Variation of kelulut (*Heterotrigona itama*) habitat landscapes in South Kalimantan

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Abstract. Honey production depends on the availability of the landscape as a habitat for producing bee's food sources. The purpose of this study was to determine different landscapes as a habitat for kelulut (*Heterotrigona itama*) bees in producing honey from 5 different stingless bee locations. The research was conducted in three districts: Hulu Sungai Tengah, Hulu Sungai Selatan and Tapin District, South Kalimantan Province. This research was conducted to record the types of vegetation in each landscape, which can be divided into three categories; 1 location was a combination type of forest and garden (type 1), 2 locations was a combination type of settlement, shrub, and paddy fields (type 2), and 1 location was a combination type of settlement, plantation, and shrub (type 3). Each meliponiculture also recorded the honey production every month. The results showed that the farmers' number of beehives was between 96 and 252 hives/farmer. The average production in the rainy season is 0.17 L hive⁻¹year⁻¹, and the dry season is 0.24 L hive⁻¹year⁻¹. Honey production per year for each location was as follows: location type 1 produces 1.59 L hive⁻¹, location type 2 produces 1.85 L hive⁻¹, and location type 3 produces 2.41 L hive⁻¹. Plant identification results at each type of location showed that the number of species found at vegetation cover type 1, 2, and 3 was 116, 128, and 107 species, respectively. At the farms with vegetation cover types 2 and 3, many different flowering shrubs provide year-round forage for the stingless bee.

1. Introduction

Kelulut honey bee (*Heterotrigona itama*) is one of the stingless bees that have natural habitat in Kalimantan (Borneo island). Stingless bees (Apidae: Meliponini) are a diverse clade of social bees (>500 species).
species) with a pantropical distribution spanning South and Central America, Africa, India, and Austral-Asia [1]. The name kelulut refers to stingless bee lives in the Indo-Malayan, including at Borneo Island. Kelulut’s greater abundance is in Thailand and Malaysia. However, the abundance of kelulut in Borneo is due to the abundance of resin-secreting trees (Dipterocarpaceae) and humid tropical climate. About 33 species of stingless bees have been identified in Kalimantan (Borneo) [2]. Among the various types of stingless bees, H. itama is the widest beekeeping by the farmer at South Kalimantan. The public’s interest in keeping stingless bees is because stingless bees are easier to maintain than honey bees (Apis spp.) that need to be treated. Stingless bees also cannot migrate like Apis spp.[3].

Habitat plays an important role in honeybee productivity. Plant types and the flowering duration differ from one place to another due to variations in geography and environmental conditions. The density and value of bee flora are significant factors for effective beekeeping [4]. Many stingless bee associates are trees, providing both food and nest sites [3]. Furthermore, habitats with vegetation as a food source for bees are certainly very supportive of colony development. Food source which is too far from hives will impact the energetic costs of foraging [5], because bees flying longer at space and time scales, may be at higher risk of biotic and abiotic injuries such as predation and wind-dissection [6]. Stingless bees visited genera of plants spanning a variety of common types of growth (herbs, trees, shrubs, vines, lianas) and including economically important plants such as crops, timber, fibers, medicinal and ornamental. In addition to native flora, stingless bees were reported to visit non-native (exotic) plants [1]. It suspects that the habitat for kelulut or landscape for kelulut farms should not only be dominated by trees, but it is better if the agricultural land provides many sources of seasonal plant flowers. Records of floral visitation of wild plants by stingless bees worldwide were records highlighting the wide variety of plants used as forage by individual stingless bee species (as many 535 plant genera for Trigona spinipes and by the Meliponini in general [1].

The purpose of this study was to characterize different landscapes as habitats for kelulut (H. itama) bee in producing honey produced from 5 different stingless bees with three different vegetation cover conditions, i.e., combination type of forest and garden (type 1), a combination type of settlement, shrub and paddy fields (type 2), and combination type of settlement, plantation, and shrub (type 3). Locations with high honey production could be examples of habitats with good vegetation cover to maintain H. itama. The information can provide knowledge for choosing a good location for H. itama meliponiculture.

