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Stingless Bee Rearing and Colony Splitting

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Abstract – Stingless bee is a diverse group of highly eusocial bees (meliponines) comprising the Meliponini subfamily of the Apidae family. Throughout the tropics, various kinds of stingless bee have been reared by beekeepers for their products (honey, propolis and bee bread) and pollination services for fruits and vegetables. This meliponiculture in logs or hives is considered safe due to the bee's inability to sting, with the latter being more preferable for monitoring and managing the colonies and harvesting the products. The source of stingless bee colonies is depending on efficient hunting of feral colonies, which might affect the ecosystem. Following to the growing trend of bee rearing in Malaysia, mainly due to the smart branding strategy of the government through research institutes and universities, e.g. Malaysian Agricultural Research and Development Institute (MARDI), Universiti Malaysia Terengganu and Universiti Sains Malaysia, it is crucial to increase the number of honey-producing hives by colony splitting. The basis of colony splitting includes provision oviposition (POP), swarming and antennation. Colony splitting is necessary due to deforestation, to expand income generation and for entomological study purposes. A more advanced approach in colony splitting is to prepare and rear the virgin queen bee *in vitro*, resulting in more queens per one single colony. With the advancement in stingless bee rearing techniques, people may apply the colony splitting strategy to maximise stingless bee products and enhance crop production.

Keywords: stingless bee, honey, meliponiculture, colony splitting

Introduction

Malaysia is known for the richness in its nature as its forest consists of diversity of flora and fauna. Stingless bee is one of the unique insects found in the Malaysia forest. It is a member of the meliponini tribe, owned by the Hymenoptera family and Meliponinae subfamily, which is divided into two groups known as Meliponini and Trigonini (Vit, Persano Oddo, Marano and Salas de Mejiax, 1998). Meliponini can be easily found in tropical regions globally (Heard, 1999). There are various species of stingless bee. A study by Hamid and colleagues (2016) has identified a total of six stingless bee species in urban and forest of four different Penang areas, namely *Heterotrigona itama, Lepidotrigona terminata, Tetrigona apicalis, Tetragonula iridipennis, Tetragonula laeviceps,* and *Tetragonula pagdeni.*

The name stingless bee came from the inability of this species to sting, which is due to their undeveloped stinger (Shackleton et al., 2015). Stingless bees are the common visitors to flowering plants in the tropics (Heard, 1999). This explains why honey and harvested pollen have different composition that depends on the availability of plant species flowering (Do Nascimento, Marchini, Carvalho, Araújo and Silveira, 2015). In Malaysia, the flowering plants preferred by stingless bee include *Antigonon leptopus* (Mexican creepers, coral vines), *Hevea brasilliensis* (rubber tree) and *Passiflora edulis* (passionfruit). Throughout the tropics, various kinds of stingless bee have been reared by beekeepers for their products (honey, propolis and bee bread) and pollination services for fruits and vegetables (Aidoo, Kwapong and Karikari, 2011). Pollination by stingless bee for various types of plant permits efficient pollination that increases a greater yield of fruits and vegetables (Campbell and Motten, 1985).

Stingless bees are able to produce honey by collecting and storing nectars in a honey pot (Danaraddi, 2007). Major components in honey that can be obtained from different types of plant are mainly glucose and fructose (Biluca et al., 2014; Manzanares, García, Galdon, Rodríguez and Romero, 2014; Baltrušaityte, Venskutonis and Cˇeksteryte, 2007). Honey is a natural food that is consumed without any processing additives and is characterised by its complex composition, which varies according to species, geographical regions, available floral source and storage conditions (Karabagias, Badeka, Kontakos, Karabournioti and Kontominas, 2014). Stingless bee honey is a valuable natural product from a diverse group of highly eusocial bees (meliponines) comprising the Meliponini subfamily of the Apidae family. Honey that is produced by stingless bee is completely different from those produced by bees of the Apis genus in terms of structure, taste and composition (Vit et al., 2009). Honey produced by Apis genus typically tastes like a well-liked sweetener and is used as a usual household product worldwide, while stingless bee honey possesses a sour and bitter flowery taste (Molan, 2001). Depending on climate change, some of the stingless bee honey might have a sweet taste like normal honey. The degree of sourness in stingless bee honey is lessened as a result of reduced fermentation process of the honey according to the low water content in the honey (Marinus, 2006). The reducing of water content in the honey can be done by dewatering process using a Low Temperature Vacuum Drying (LTVD) with induced nucleation technique (Ramli et al., 2017).

