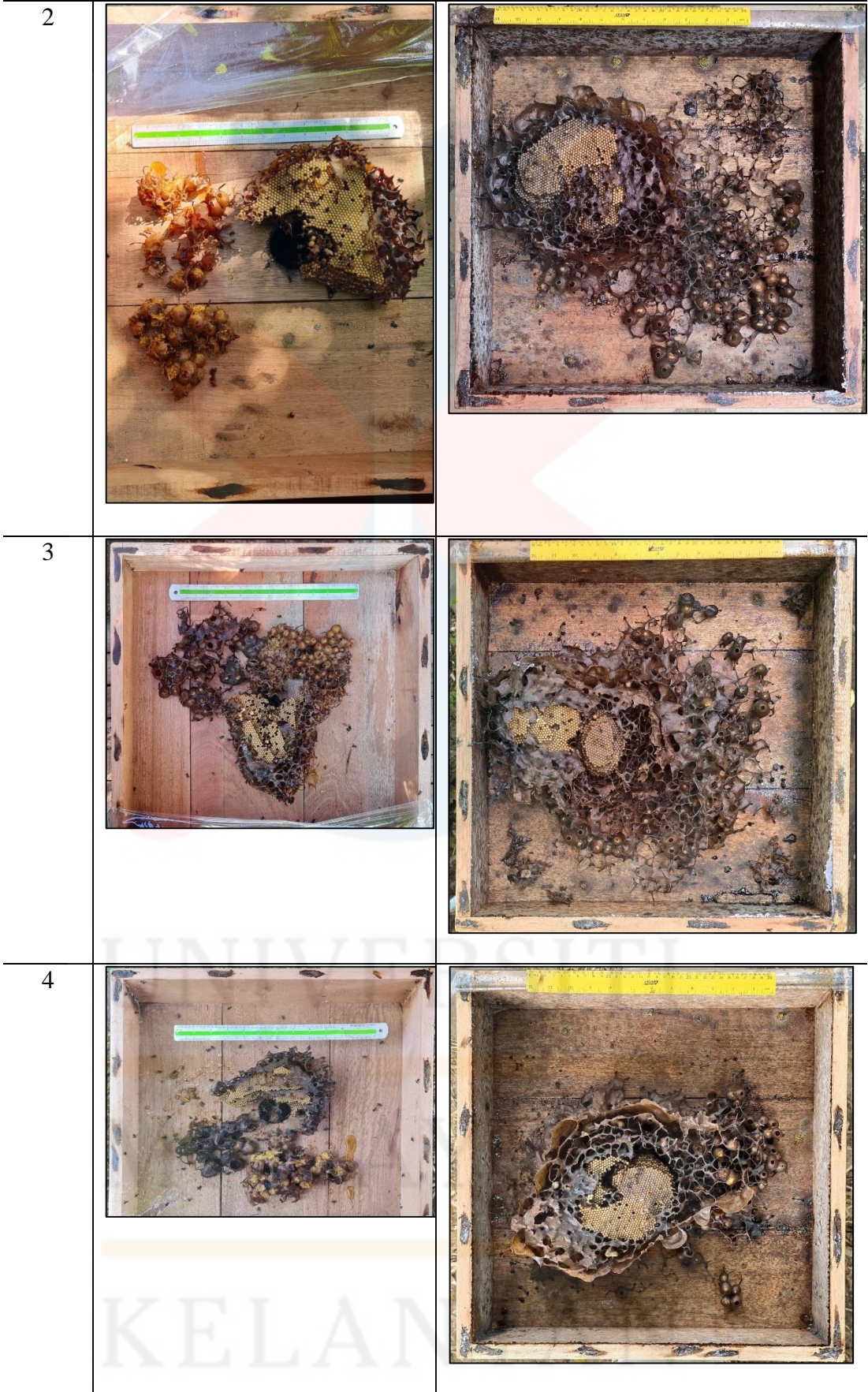
### RESULT AND DISCUSSION

#### 4.1 Evaluation of the MORY Technique in Transplanting the Queen *Heterotrigona itama*

Table 4.1 below shows the initial and final of the nine colonies of *Heterotrigona itama* using the MORY technique. The final images of the colonies were captured after 3 months of period of the study.