2. Materials and methods

2.1. Study sites
This study was carried out at Hulu Sungai Tengah (HST), Hulu Sungai Selatan (HSS), and Tapin Districts, South Kalimantan Province. The observation was conducted from June 2019 until June 2020 at five different meliponiculture locations. Habitat condition whole meliponiculture is different and influenced by the vegetation coverage, which classified into three groups: one location is a combination type of forest and garden (type 1), two locations are a combination type of settlement, shrub and paddy fields (type 2), and one location is a combination type of settlement, plantation, and shrub (type 3). The observation activities were carried out at dry and rainy seasons to determine stingless bee productivity from both seasons. Classification of five meliponiculture based on land coverage type condition presented in table 1.
Table 1. Condition of five meliponiculture and their land coverage types.

| Meliponiculture | Land coverage type | District | Coordinate          |
|------------------|--------------------|----------|---------------------|
| Fahrudin         | Type 1             | HST      | 115° 28’ 37” E 2° 36’ 30” S |
| Warhamni         | Type 2             | HSS      | 115° 16’ 18” E 2° 45’ 02” S |
| Yusuf            | Type 2             | HST      | 115° 22 ’07” E 2° 34’ 10” S |
| Suriyani         | Type 3             | HST      | 115° 18’ 51” E 2° 36’ 26” S |
| Ibnu Kasir       | Type 3             | Tapin    | 115° 09’ 21” E 2° 03’ 52” S |

2.2. Experimental design
This study used two models were (1) survey and (2) interview, and two observations were (1) vegetation composition around of meliponiculture location, and (2) honey bee production from 5 meliponiculture with different land coverage types (table 1).

2.2.1. Vegetation composition. Vegetation composition data were collected from vegetation analysis, which used multiple nested plots placed systematically around meliponiculture in a 500 m. The determination of this distance based on the range of stingless bee's flight for foraging activity is ± 500 m [2]. Each meliponiculture consists of 20 square nested plots. Inside nested plot consist 4 observation plots i.e: 20 x 20 meter for tree-level observation, 10 x 10 meter for pole level observation, 5 x 5 meter for sapling level, and 2 x 2 meter for seedling level observation (figure 1). Parameters recorded were, i.e., name of species and their amount, and diameter and height (at pole and tree level). The placement of 20 nested plots at five meliponiculture is presented in figure 1.

2.2.2. Honey bee production. Data honey production was carried out from interviewed farmer beekeepers by questionnaire. Topics interviewed included, i.e., amount of beehives, various stingless bee species, honey production, colony maintenance, variety of stingless bee forage, and stingless bee growth cycle. The object of this study was farmers, beekeepers from five meliponiculture (table 1.). Farmers beekeepers were selected by purposive sampling with several criteria i.e., having a large number of *H. itama* hives (± 100 hives or more) and has been maintaining *H. itama* for more than three years. A farmer with experience of at least three years was assumed to have the skill and expertise to manage bees colonies and actively provide bee forage for sustainable honey production.
Honey production of *H. itama* is diverse in the dry and rainy seasons [2]. From 12 months of observation, two months were identified as the "dearth period" which no honey flow period [4]. The dearth period from *H. itama* at the research location occurred during the peak rainy season (January-February). During the rainy season, the activity of bees looking for nectar, pollen, and resin decreases greatly.

2.3. Analysis

2.3.1. Vegetation composition. In vegetation analysis, species and amount of bee forage were calculated, as well as the values of relative species density (RDen), relative species frequency (RF), and relative dominance (RD). The important value index (IVI) was analyzed the dominance of a species in a certain community. The mathematical formula for calculating IVI is presented in the following formula [7]:

\[
\text{Density (Den)} = \frac{\text{Amount of a species}}{\text{Area of sampling plot}}
\]

(1)

\[
\text{Relative Density (RDen)} = \frac{\text{Density of a species}}{\text{Sum of densities of all species}} \times 100\%
\]

(2)

\[
\text{Frequency (F)} = \frac{\text{The number of plots where a species is observed}}{\text{Total number of survey plots}}
\]

(3)

\[
\text{Relative Frequency (RF)} = \frac{\text{Frequency of a species}}{\text{Sum of frequencies of all species}} \times 100\%
\]

(4)

\[
\text{Dominance (D)} \equiv \frac{\text{Total basal area of a species}}{\text{Large of sampling plot}}
\]