Rearing Methods of Stingless Bee

Meliponiculture is the activity of stingless bee keeping where the colony of stingless bees is extracted from the wild for domestication (Saufi and Thevan, 2015). In general, rearing methods of stingless bee depend on place and condition (Kelly, Farisya, Kumara and Marcela, 2014). Since Malaysia is considered one of the tropical countries, rearing stingless bee can become a major success. Due to their inability to sting, rearing stingless bees at home is considered safe and has gradually become a trend. There are two most common rearing methods in Malaysia, which are by using log or hive.

Rearing Stingless Bee from Log

When farmers began to use stingless bees as pollinators to enhance the production of their crops, meliponiculture is rising as a more relevant industry. Usually, the knowledge on beekeeping is passed by the older generation among them, leading to variance of information from one location to another (Cortopassi-Laurino et al., 2006). In the early stage of meliponiculture era, people obtain the colony from their original habitat and take it home to harvest the honey (Quezada-Euán, Jesús May-Itzá and González-Acereto, 2001). Medicine experts in a place called Gorotire mainly search for stingless bee colony during the night and they can easily identify the species of the stingless bee from the sound of colony (Kajobe and Roubik, 2006). This practice is still common for the local people of many Eastern Amazon areas where these beekeepers make a spot at their target colonies during their hunting session and collect them during the day (Cortopassi-Laurino et al., 2006). When a bigger scale of colonies is reared, beekeepers will normally have limited time and attention for efficiently monitoring the colonies, leading to a gradual decrease in colonies survival rate. By using log as a method for rearing stingless bee, the observation or progress on the colony cannot be possibly done due to the conditions of log used. In addition, the colony's growth rate will be interrupted by the food storage area due to the limited space inside the logs. Furthermore, since there is no separation between the broods and food storage (Figure 1), the pots can be easily crushed during harvesting, which resulted in the mixing of dead stingless bees inside the honey flood that reduces the colony size abruptly (Quezada-Euán et al., 2001).

Figure 1. The internal structure of the stingless bee *H. itama* colony, with no separation between the broods and food storage.

Rearing stingless bee inside the hive
As the meliponiculture expands, a reliable method is necessary to sustain the consistency and standard of the stingless bee (Kumara, Farisya, Wan Noor Aida, Marcela and Ahmad, 2016). A more recent method used for rearing stingless bee is in a wooden box where a few patterns have been built and utilised with success (Quezada-Euán et al., 2001). Following the broader dissemination of knowledge, people have discovered bee colony separation techniques and ecological factors that can influence beekeeping (Cortopassi-Laurino et al., 2006). Fortunately, the drawbacks of using logs can be overcome using hive. However, hives are compartmentalised, which makes them difficult to be built. This has caused the price of a modern hive to be expensive and burdens the beekeepers in rural areas (Quezada-Euán et al., 2001).

Colony Transfer from Log to Hive
The first step of colony transfer from log to hive is to keep the colony inside its original place; for example, in the large limbs of tree. The colony of stingless bee is usually located in the empty space of a tree, which makes it more convenient to transfer and keep the colony inside the hive. Observation and management of the colonies inside hives are easier and more practical compared to using logs (Cortopassi-Laurino et al., 2006). The process of harvesting honey and bee pollen can also be done without any contamination and difficulty. With these skills, number of stingless bee colonies can be retained for a longer period and can also increase the standard of the stingless bee products (Quezada-

Euán et al., 2001). Besides that, hives allow colony transfer from one site to another (Heard, 1999). Silva, Venturieri and Silva (2004) claimed that colonies in hives can yield higher products compared to colonies reared in logs. The typical yearly yield is ranging from one to two litres per hive (Cortopassi-Laurino et al., 2006). However, these studies did not provide distinctive data on the colonies yield from logs for comparison.

Colony Splitting

In order to increase the production of a hive, the size of bee colonies have to be divided or split. Colony splitting is a term called for the process of creating two colonies from one existing colony at one particular hive. It is necessary due to several factors. First, colonies of stingless bee in natural habitat are commonly jeopardised by deforestation. In Malaysia, deforestation lessens the colony of stingless bee and affects the original role of stingless bee as the forest pollinators (Eltz, Brühl, Imiyabir and Linsenmair, 2003). Excessive activity of cutting down the trees disturbs the natural habitat of stingless bee where their homes are harassed by human who hunt for the stingless bee colonies (Villanueva, Roubik and Colli-Ucán, 2005). Therefore, colony splitting is crucial to sustain the activity of massive colony hunting in the forest.

With a good market price for stingless bee products, i.e. honey (RM35 per 300g), bee bread (RM30 for 200g) and propolis (RM25 for 10mL) (Kelly et al., 2014), rearing stingless bees is not only done for personal consumption, but has also become an income generator. Knowledge on colony splitting allows beekeepers to expand their business using the few original colony stocks they possessed. This knowledge is also important for the expansion of entomological studies of stingless bee, including the ethological and ecological observations.

