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The effect of different beehives on the activity of foragers, honey pots number, and honey production from stingless bee *Tetragonula* sp.

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Abstract

Tetragonula sp. is one of stingless bee species nesting in bamboos hive and produced honey, bee pollen (bee bread), and propolis. The objective of this study was to evaluate the exit activity of foragers, honey pots number, honey volume each pot, and production of honey from stingless bee *Tetragonula* sp. Thirty colonies of stingless bee *Tetragonula* sp. from bamboos hive were divided into two groups were bamboos and boxes hives, each group consisted of 15 colonies. The colonies from bamboos hive were transferred to boxes hive consisted of a queen bee, foragers, drones, brood cells, and then meliponiculture one-month in Sukadana Bee Village, North Lombok, Indonesia. The results showed that exit activity in the morning and afternoon of foragers from stingless bee *Tetragonula* sp. in the boxes hives was higher than bamboos hive ($P<0.01$). The honey pots number, honey volume each pot, and honey production (big, medium, and small pots) in boxes hive were higher than in bamboos hive ($P<0.01$).

Keywords: meliponiculture, Sukadana bee village, bamboo hive, box hive, nectar

Introduction

The stingless bees include tropical bee groups, in the world, more than 500 species have been identified and possibly more than 100 species unidentified. The colonies consist of three castes (a queen, workers, and drones) and usually only one queen as the female reproductive for each colony. In addition, the morphologically different worker and queen, and reduced stings that impact them cannot sting (Michener 2013). In Indonesia, the stingless bees (*tribe Meliponini*) are at least 46 species (Kahono et al 2018). Stingless bees in Indonesia mostly found nesting in bamboos, sugar palm stalks, tree trunks or woods, and in the ground (Agussalim et al 2015).

Tetragonula sp. is one of the stingless bee species that nesting in a bamboo (Agus et al 2019a; Agussalim et al 2019). *Tetragonula* sp. can produce honey, bee pollen or bee bread, and propolis. Honey is used by the bees as the food reserve when lacking foods, especially in the rain season to maintain from collapse colonies. Honey is defined as the natural food made from the nectar that collects by foragers from plant flowers, extrafloral nectar, and honeydew or excretions of plants sucking insects (Codex Alimentarius 2001) that deposited in the pots for stingless bees and the comb for honeybees. Honey production from stingless bee *Trigona* sp. (*Tetragonula* sp.) after meliponiculture two months was ranged from 49.20 to 66.60 ml (Agussalim et al 2017). The objective of this study was to evaluate the exit activity of foragers, honey pots number, honey volume each pot, and production of honey from stingless bee *Tetragonula* sp.

Materials and Methods

Colony Transfer

The stingless bee *Tetragonula* sp. as much 30 colonies were adapted for one week in the Sukadana Bee Village, Bayan, North Lombok, Indonesia. The colonies were divided into two groups and each group consists of 15 colonies. The first group was box as the modern hive with size 40 x 20 x 15 cm. The second group was bamboo as the natural hive with the length 30 to 40 cm and diameter 7 to 8 cm. Fifteen colonies from bamboos were transferred to boxes consisted of a queen bee, workers (foragers), drones, brood cells or eggs, and all of the colonies were meliponiculture for one-month.

Temperature and Humidity Environment

The temperature and humidity environment were measured every day for one month using thermo-hygrometer in the morning (08:00 am) and in the afternoon (4:00 pm).

Honey Production

Honey production of stingless bee *Tetragonula* sp. was measured after meliponiculture one month. In brief, honey was harvested from boxes and bamboos with cutting the propolis as the construction in the boxes wall, then the honey was placed in the plastic bottles. Furthermore, honey was squeezed using hand to separated honey from propolis, then honey was measured by graduated cylinders. The plant types as the source of nectar to produce honey were identified.

Daily Activity of Foragers

The daily activity of the foragers was counted every day for one month i.e. the exit activity from hives was counted using hand counter check. The exit number of foragers from hives was counted by standing in front of the hive entrance at a distance 1 meter for 5 minutes each hive and was performed in the morning (08:00 am) and in the afternoon (4:00 pm). The number of entering foragers to the hives was not counted because the exit foragers will be entering back to the hives.