**Table 4.1:** Survivability of nine colonies of *Heterotrigona itama*

LOG	INITIAL	FINAL
1		



5



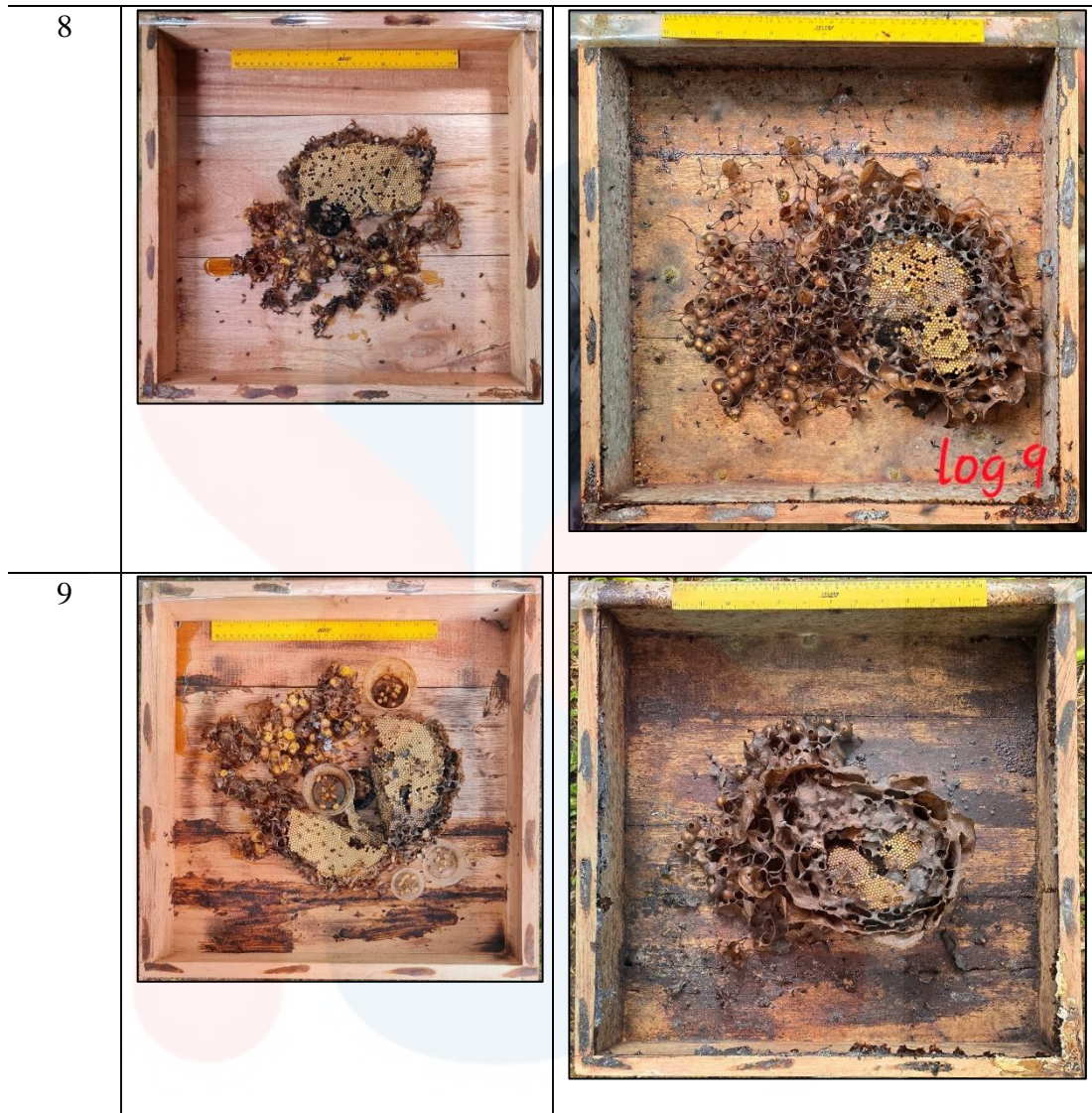
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There are many techniques in the propagation of the stingless bee colony and one of them is the MUSTAFA - hive. Figure 4.1 shows the compartment housing the brood cells, the honey cassette and the roof make up the three primary parts of the MUSTAFA - hives. For stingless bees, the only way in and out of the brood cell compartment is through a 25mm diameter hole. A hole of 35mm in diameter connects the brood cell compartment to the honey cassette (Luqman et al., 2017). This allowed the bees to store honey.

Furthermore, the UTOB hive is also known as the stingless beehive (Figure 4.2). Tobago's Utrecht University established the UTOB. The hive must be able for

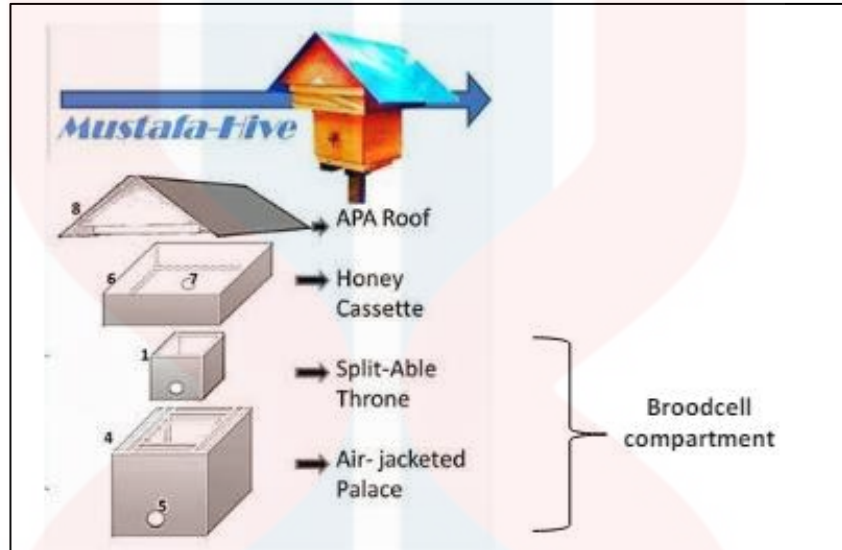
successful honey harvesting without causing damage or destruction to pollen pots (Sommeijer, 2015). A well-developed colony should not require much manipulation to access the brood chamber, which should be a separate unit that may be opened for inspection. The size of the brood chamber should be just right to accommodate a sizable brood nest and a small number of store pots. To prevent phorid flies from attacking, removal and replacement should cause only minor damage and cracks.

MUSTAFA and UTOB hive designs are only focused on the hive. In contrast, the MORY technique focuses on the queen and hive. This is the benefit of the MORY technique. It is present in Figure 4.3, which shows the success of this approach. These findings proved that this novel technique ensures 100% survival for *H. itama* colonies. All nine colonies were successfully developed during the study period.

The MORY technique was found suitable for the queen or immature queen in helping the colony develop well. The queen has an essential role in the colony, maintaining its unity and ensuring the development and survival of these matriarchal societies (Bueno et al., 2023). Usually, a colony has only one queen at a time. According to Mohamad Syukri Tan Shilan et al. (2022), the emergence of a mature queen may harm the artificial propagation strategy due to its pheromone function. The argument can be disputed because the MORY approach was proven of their effectiveness in establishing a new colony with a queen or immature queen.