(5)

\[
\text{Relative Dominance (RD)} = \frac{\text{Dominance of a species}}{\text{The sum of dominance of all species}} \times 100\%
\]

(6)

\[
\text{Important Value Index (IVI)} = \text{RDen} + \text{RF} + \text{RD}
\]

(7)

2.3.2. Honey bee production. Every month, data of *H. itama* honey bee production were calculated from average production per hives for each season. The following formula calculated total honey production year-1 hives-1:

\[
\text{Honey prod (per hives per season)} = \left( \frac{\text{Honey prod dry/rainy season}}{\text{Amount hives}} \right) \times 5 \text{ months}
\]

(8)

\[
\text{Total prod (per hives per year)} = \text{Prod. at dry season} + \text{Prod. at rainy season}
\]

(9)

\[
\text{Average honey prod by type area} = \frac{\text{(8) at location A} + \text{(9) at location B}}{\text{at n location}}
\]

(10)

3. Results and discussion

3.1. Type of vegetation

The result of plant identification showed the number of species found at vegetation coverage types 1, 2, and 3 were 116 species; 128±2.8 species; and 107±16.3 species, respectively (table 4). These species consists of flowering plant with variety habitus such as grass, shrub, sapling, pole and woody tree. The largest contributor of bee forage was originated from seedling level (70±7.6 species), followed by sapling level (20±7.5 species); tree level (15±4.2 species); and pole level (13±3.5 species).
A large number of the seedling plant as bees forage mainly originated from habitat combinations of settlement and agriculture, including paddy fields. Though settlements often assumed to have fewer plants than gardens and forests, this study showed that various types of flowering plants and vegetables can be found at settlements. Another study showed that herbs represented the highest floristic composition as bee forage, followed by shrubs and trees and climbers/lianas [8]. Some types of bee forage which found around a settlement, i.e., chili (Capsicum spp.), tomato (Solanum lycopersicum), eggplant (Solanum melongena), yellow-ray flower (Cosmos caudatus), asoka flower (Saraca asoca), zinnia flower (Zinnia elegans), mallow flower (Abutilon indicum), moserose (Portulaca oleracea), sunflower (Helianthus annuus), butter daisy (Melampodium divaricatum), jasmine (Jasminum sambac), pinwheel flower (Tabernaemontana corymbosa), star gooseberry (Sauropogus androgynus), papaya (Carica papaya), sparrow eggplant (Solanum torvum) and pintoi beans (Arachis pintoi). The flower-like sunflower is abundant with pollen and nectar, which attracts several honey bees, inducing them to forage in the cultivated areas [9]. A regression model indicated that high nectar production rates increased insect visitation rates [10]. Nectar forms the basis of honey, the energy rich (carbohydrate) food that stingless bees need to sustain the life of the colony, while pollen provides the protein, vitamin, and other nutrients needed for the developing larvae to increase the population of the bee colony [2, 8].

While the type of bee forage found around paddy field, i.e., paddy (Oryza sativa), velvetleaf (Limnocharis flava), cutleaf groundcherry (Physalis angulata), sun hemp (Crotalaria juncea), shame plant (Mimosa pudica), goatweed (Ageratum conyzoides), peruvian water primrose (Ludwigia peruviana), and water spinach (Ipomoea aquatica), the result of palynological analysis from stingless bee pot pollen was found that the types above are favored by H. itama [11].

| Table 2. Species found at meliponiculture with different type coverage vegetation. |
|---------------------------------------------------------------|
| Level of vegetation | Seedling | Sapling | Pole | Tree | Sum of species | Average species |
|----------------------|----------|---------|------|------|----------------|----------------|
|                      | all flower | all flower | all flower | all flower |               |                |
| Fahrudin a            | 62       | 25      | 27   | 11   | 15            | 12             | 12             | 81              | 116 b            |
| Warhamni b           | 80       | 44      | 18   | 9    | 12            | 20             | 18             | 130             | 128 b            |
| Yusuf b              | 75       | 43      | 19   | 12   | 8             | 20             | 20             | 126             |                  |
| Suriyani c           | 64       | 32      | 27   | 13   | 16            | 9              | 12             | 119             | 107 c            |
| Ibnu Kasir c         | 67       | 36      | 9    | 8    | 5             | 13             | 13             | 96              |                  |
| Average              | 70       | 36      | 20   | 11   | 12            | 9              | 15             | 15              |                  |
| S indiv             | 7.6      | 7.8     | 7.5  | 2.1  | 3.5           | 3.0            | 4.2            | 3.7             |                  |