Honey Pots Number

The pots honey number was counted after meliponiculture one month were divided into three categories were big pots (diameter mean 1.1 cm), medium pots (diameter mean 0.7 cm), and small pots (diameter mean 0.4 cm). The boxes and bamboos hives were opened and then the number of honey pots was counted in the night was equipped with lighting. In addition, the production of honey from each honey pot was aspirated using syringe 1 ml and the honey volume each pot was measured.

Statistical analysis

The data of honey production, exit activity of foragers, pots honey number, and honey volume each pot from stingless bee *Tetragonula* sp. were analyzed by T-test, and the temperature and humidity environment were analyzed by descriptive analysis using SPSS statistics version 23.

Results and Discussion

Temperature and Humidity Environment

The results showed that the environment temperature in the Sukadana Bee Village, North Lombok was ranged from 25.0 to 26.1°C in the morning, while in the afternoon was ranged from 28.6 to 30.4°C. The environment humidity was ranged from 68.0 to 74.4% in the morning, while in the afternoon was ranged from 57.9 to 64.9% (Table 1). The temperature and humidity environment in the Sukadana Bee Village, North Lombok was including the normal temperature and humidity required by stingless bees to optimally productivity.

Table 1. The mean of temperature and humidity environment every week in the Sukadana Bee Village, North Lombok

Weeks	Temperature (°C)		Humidity (%)	
	Morning	Afternoon	Morning	Afternoon
First	25.1	28.6	74.7	63.9
Second	25.7	30.4	68.0	61.3
Third	26.1	29.1	68.4	64.9
Fourth	25.0	30.1	69.9	57.9

The environment temperature required by the bees to collect food was ranged from 5 to 45°C and if under or above it, decrease the activities of honeybees and even until its death (Abrol 2011). The elevated temperatures and the concomitant lack of water during dry periods can be induced absconding in stingless bees (Maia-Silva et al 2015). Heard and Hendrikz (1993) explained that the temperature was a significant effect on the flight activity of stingless bee *Trigona carbonaria*, but not consistent on humidity relative. The temperature threshold to activity was ranged from 18 to 19°C. The peak activity *T. carbonaria* was ranged from 26.1 to 29.8°C with humidity relative 35 to 90%. The temperature and humidity in the study was differ from those previously reported Agussalim et al (2015) for *Trigona* sp. (*Tetragonula* sp.) and Heard and Hendrikz (1993) for *T. carbonaria*.

Daily Activity of Foragers

The results showed that the exit activity from hives by foragers in boxes hive in the morning was higher than the exit activity hive in bamboos hive (50.1 versus 36.6 heads/5 minutes) and in the afternoon (29.3 versus 25.3 heads/5 minutes) ($P<0.01$). In addition, the exit activity from hives by foragers in the morning was higher than in the afternoon for bamboos hive (36.6 versus 25.3 heads/5 minutes) and boxes hive (50.1 versus 29.3 heads/5 minutes) ($P<0.01$) (Table 2). The exit activity from boxes hives was higher than bamboos hives might be the foragers in the boxes must gather more materials to build the nest and be creating comfort conditions than bamboos hives. In addition, it also might be affected by the foragers and egg number, and the productivity of the queen bee, but in our study not measured.

Table 2. The mean of exit activity of foragers stingless bee *Tetragonula* sp. from bamboos and boxes hives

Observation time	Bamboos hive (heads/5 minutes)	Boxes hive (heads/5 minutes)	SEM	*P*
Morning (08:00 am)	36.6^{bx}	50.1^{ax}	0.47	0.00
Afternoon (4:00 pm)	25.3^{by}	29.3^{ay}	0.22	0.00

[a,b] Different superscripts within rows indicate differences at p<0.05
[x,y] Different superscripts within column indicate differences at p<0.05

The exit activity of foragers stingless bee *Tetragonula* sp. in the morning was higher than in the afternoon because in the morning very abundant blooming flowers as the food source like nectar (raw material to produce honey) and pollen (raw material to produce bee-pollen or bee bread), and resin (raw material to produce propolis). The exit activity hives from stingless bee *Tetragonula* sp. in this study was differ from those previously for stingless bees *Tetragonula laeviceps*, *Heterotrigona itama*, and *Lepidotrogona terminata* (Atmowidi et al 2018), for *T. laeviceps* (Agus et al 2019b; Gadhiya and Pastagia 2019), and for *Trigona* sp. (*Tetragonula* sp.) (Agussalim et al 2015). The different daily activity from each stingless bee was affected by the different stingless bee species, geographical origin (related to temperature, humidity, light intensity, wind velocity), foragers and egg number.