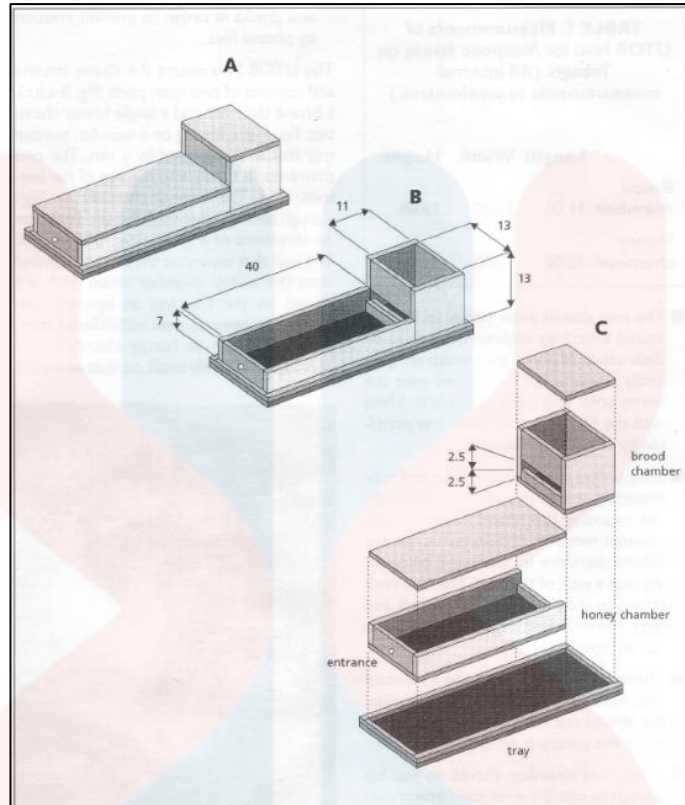
There are weaknesses in the UTOB hive design which are it cannot support the larger colonies of stingless bees (Darla, & Sherpa, 2023). Then, the MUSTAFA hive design has a lot of compartments that make this design complicated to build. In contrast with the MORY technique, this technique can support the larger size of the colony and is simple to build. This is because the MORY technique uses 0.51 meters

and 0.36 meters of topping as their hive. Then, the MORY technique shows the quick development of a new colony within a week (Figure 4.3).



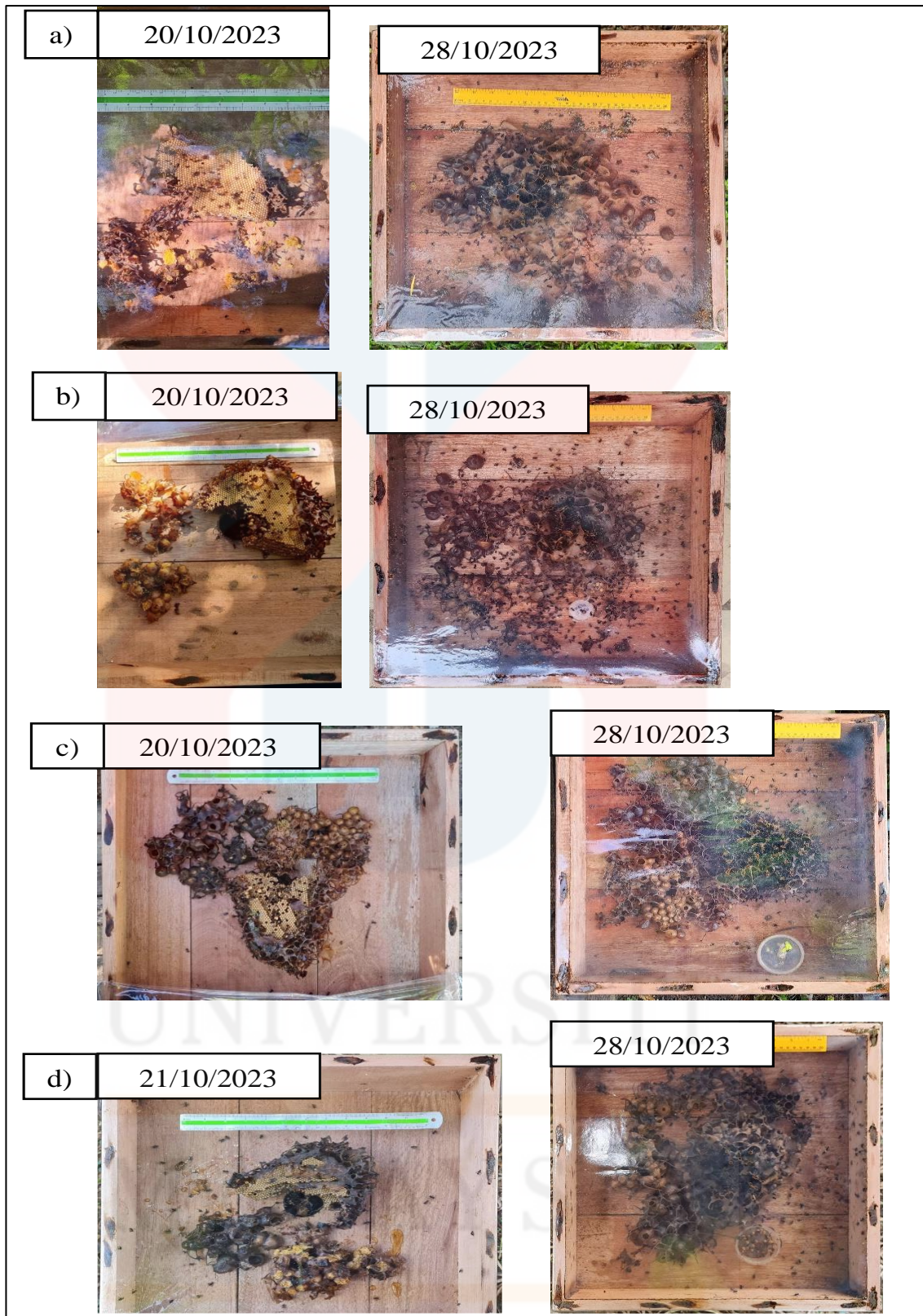
(Source: Luqman et al., 2017)