all: All species identified at sampling plot
fl: Flowering species identified at sampling plot
a Land coverage by combination forest and garden.
b Land coverage by combination settlement, shrub, and paddy fields.
c Land coverage by combination settlement, plantation, and shrubs.

Generally, the diversity of bee forage from sapling, pole, and tree-level was less than seedling-level. From all types of land coverage (type 1,2 and 3), the sapling, pole, and tree level vegetation are composed of fruit, woody, and plantation trees, i.e., rubber (Hevea braziliensis), sungkai (Peronema canescens), karoi tree (Albizia procera), alaban (Vitex pubescens), blackboard tree (Alstonia scholaris) and Java kapok (Ceiba pentandra).

3.1.1. Forest and garden type. Habitat with combination forest and garden (type 1) was found 81 species from 54 families, potentially as bee forage. Flowering plants were found to mostly originated from the
family: Asteraceae, Euphorbiaceae, and Fabaceae. A list of species dominating from each vegetation level is presented in table 3.

3.1.2. Settlement, shrub, and paddy fields type. At habitat with combination settlement, shrub and paddy fields (type 2) were found 110 species from 45 families, potentially as bee forage. The flowering plants that dominate are from the family: Anacardiaceae, Asteraceae, Euphorbiaceae, Fabaceae, Moraceae, and Poaceae.

Compared to habitat type 1, flowering plants were found in habitat type 2 are more varied. Family Asteraceae and Anacardiaceae are generally found around the settlement. Euphorbiaceae and Moraceae are more found in shrub habitats. Fabaceae and Poace families were found more at paddy fields. The family is found in habitat type 2 is almost the same as habitat type 3. A difference between both types is the presence of the Moraceae family, such as cempedak (Artocarpus integer), jackfruit (A. heterophyllus), and tarap (A. odarattissimus). These three species are fruit-producing trees widely grown in gardens, both planted by the community and growing naturally. Bees favor resin from these trees as a raw material for propolis. Dominate species at type habitat combination forest and garden for each level vegetation presented in table 4.

### Table 3. Dominant species at type habitat combination forest and garden (type 1).

| Level of vegetation | Name of species          | Rden (%) | RF (%) | DR (%) | IVI (%) |
|---------------------|--------------------------|----------|--------|--------|---------|
| Seedling            | Asystasia intrusa        | 14.41    | 0.60   | 15.00  |         |
|                     | Commelina diffusa        | 10.64    | 1.80   | 12.44  |         |
|                     | Cyperus rotundus         | 4.37     | 5.39   | 9.76   |         |
|                     | Ageratum conyzoides      | 4.44     | 2.40   | 6.83   |         |
| Sapling             | Macaranga gigantea       | 5.94     | 8.20   | 14.13  |         |
|                     | Macaranga triloba        | 5.94     | 8.20   | 14.13  |         |
|                     | Musa paradisiaca         | 3.44     | 4.92   | 8.36   |         |
|                     | Vitex pubescens          | 1.88     | 3.28   | 5.15   |         |
| Pole                | Hevea brasiliensis       | 83.82    | 37.93  | 79.20  | 200.94  |
|                     | Peronema canescens       | 2.89     | 6.90   | 7.54   | 17.33   |
|                     | Piper aduncum            | 1.16     | 6.90   | 0.21   | 8.27    |
|                     | Arenga pinnata           | 0.58     | 3.45   | 3.51   | 7.53    |
| Tree                | Piper aduncum            | 80.95    | 43.5   | 67.9   | 192.28  |
|                     | Peronema canescens       | 3.57     | 13.0   | 4.5    | 21.09   |
|                     | Tamarindus indica        | 1.19     | 4.3    | 8.9    | 14.41   |
|                     | Durio zibethinus         | 2.38     | 4.3    | 7.3    | 13.99   |
|                     | Artocarpus integer       | 3.57     | 4.3    | 2.4    | 10.30   |
Table 4. Dominate species at type habitat combination forest and garden (type 2).