Basis for Colony Duplication

Provision Oviposition (POP)

Oviposition for stingless bee begins with the formation of connection between the queen and the workers (Drumond, Oldroyd, Dollin and Dollin, 1999). To start the process, it is important that sufficient amount of food storage for the growth of the stingless bee is provided. Workers will disgorge food required into the newly formed brood cell. This is followed by cell provisioning where the queen will put her egg on the food. The process ends when the workers close and seal the cell (Nunes et al., 2014; Drumond, Zucchi and Oldroyd, 2000; Wittmann, Bego, Zucchi and Sakagami, 1991; Michener, 1974). Almost all stingless bees build their brood layers in a same shape, which are in horizontal form. This brood contains cocoons and virgin queen eggs that are usually located in the middle of the colony (Wille, 1983; Michener, 1974). The strength of the physogastric queen of the stingless bee will determine the growth pattern of the colony depending on the queen's pheromone to develop and maintain their colony with enough food supply (Nunes-Silva, Alves, Hilário, Santos-Filho and Imperatriz-Fonseca, 2014). However, there are a couple of species that build their broods in inconsistent shapes adapting to the small space or a large branch of trees (Wille, 1983; Michener, 1961).

Swarming

Stingless bee exists in a community replicated by natural activity termed as swarming. New colonies will gradually begin to form by the splitting of old colony where the new virgin queen leaves the old house to a new house, trailing by a swarm of stingless bee workers (Nunes-Silva et al., 2014). To develop a new colony, the stingless bee workers will transfer the materials needed for building a new house and also supply enough nutrients from the original house. Stingless bee colonies are able to survive for a long period of time, typically for more than 50 years, however the numbers of swarming time are yet to be known including the queen's lifespan (Cortopassi-Laurino et al., 2006). The former queen of the colony will be replaced by a new queen once the queen is no longer attractive to the workers. A practical way to multiply the stingless bee colony is by making an artificial nest where the process of stingless bee swarming can be done in a natural way (Cortopassi-Laurino et al., 2006).

Antennation

For *Melipona* species, the need of a new queen is only triggered when the original queen dies or when the colony is in the urge of splitting for swarming process (Winston, 1987). The process of antennation starts when the former queen of the colony died or removed by the workers due to the decreased pheromone level as it can weaken her attractiveness towards the workers. The new virgin queen has its own smell that can attract the drones to assemble at the colony's door (Gary, 1962). The drones will assemble near the hive where the attractive new unmated virgin queen can be found and this is where the process of copulation occurs (Thornhill and Alcock, 1983; Sullivan, 1981; Emlen and Oring 1977). Interestingly, the virgin queen of stingless bee will not only attract drones from her own species, but also from others. However, only the best drones can win the competition (Dos Santos, Ferreira-Caliman and Nascimento, 2015). Once mating happen, antennation will occur inside the colony.

In Vitro Queen Rearing

Traditionally, stingless bee colony splits and doubles their colony amount according to species. The process and procedure usually happen every one to two years, thus extending the length of time to maintain and stabilise the colony after multiplication process. Although it is feasible to split the established colony (Leão, Queiroz, Veiga,Contrera and Venturieri, 2016), a more advanced approach in colony splitting is via *in vitro* queen rearing. Due to the typically less number of queens in most bee colonies, *in vitro* queen rearing aims to produce more queens in a colony (Menezes, Vollet-Neto and Fonseca, 2013). With the advancement in stingless bee rearing techniques, beekeepers apply this mechanism to enhance crop production and to maximise stingless bee products such as bee bread, propolis and honey (Baptistella, Souza, Santana and Soares, 2014). To formulate an *in vitro* queen, it is necessary to determine the amount and stock of larval food necessary for the growth of queens and transfer of larvae. When the immature larvae become milky white in colour with their stomachs fully formed, these larvae will be selected for larval feeding process. Once the process completed, the virgin queen will appear and her weight will be measured and compared to the natural colony-induced virgin queens (Baptistella et al., 2014).

Conclusion

Knowledge on bee rearing and colony splitting techniques should be widely spread not only to beekeepers, but also to potential beekeepers and farmers for sustaining the growth rate of meliponiculture. Continuous effort is crucial to create awareness on harvesting and exploiting stingless bee honey in the most appropriate way.

Conflict of Interest

None of the authors of this paper has any financial or personal relationship with other people or organizations that could inappropriately influence or bias the content of the paper.

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