**Figure 4.1:** MUSTAFA – hive technique

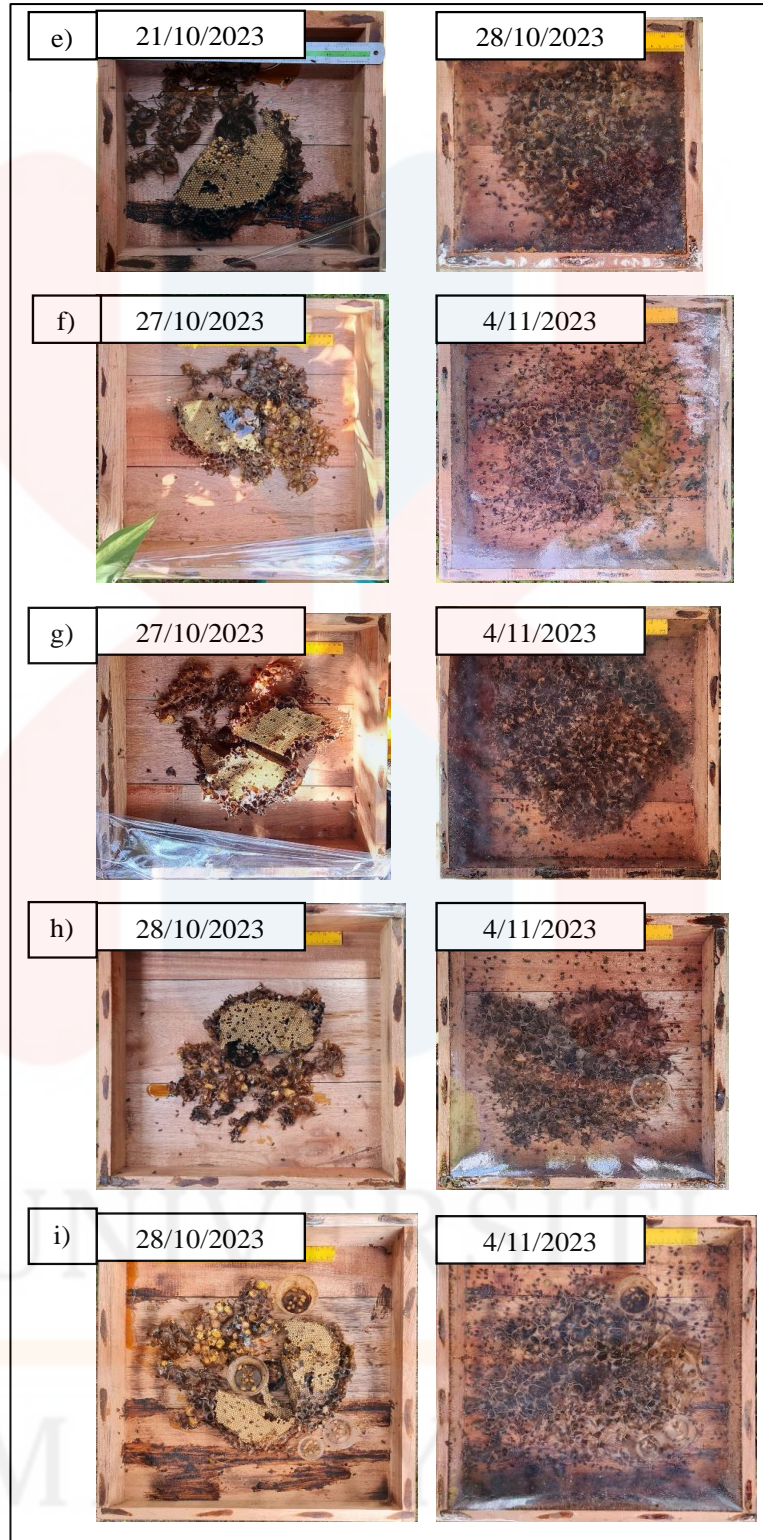


(Source: Sommeijer, 2015)

**Figure 4.2:** UTOB hive technique



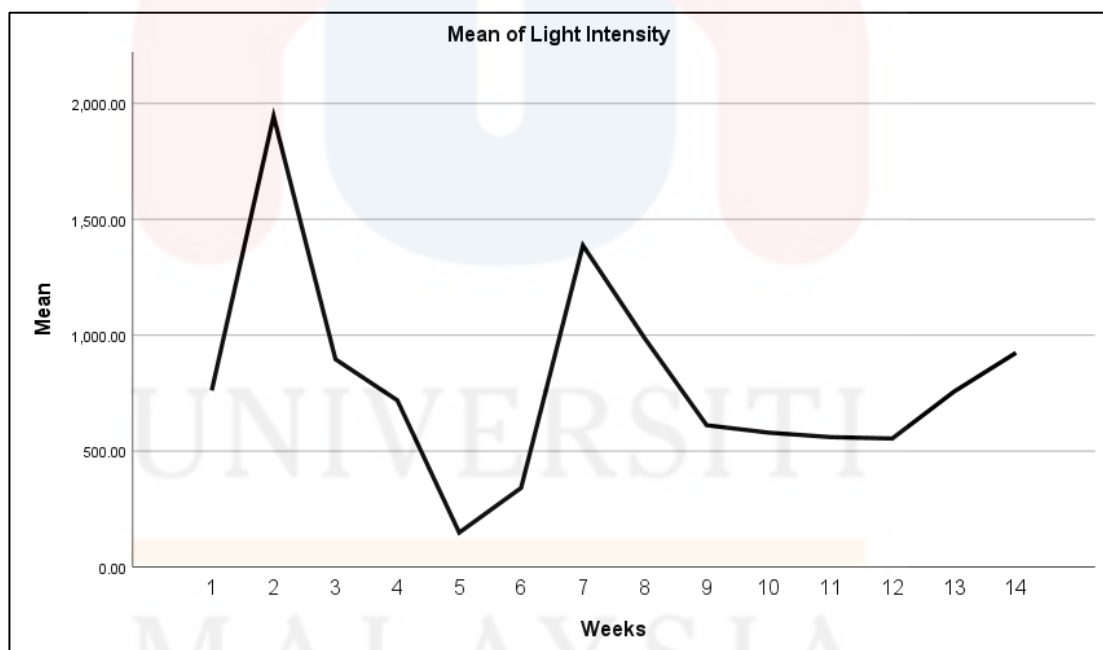
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**Figure 4.3:** A week of development for: a) Log 1; b) Log 2; c) Log 3; d) Log 4; e) Log 5; f) Log 6; g) Log 7; h) Log 8; and i) Log 9