| Level of vegetation | Name of species          | Rden (%) | RF (%) | DR (%) | IVI (%) |
|---------------------|--------------------------|----------|--------|--------|--------|
| Seedling            | *Synedrella nodiflora*   | 38.82    | 0.67   | 39.49  |        |
|                     | *Oryza sativa*           | 11.08    | 4.03   | 15.11  |        |
|                     | *Ageratum conyzoides*    | 6.75     | 3.50   | 10.25  |        |
|                     | *Eclipta alba*           | 5.75     | 4.90   | 10.64  |        |
|                     | *Ludwigia octovalvis*    | 3.50     | 2.10   | 5.59   |        |
|                     | *Melampodium divaricatum*| 3.88     | 0.67   | 4.55   |        |
| Sapling             | *Musa paradisiaca*       | 39.89    | 12.50  | 52.39  |        |
|                     | *Hevea brasiliensis*     | 7.65     | 10.00  | 17.65  |        |
|                     | *Nephelium lappaceum*    | 3.28     | 12.50  | 15.78  |        |
|                     | *Bouea macrophylla*      | 4.92     | 6.90   | 11.81  |        |
|                     | *Cocos nucifera*         | 3.28     | 6.90   | 10.18  |        |
|                     | *Mangifera indica*       | 3.28     | 6.90   | 10.18  |        |
| Pole                | *Nephelium lappaceum*    | 22.58    | 19.05  | 24.62  | 66.25  |
|                     | *Musa paradisiaca*       | 22.58    | 14.29  | 18.51  | 55.38  |
|                     | *Hevea brasiliensis*     | 32.26    | 10.00  | 10.63  | 52.89  |
|                     | *Artocarpus heterophyllus*| 19.35    | 20.00  | 9.04   | 48.39  |
|                     | *Lansium domesticum*     | 9.68     | 14.29  | 7.55   | 31.51  |
|                     | *Durio zibethinus*       | 9.68     | 9.52   | 10.27  | 29.47  |
|                     | *Cocos nucifera*         | 3.23     | 5.00   | 11.66  | 19.89  |
| Tree                | *Hevea brasiliensis*     | 91.67    | 57.14  | 14.72  | 163.53 |
|                     | *Arenga pinnata*         | 36.67    | 36.67  | 83.82  | 157.15 |
|                     | *Nephelium lappaceum*    | 1.19     | 14.29  | 14.63  | 30.10  |
|                     | *Albizia chinensis*      | 1.19     | 9.52   | 14.07  | 24.79  |
|                     | *Mangifera caesia*       | 6.67     | 6.67   | 2.89   | 16.22  |
|                     | *Artocarpus integer*     | 6.67     | 6.67   | 1.73   | 15.07  |
|                     | *Baccaurea motleyana*    | 6.67     | 6.67   | 1.16   | 14.49  |

However, some things need to be considered in choosing the habitat of paddy fields as a source of bee forage, namely the dangers of pesticides and insecticides that can disrupt the supply of stingless bees. The study [12] showed that major constraints in beekeeping were insecticide usage, birds, and misuse of pesticides.

3.1.3. Type of settlement, plantation, and shrub. At habitat with combination forest and garden (type 3) was found 102 species from 42 families, potentially bee forage. The flowering plants dominated some families, i.e., Fabaceae, Euphorbiaceae, Asteraceae, Poaceae, Rubiaceae, and Anacardiaceae.

Different from habitat type 2, habitat type 3 presence of Rubiaceae family, which also dominate. Types of plants from the Rubiaceae family that are a source of nectar for stingless bees, i.e., broadleaf buttonweed (*Borreria latifolia*), noni (*Morinda citrifolia*), and coffee (*Cofea liberica*). Dominate species at type habitat 3 for each level vegetation are presented in table 5.
Table 5. Dominate species at type habitat combination settlement, plantation, and shrub (type 3).