## 4.2 The Environmental Parameters

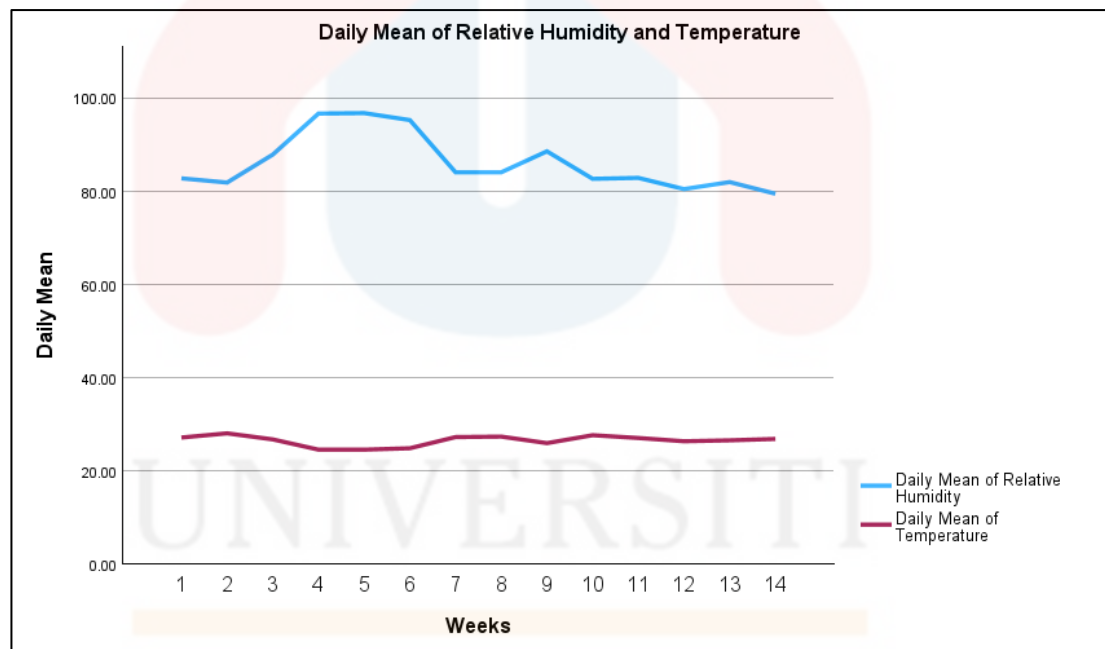
Environmental data plays an important role in the insect cycle, especially stingless bees. In general, the placement of hives and the environment in which they are situated play critical roles in providing stingless bee colonies and a high productive yield for each colony (Harun, 2015). There were no significant changes in light intensity between the nine colonies' locations [ $t(13) = -.861, p = .202$ ]. This shows that the colonies are organized in the same area which is their natural habitat. Based on Figure 4.4, the average light intensity was 1,000.00. The t-test data for light intensity is shown in Appendix B while Appendix A was the data for mean of light intensity.



**Figure 4.4:** Line graph for the mean of light intensity

Moreover, the daily mean of temperature results demonstrate substantial differences across the nine colonies [ $t(13) = 21.35, p < 0.001$ ]. The study found significant differences in the daily mean of relative humidity among the nine colonies

( $t(13) = 9.96, p < 0.001$ ). Figure 4.5 shows that the daily mean of relative humidity and daily mean of temperature have increased and decreased data. Stingless bees are classified as insects and are also known as poikilotherms. The body temperature of bees varies significantly with the surroundings and their actions are heavily influenced by air temperature (Dantas, 2016). The t-test data for daily mean of temperature and daily mean of relative humidity are shown in Appendices C and D respectively. Then, the Malaysian Meteorological Department (MET Malaysia) provides statistics on the daily mean of temperature and daily mean of relative humidity in Appendices F and G.



**Figure 4.5:** Line graph for the daily mean of relative humidity and temperature

### 4.3 The Growth of Colony and Yield of Newly Propagated Colony.

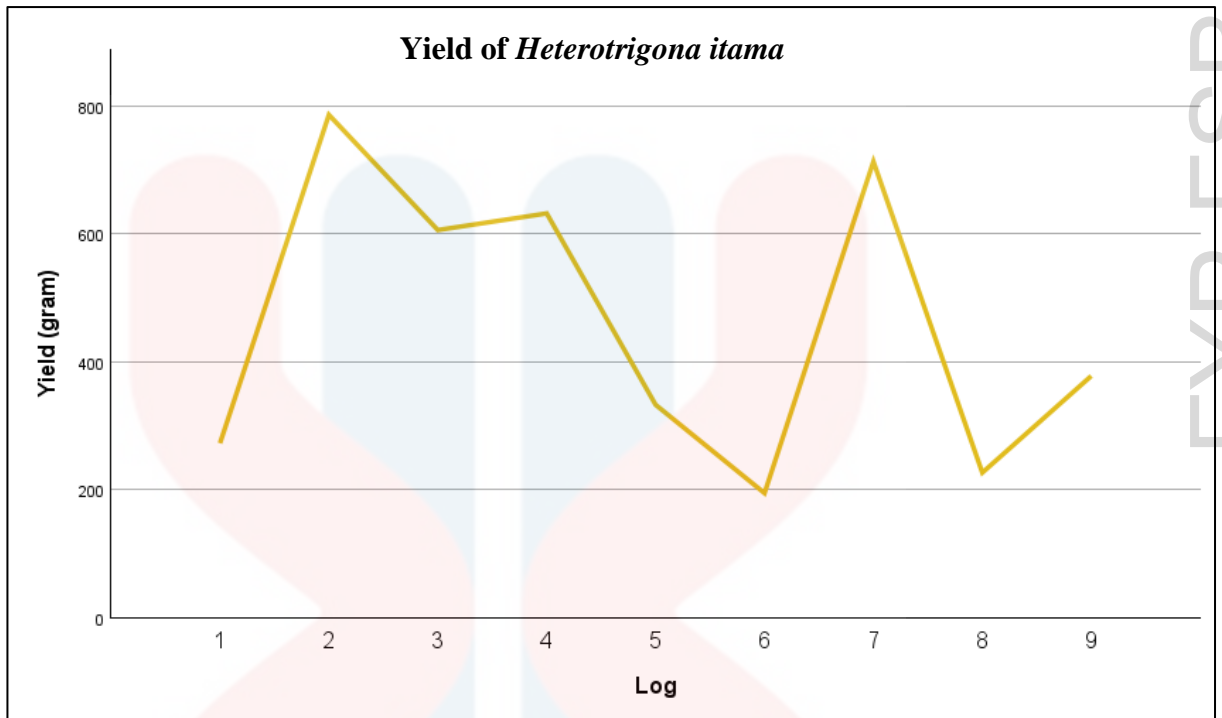
The effect of colony growth was significant, according to an analysis of variance, [ $F(109.92, 41.08) = 8, p = < .001$ ]. Post hoc analyses using the Tukey HSD were done in this study to define the significance between the logs in Appendix E. The

significance of brood is from logs 1, 2, 3, 4, 6, 7 and 9 while the honey and pollen pots are from logs 2, 3, 4, 5, 6, 7, 8 and 9. The brood size is significant because these logs have different sizes of it. Then, the honey and pollen pots were also affected because these became the main food sources for the colony during the study period due to the monsoon season.

Thus, the worker stingless bees gather nectar and pollen from flowers is essential to the colony's survival. The MORY method is effective even when propagated during the wet season. This can be explained by the fact that they are more active during the wet season than during the dry. Additionally, other environmental factors, such as the types of flora that surround the stingless bee meliponiculture, internal colony conditions and bee behavior, may also have an impact on the foraging activities of these bees (Wan Nur Asiah et al., 2021).

Figure 4.6 shows the yield from the nine colonies of *H. itama*. The weightiest yield is from log 2 in Appendix H. The honey collection was done 5 months after the setup date. This is because it took time for honey to be filled in the new hive. The date for logs 1, 2, 3, 4 and 5 for yield collection is 10 May 2024 while for logs 6, 7, 8 and 9 is 11 May 2024. This can be compared to the previous study conducted by Seprido & Nariman Hadi, 2024. The study was conducted for 6 months of meliponiculture for *H. itama* species and the total volume of honey per pot is 41 ml.

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**Figure 4.6:** Line chart for yield of *Heterotrigena itama*

## CHAPTER 5

### CONCLUSION AND RECOMMENDATIONS

#### 5.1 Conclusion

The MORY approach is successful in propagating nine colonies of *Heterotrigona itama* species. This supports Mohd Rosli Bin Yaakub's innovative technique. It has the potential to speed up the development of a new stingless bee colony. The MORY approach can improve the production of new colonies. The environment influences well the colony's development. A statical analysis has been done to identify the significance of the colony's development with the environment like light intensity, daily mean of temperature and daily mean of relative humidity.

#### 5.2 Recommendations

Future research should be conducted with another species, such as *Geniotrigona thoracica*. This is due to its larger morphology compared to other stingless bee species. Then, perhaps another factor that can influence the establishment of a new colony, such as a fungus at the topping and the predator's impact on the colony, can be included.

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## APPENDICES

### APPENDIX A

Data for mean of light intensity

WEEK	MEAN OF LIGHT INTENSITY
1	761.62
2	1944.62
3	896.16
4	718.84
5	148.31
6	341.13
7	1387.20
8	985.93
9	611.47
10	579.53
11	560.27
12	554.13
13	756.87
14	923.89

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**APPENDIX B**

T-test data for the mean of light intensity

<b>One-Sample Statistics</b>				
	N	Mean	Std. Deviation	Std. Error Mean
Lux	14	797.8550	443.87408	118.63034

<b>One-Sample Test</b>							
Test Value = 900							
	t	df	Significance		Mean Difference	95% Confidence Interval of the Difference	
			One-Sided p	Two-Sided p		Lower	Upper
Lux	-.861	13	.202	.405	-102.14500	-358.4303	154.1403

## APPENDIX C

T-test data for the daily mean of temperature

One-Sample Statistics				
	N	Mean	Std. Deviation	Std. Error Mean
Temperature	14	26.4429	1.12913	.30177

One-Sample Test							
Test Value = 20							
	t	df	Significance		Mean Difference	95% Confidence Interval of the Difference	
			One-Sided p	Two-Sided p		Lower	Upper
Temperature	21.350	13	<.001	<.001	6.44286	5.7909	7.0948

**APPENDIX D**

T-test data for the daily mean of relative humidity

<b>One-Sample Statistics</b>				
	N	Mean	Std. Deviation	Std. Error Mean
Humidity	14	86.0286	6.01938	1.60875

<b>One-Sample Test</b>							
Test Value = 70							
	t	df	Significance		Mean Difference	95% Confidence Interval of the Difference	
			One-Sided p	Two-Sided p		Lower	Upper
Humidity	9.963	13	<.001	<.001	16.02857	12.5531	19.5041

**APPENDIX E**

One – Way ANOVA data for the brood, honey and pollen pots of newly propagated colony

		<b>ANOVA</b>				
		Sum of Squares	df	Mean Square	F	Sig.
Brood	Between Groups	65659.812	8	8207.477	109.924	<.001
	Within Groups	8437.155	113	74.665		
	Total	74096.967	121			
Pots	Between Groups	202331.187	8	25291.398	41.076	<.001
	Within Groups	69577.332	113	615.729		
	Total	271908.519	121			