| Level of vegetation | Name of species | Rden (%) | RF (%) | DR (%) | IVI (%) |
|---------------------|-----------------|----------|--------|--------|---------|
| Seedling            | Borrearia lafolia| 26.85    | 5.59   | 32.44  |         |
|                     | Ageratum conyzoides | 22.55    | 5.03   | 27.58  |         |
|                     | Phyllanthus urinaria | 6.99    | 4.29   | 11.28  |         |
|                     | Ipomoea triloba    | 4.57     | 3.91   | 8.48   |         |
|                     | Sonchus arvensis   | 4.72     | 2.14   | 6.86   |         |
|                     | Asystasia intrusa  | 2.74     | 2.79   | 5.53   |         |
|                     | Clibadium surinamense | 1.20    | 2.79   | 4.00   |         |
| Sapling             | Musa paradisiaca  | 35.00    | 26.67  | 61.67  |         |
|                     | Hevea brasiliensis| 30.00    | 26.67  | 56.67  |         |
|                     | Peronema canescens | 20.38    | 16.67  | 37.04  |         |
|                     | Gliricidia sepium  | 15.00    | 6.67   | 21.67  |         |
|                     | Macaranga gigantea | 5.96     | 8.33   | 14.29  |         |
|                     | Macaranga triloba  | 6.90     | 6.67   | 13.56  |         |
|                     | Arenga pinnata     | 5.00     | 6.67   | 11.67  |         |
| Pole                | Hevea brasiliensis| 91.67    | 57.14  | 14.72  | 163.53  |
|                     | Arenga pinnata     | 36.67    | 36.67  | 83.82  | 157.15  |
|                     | Nephehium lappaceum| 1.19     | 14.29  | 14.63  | 30.10  |
|                     | Albizia chinensis  | 1.19     | 9.52   | 14.07  | 24.79  |
|                     | Mangifera caesia   | 6.67     | 6.67   | 2.89   | 16.22  |
|                     | Artocarpus integer | 6.67     | 6.67   | 1.73   | 15.07  |
|                     | Baccaurea motleyana | 6.67    | 6.67   | 1.16   | 14.49  |
| Tree                | Mangifera caesia   | 67.85    | 80.95  | 43.48  | 192.28  |
|                     | Arenga pinnata     | 83.82    | 36.67  | 36.67  | 157.15  |
|                     | Hevea brasiliensis | 7.22     | 79.53  | 30.00  | 116.75  |
|                     | Archidendron pauciflorum | 7.22 | 3.94 | 16.67 | 27.82 |
|                     | Albizia chinensis  | 7.32     | 2.36   | 13.33  | 23.02  |
|                     | Durio kutejensis   | 4.48     | 3.57   | 13.04  | 21.09  |
|                     | Artocarpus integer | 10.93    | 3.15   | 3.33   | 17.42  |

3.2. Potential of bee food plants.

All plants identified found that 60 families have potential as bee-forage plants from 5 meliponiculture (table 6.). Some families were found in all research locations ranging from seedlings, saplings, poles, and trees, and some families were just found in certain locations. The most family are Euphorbiaceae, Fabaceae, Areaceae, Malvaceae, and Moraceae, respectively.

Bee interaction with many of the tropic's most species also has been reported [1], ten plant families with the largest number of genera visited by stingless bees were Fabaceae (legumes), Asteraceae (daisies), Rubiaceae (madders), Malvaceae (mallows), Euphorbiaceae (spurges), Areaceae (palms), Lamiales (mints), Poaceae (grasses), Myrtaceae (myrtles), Apocynaceae (dogbanes), Bignoniaceae (bignonias), Melastomataceae (melastomes), Orchidaceae (orchids) and Sapindaceae (soapberries). Another research also reported that other families like Acanthaceae [8] are the most frequent families visited by the bees.