Multiple Comparisons							
Tukey HSD							
Dependent Variable	(I) Log	(J) Log	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Brood	Log 1	Log 2	-4.35729	3.26595	.919	-14.6868	5.9722
		Log 3	5.21343	3.26595	.805	-5.1161	15.5429
		Log 4	12.73621*	3.26595	.005	2.4067	23.0657
		Log 5	-42.74514*	3.26595	<.001	-53.0746	-32.4156
		Log 6	29.22225*	3.32817	<.001	18.6960	39.7485
		Log 7	12.66455*	3.32817	.007	2.1383	23.1908
		Log 8	46.02009*	3.32817	<.001	35.4938	56.5464
		Log 9	17.70163*	3.32817	<.001	7.1754	28.2279
		Log 2	Log 1	4.35729	3.26595	.919	-5.9722
	Log 3		9.57071	3.26595	.092	-.7588	19.9002
	Log 4		17.09350*	3.26595	<.001	6.7640	27.4230
	Log 5		-38.38786*	3.26595	<.001	-48.7174	-28.0584
	Log 6		33.57953*	3.32817	<.001	23.0533	44.1058
	Log 7		17.02184*	3.32817	<.001	6.4956	27.5481
	Log 8		50.37738*	3.32817	<.001	39.8511	60.9037
	Log 9		22.05892*	3.32817	<.001	11.5326	32.5852
	Log 3		Log 1	-5.21343	3.26595	.805	-15.5429
		Log 2	-9.57071	3.26595	.092	-19.9002	.7588
		Log 4	7.52279	3.26595	.349	-2.8067	17.8523
		Log 5	-47.95857*	3.26595	<.001	-58.2881	-37.6291
		Log 6	24.00882*	3.32817	<.001	13.4825	34.5351
		Log 7	7.45113	3.32817	.388	-3.0751	17.9774
		Log 8	40.80666*	3.32817	<.001	30.2804	51.3329
		Log 9	12.48820*	3.32817	.008	1.9619	23.0145
		Log 4	Log 1	-12.73621*	3.26595	.005	-23.0657
	Log 2		-17.09350*	3.26595	<.001	-27.4230	-6.7640
	Log 3		-7.52279	3.26595	.349	-17.8523	2.8067
	Log 5		-55.48136*	3.26595	<.001	-65.8109	-45.1519
	Log 6		16.48603*	3.32817	<.001	5.9598	27.0123
	Log 7		-.07166	3.32817	1.000	-10.5979	10.4546
	Log 8		33.28388*	3.32817	<.001	22.7576	43.8102
	Log 9		4.96542	3.32817	.857	-5.5609	15.4917
	Log 5		Log 1	42.74514*	3.26595	<.001	32.4156
		Log 2	38.38786*	3.26595	<.001	28.0584	48.7174
		Log 3	47.95857*	3.26595	<.001	37.6291	58.2881
		Log 4	55.48136*	3.26595	<.001	45.1519	65.8109
		Log 6	71.96739*	3.32817	<.001	61.4411	82.4937
		Log 7	55.40970*	3.32817	<.001	44.8834	65.9360
		Log 8	88.76524*	3.32817	<.001	78.2390	99.2915
		Log 9	60.44677*	3.32817	<.001	49.9205	70.9730
		Log 6	Log 1	-29.22225*	3.32817	<.001	-39.7485
	Log 2		-33.57953*	3.32817	<.001	-44.1058	-23.0533
	Log 3		-24.00882*	3.32817	<.001	-34.5351	-13.4825
	Log 4		-16.48603*	3.32817	<.001	-27.0123	-5.9598
	Log 5		-71.96739*	3.32817	<.001	-82.4937	-61.4411
	Log 7		-16.55769*	3.38924	<.001	-27.2771	-5.8383
	Log 8		16.79785*	3.38924	<.001	6.0784	27.5173
	Log 9		-11.52062*	3.38924	.025	-22.2400	-.8012
	Log 7		Log 1	-12.66455*	3.32817	.007	-23.1908
		Log 2	-17.02184*	3.32817	<.001	-27.5481	-6.4956
		Log 3	-7.45113	3.32817	.388	-17.9774	3.0751
		Log 4	.07166	3.32817	1.000	-10.4546	10.5979
		Log 5	-55.40970*	3.32817	<.001	-65.9360	-44.8834
		Log 6	16.55769*	3.38924	<.001	5.8383	27.2771
		Log 8	33.35554*	3.38924	<.001	22.6361	44.0750
		Log 9	5.03708	3.38924	.860	-5.6824	15.7565
		Log 8	Log 1	-46.02009*	3.32817	<.001	-56.5464
	Log 2		-50.37738*	3.32817	<.001	-60.9037	-39.8511
	Log 3		-40.80666*	3.32817	<.001	-51.3329	-30.2804
	Log 4		-33.28388*	3.32817	<.001	-43.8102	-22.7576
	Log 5		-88.76524*	3.32817	<.001	-99.2915	-78.2390
	Log 6		-16.79785*	3.38924	<.001	-27.5173	-6.0784
	Log 7		-33.35554*	3.38924	<.001	-44.0750	-22.6361
	Log 9		-28.31846*	3.38924	<.001	-39.0379	-17.5990
	Log 9		Log 1	-17.70163*	3.32817	<.001	-28.2279
		Log 2	-22.05892*	3.32817	<.001	-32.5852	-11.5326
		Log 3	-12.48820*	3.32817	.008	-23.0145	-1.9619
		Log 4	-4.96542	3.32817	.857	-15.4917	5.5609
		Log 5	-60.44677*	3.32817	<.001	-70.9730	-49.9205
		Log 6	11.52062*	3.38924	.025	.8012	22.2400
		Log 7	-5.03708	3.38924	.860	-15.7565	5.6824
		Log 8	28.31846*	3.38924	<.001	17.5990	39.0379

Pots	Log 1	Log 2	Log 3	Log 4	Log 5	Log 6	Log 7	Log 8	Log 9
		69.33957*	9.37876	<.001	39.6766	99.0026			
		53.02357*	9.37876	<.001	23.3606	82.6866			
		62.82300*	9.37876	<.001	33.1600	92.4860			
		113.80964*	9.37876	<.001	84.1466	143.4727			
		94.50534*	9.55742	<.001	64.2773	124.7334			
		107.75934*	9.55742	<.001	77.5313	137.9874			
		96.65819*	9.55742	<.001	66.4301	126.8863			
		150.74465*	9.55742	<.001	120.5166	180.9727			
	Log 2	-69.33957*	9.37876	<.001	-99.0026	-39.6766			
		-16.31600	9.37876	.721	-45.9790	13.3470			
		-6.51657	9.37876	.999	-36.1796	23.1464			
		44.47007*	9.37876	<.001	14.8071	74.1331			
		25.16577	9.55742	.185	-5.0623	55.3939			
		38.41977*	9.55742	.003	8.1917	68.6479			
		27.31862	9.55742	.110	-2.9095	57.5467			
		81.40508*	9.55742	<.001	51.1770	111.6332			
	Log 3	-53.02357*	9.37876	<.001	-82.6866	-23.3606			
		16.31600	9.37876	.721	-13.3470	45.9790			
		9.79943	9.37876	.980	-19.8636	39.4624			
		60.78607*	9.37876	<.001	31.1231	90.4491			
		41.48177*	9.55742	.001	11.2537	71.7099			
		54.73577*	9.55742	<.001	24.5077	84.9639			
		43.63462*	9.55742	<.001	13.4065	73.8627			
		97.72108*	9.55742	<.001	67.4930	127.9492			
	Log 4	-62.82300*	9.37876	<.001	-92.4860	-33.1600			
		6.51657	9.37876	.999	-23.1464	36.1796			
		-9.79943	9.37876	.980	-39.4624	19.8636			
		50.98664*	9.37876	<.001	21.3236	80.6497			
		31.68234*	9.55742	.032	1.4543	61.9104			
		44.93634*	9.55742	<.001	14.7083	75.1644			
		33.83519*	9.55742	.016	3.6071	64.0633			
		87.92165*	9.55742	<.001	57.6936	118.1497			
	Log 5	-113.80964*	9.37876	<.001	-143.4727	-84.1466			
		-44.47007*	9.37876	<.001	-74.1331	-14.8071			
		-60.78607*	9.37876	<.001	-90.4491	-31.1231			
		-50.98664*	9.37876	<.001	-80.6497	-21.3236			
		-19.30430	9.55742	.533	-49.5324	10.9238			
		-6.05030	9.55742	.999	-36.2784	24.1778			
		-17.15146	9.55742	.686	-47.3795	13.0766			
		36.93501*	9.55742	.006	6.7069	67.1631			
	Log 6	-94.50534*	9.55742	<.001	-124.7334	-64.2773			
		-25.16577	9.55742	.185	-55.3939	5.0623			
		-41.48177*	9.55742	.001	-71.7099	-11.2537			
		-31.68234*	9.55742	.032	-61.9104	-1.4543			
		19.30430	9.55742	.533	-10.9238	49.5324			
		13.25400	9.73280	.910	-17.5288	44.0368			
		2.15285	9.73280	1.000	-28.6299	32.9356			
		56.23931*	9.73280	<.001	25.4565	87.0221			
	Log 7	-107.75934*	9.55742	<.001	-137.9874	-77.5313			
		-38.41977*	9.55742	.003	-68.6479	-8.1917			
		-54.73577*	9.55742	<.001	-84.9639	-24.5077			
		-44.93634*	9.55742	<.001	-75.1644	-14.7083			
		6.05030	9.55742	.999	-24.1778	36.2784			
		-13.25400	9.73280	.910	-44.0368	17.5288			
		-11.10115	9.73280	.967	-41.8839	19.6816			
		42.98531*	9.73280	<.001	12.2025	73.7681			
	Log 8	-96.65819*	9.55742	<.001	-126.8863	-66.4301			
		-27.31862	9.55742	.110	-57.5467	2.9095			
		-43.63462*	9.55742	<.001	-73.8627	-13.4065			
		-33.83519*	9.55742	.016	-64.0633	-3.6071			
		17.15146	9.55742	.686	-13.0766	47.3795			
		-2.15285	9.73280	1.000	-32.9356	28.6299			
		11.10115	9.73280	.967	-19.6816	41.8839			
		54.08646*	9.73280	<.001	23.3037	84.8692			
	Log 9	-150.74465*	9.55742	<.001	-180.9727	-120.5166			
		-81.40508*	9.55742	<.001	-111.6332	-51.1770			
		-97.72108*	9.55742	<.001	-127.9492	-67.4930			
		-87.92165*	9.55742	<.001	-118.1497	-57.6936			
		-36.93501*	9.55742	.006	-67.1631	-6.7069			
		-56.23931*	9.73280	<.001	-87.0221	-25.4565			
		-42.98531*	9.73280	<.001	-73.7681	-12.2025			
		-54.08646*	9.73280	<.001	-84.8692	-23.3037			

\*. The mean difference is significant at the 0.05 level.

**APPENDIX F**

Data for daily mean of temperature

WEEK	DAILY MEAN TEMPERATURE ( ° C )
1	27.10
2	28.00
3	26.70
4	24.50
5	24.50
6	24.80
7	27.20
8	27.30
9	25.90
10	27.60
11	27.00
12	26.30
13	26.50
14	26.80

(Source: Meteorological station of Kota Bharu by MET Malaysia, 2024)

## APPENDIX G

Data for daily mean of relative humidity

WEEK	DAILY MEAN RELATIVE HUMIDITY ( % )
1	82.70
2	81.80
3	87.80
4	96.60
5	96.70
6	95.20
7	84.00
8	84.00
9	88.50
10	82.60
11	82.80
12	80.40
13	81.90
14	79.40

(Source: Meteorological station of Kota Bharu by MET Malaysia, 2024)

**APPENDIX H**Yield of new colony for *Heterotrigena itama*

LOG	MASS OF YIELD (gram)
1	273
2	786
3	606
4	632
5	333
6	195
7	713
8	227
9	378