Table 6. Family of flowering species from 3 type variation habitat from H. itama.

| Location of meliponiculture | Family     | Fahruin a | Warhammi b | Yusuf b | Suriyani c | Ibnu Kasir c |
|-----------------------------|------------|-----------|------------|---------|------------|-------------|
|                             | Acanthaceae|           |            |         |            |             |
|                             | Amaranthaceae |         |            |         |            |             |
|                             | Anacardiaceae |         |            |         |            |             |
|                             | Annonaceae   |           |            |         |            |             |

8
| Family               | Location of meliponiculture | Fahrudin | Warhamni | Yusuf | Suriyani | Ibnu Kasir | Sum |
|----------------------|------------------------------|----------|----------|-------|----------|------------|-----|
| Apocynaceae          |                              | 2        |          |       |          |            |     |
| Arecales             |                              |          |          |       |          |            |     |
| Asteraceae           |                              |          |          |       |          |            |     |
| Balsaminaceae        |                              |          |          |       |          |            |     |
| Berberidaceae        |                              |          |          |       |          |            |     |
| Boraginaceae         |                              |          |          |       |          |            |     |
| Brassicaceae         |                              |          |          |       |          |            |     |
| Bromeliaceae         |                              |          |          |       |          |            |     |
| Cannabaceae          |                              |          |          |       |          |            |     |
| Capparidaceae        |                              |          |          |       |          |            |     |
| Clusiaceae           |                              |          |          |       |          |            |     |
| Commelinaceae        |                              |          |          |       |          |            |     |
| Compositae           |                              |          |          |       |          |            |     |
| Convolvulaceae       |                              |          |          |       |          |            |     |
| Costaceae            |                              |          |          |       |          |            |     |
| Cyperaceae           |                              |          |          |       |          |            |     |
| Dipterocarpaceae     |                              |          |          |       |          |            |     |
| Euphorbiaceae        |                              |          |          |       |          |            |     |
| Hypoxidaceae         |                              |          |          |       |          |            |     |
| Fabaceae             |                              |          |          |       |          |            |     |
| Gramineae            |                              |          |          |       |          |            |     |
| Lamiaceae            |                              |          |          |       |          |            |     |
| Lauraceae            |                              |          |          |       |          |            |     |
| Limnocharitaceae     |                              |          |          |       |          |            |     |
| Linderniaceae        |                              |          |          |       |          |            |     |
| Malvaceae            |                              |          |          |       |          |            |     |
| Maranthaceae         |                              |          |          |       |          |            |     |
| Melastomataceae      |                              |          |          |       |          |            |     |
| Meliaceae            |                              |          |          |       |          |            |     |
| Moraceae             |                              |          |          |       |          |            |     |
| Musaceae             |                              |          |          |       |          |            |     |
| Myrtaceae            |                              |          |          |       |          |            |     |
| Oleaceae             |                              |          |          |       |          |            |     |
| Onagraceae           |                              |          |          |       |          |            |     |
| Orchidaceae          |                              |          |          |       |          |            |     |
| Oxalidaceae          |                              |          |          |       |          |            |     |
| Passifloraceae       |                              |          |          |       |          |            |     |
| Plantaginaceae       |                              |          |          |       |          |            |     |
| Phyllanthaceae       |                              |          |          |       |          |            |     |
| Piperaceae           |                              |          |          |       |          |            |     |
| Poaceae              |                              |          |          |       |          |            |     |
| Portulacaceae        |                              |          |          |       |          |            |     |
| Polygalaceae         |                              |          |          |       |          |            |     |
| Polygonaceae         |                              |          |          |       |          |            |     |
| Primulaceae          |                              |          |          |       |          |            |     |
| Rubiaceae            |                              |          |          |       |          |            |     |
| Rutaceae             |                              |          |          |       |          |            |     |
| Sapindaceae          |                              |          |          |       |          |            |     |
| Sapotaceae           |                              |          |          |       |          |            |     |
| Solanaceae           |                              |          |          |       |          |            |     |
3.3. Honey bee production

The majority of farmer beekeepers maintained *H. itama* species because this species is more productive than others. Beside *H. itama*, farmers also maintained another species such: *Geniotrigona thoracica*, *Lepidotrigona terminata*, *Tetragonula laeviceps*, *Tetragonula fuscobalteata*, *Tetragonula melina*, *Tetragonula minangkabau* and *Lepidotrigona latebalteata*.

The number of *H. itama* hives from each meliponiculture location is very diverse, from 96 to 252 hives. Generally, the amount of farmers' maintained colony is not regarded to the carrying capacity with their available bee forages. The number of colonies with available bee forage resources frequently is less comparable. With that condition, the average of *H. itama* honey bee production is 2.02 (Lyear⁻¹hives⁻¹). However, at another location, honey bee production can reach (3 Lyear⁻¹hives⁻¹), whereas at another location just (1.59 Lyear⁻¹hives⁻¹) (table 7).

### Table 7. Honey bee production at dry and rainy season.

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

| Family | Location | Average |
|--------|----------|---------|
| Sphenocleaceae | 1 | 7 |
| Tetramelaceae | 1 | 1 |
| Verbenaceae | 1 | 5 |
| Vitaceae | 1 | 5 |
| Zingiberaceae | 1 | 5 |
| Zygophyllaceae | 1 | 5 |

| Species | Land coverage |
|---------|---------------|
| *H. itama* | a Land coverage by combination forest and garden. |
| *T. minangkabau* | b Land coverage by combination settlement, shrub, and paddy fields. |
| *L. latebalteata* | c Land coverage by combination settlement, plantation, and shrubs. |

### Table 7. Honey bee production at dry and rainy season.

| Meliponiculture location | Sum of hives | Honey production at rainy season | Honey production at dry season |
|--------------------------|--------------|----------------------------------|--------------------------------|
|                          | All hives (Lmonth⁻¹) | Per hive (L) | For 5 months (L) | All hives (Lmonth⁻¹) | Per hive (L) | For 5 months (L) |
| **Fahrudin** a | 252 | 30 | 0.12 | 0.60 | 50 | 0.20 | 0.99 | 1.59 | 400 |
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### Table 7. Honey bee production at dry and rainy season.

| Location | Sum of hives | Honey production at rainy season | Honey production at dry season |
|----------|--------------|----------------------------------|--------------------------------|
| **Family** | **Location** | **Honey production at rainy season** | **Honey production at dry season** |
| | | **All hives** | **Per hive** | **For 5 months** | **All hives** | **Per hive** | **For 5 months** |
| Sphenocleaceae | 1 | 7 |
| Tetramelaceae | 1 | 1 |
| Verbenaceae | 1 | 5 |
| Vitaceae | 1 | 5 |
| Zingiberaceae | 1 | 5 |
| Zygophyllaceae | 1 | 5 |

Seasons are affected by honey production per year. Data from table 7 showed that honey production in the dry season mostly ≥ at rainy season. The average honey bee production at the rainy season is 0.17±0.05 (Lhives⁻¹), but the dry season reaches 0.24±0.07 (Lhives⁻¹) or increases 41±14.1%. The difference of average honey production between dry and rainy seasons based on the t-test very significant results (t₀ₐₛ 49.96 > t₀ₐₛ 4.60). In summer, there are more floras in the field for storing surplus food, and days are long for storing sufficient honey for the winter. Temperature and rainfall have a marked effect on honey bee activity. Colony strength is directly related to the temperature at which bees forage, with rainfall bee foraging activities halts. And the strong wind tends to reduce the ground speed of bees, which reduces the number of flights per day [4].
If separated the effect of kelulut habitat type on honey production, it has been known that the highest honey production was found in habitat type 3, namely a combination of settlement, plantation, and shrubs. While habitat types 1 and 2 from the results of this study have no significant effect on honey yields (table 8).

### Table 8. Honey bee production from three types of habitat

| Type habitat                        | Land coverage                        | Honey bee prod (Lhives \(^{\text{a}}\)year\(^{-1}\)) |
|-------------------------------------|--------------------------------------|-------------------------------------------------|
| Type 1                              | Combination of forest and garden      | 1.59\(^{\text{a}}\)                              |
| Type 2                              | Combination of settlement, shrub, and paddy fields | 1.85\(^{\text{a}}\)                              |
| Type 3                              | Combination of settlement, plantation, and shrubs | 2.41\(^{\text{b}}\)                              |

### 4. Conclusion
We found that habitats are more diverse and provide several levels of plants ranging from the cover crop, herbs, trees, shrubs, vines, and lianas founded in habitat with a combination of settlement, plantation, and shrub. The farms with vegetation cover type 2 (combination of settlement, shrub, and paddy fields), and type 3 (combination of settlement, plantation, and shrubs) have many different flowering shrubs that provide year-round forage for the stingless bee. That is from the presence of weeds and crops that grow in paddy fields, gardens, and settlements.

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