Honey Production

The results showed that the honey pots number after meliponiculture one-month from boxes hive was higher than from bamboos hive for all of the honey pots size were 18.1 versus 8.27 pots for big pots, 25.8 versus 16.3 pots for medium pots, and 26.8 versus 17.6 pots for small pots (P<0.01) (Table 3). The honey pots number was higher in the boxes hive was affected by the good development of colonies from boxes such as eggs or brood cells and foragers number much more that impact on the higher exit activity from the hive by foragers in boxes hive than in bamboos hive (Table 2).

Table 3. The mean of honey pots number from stingless bee *Tetragonula* sp. after one-month meliponiculture

Honey Pots Number	Bamboos hive (pots)	Boxes hive (pots)	SEM	*P*
Big	8.27[b]	18.1[a]	1.11	0.00
Medium	16.3[b]	25.8[a]	1.34	0.00
Small	17.6[b]	26.8[a]	1.53	0.00

[a,b] Different superscripts within rows indicate differences at p<0.05

The foragers in the boxes hive very actively to collect nectar from flowers and resin from plants than from bamboos hive was shown by the higher exit activity of foragers (Table 2). In addition, the volume from boxes hive was proportional for *Tetragonula* sp. than bamboos hive volume was smaller, thus allowing the colonies in boxes hives to develop properly. The volume each honey pot from boxes hive was higher than bamboo hive for all of the honey pots size were 0.37 versus 0.32 ml for the big pot, 0.28 versus 0.25 ml for the medium pot, and 0.18 versus 0.14 ml for the small pot (P<0.01) (Table 4). The higher of honey volume each pot from boxes hive might be related to the ability of workers to produce the big pot and the foragers very active to collect nectar and resin from plants was shown by the higher exit activity of foragers in boxes hive than in bamboos hive (Table 2).

Table 4. The mean of honey volume each pot from bamboos and boxes hives by stingless bee *Tetragonula* sp.

Honey volume (mL)	Bamboos hive	Boxes hive	SEM	*P*
Big pot	0.32[b]	0.37[a]	0.01	0.01
Medium pot	0.25[b]	0.28[a]	0.01	0.02
Small pot	0.14[b]	0.18[a]	0.01	0.01

[a,b] Different superscripts within rows indicate differences at p<0.05

The honey production of stingless bee *Tetragonula* sp. from Boxes hive was higher than bamboos hive for all of the honey pot were 6.68 versus 2.65 ml for the big honey pot, 7.22 versus 4.07 ml for the medium honey pot, and 4.82 versus 2.46 ml for the small honey pot ($P<0.01$) (Table 5). The honey production in Sukadana Bee Village was supported by plants as the source of nectar were longan, banana, mango, cashew, sunflowers, start fruit, bilimbi, coconut, calliandra, Jamaica cherry, papaya, and cassava. The plants have different times for flowering and blooming, but they support each other.

Table 5. Honey production of stingless bee *Tetragonula* sp. for one-month meliponiculture in Sukadana Bee Village, North Lombok

Honey production (mL)	Bamboos hive	Boxes hive	SEM	*P*
Big pot	2.65[b]	6.68[a]	0.43	0.00
Medium pot	4.07[b]	7.22[a]	0.39	0.00
Small pot	2.46[b]	4.82[a]	0.29	0.00

[a,b] Different superscripts within rows indicate differences at $p<0.05$

The higher honey production in boxes hive than bamboos hive was affected the higher exit activity of foragers in the boxes hive than bamboos hive in the morning and afternoon (Table 2) that impact on much more nectar and resin has been collected by foragers to produce honey and propolis. Furthermore, the nectar and resin much more will impact the increase of honey pots number (Table 3).

Production of honey stingless bee *Tetragonula* sp. in this study (Table 5) was differ from reported by Agussalim et al (2017) for stingless bee *Trigona* sp. (*Tetragonula* sp.). The difference of honey production with this study was affected by the plant types as the food source, the bee species which involved in honey production, the daily activities of foragers especially when collecting nectar, and resin from plants and also foragers number. In addition, in Sukadana Bee Village was the center for research, development, empowerment, and community service to poverty alleviation and livelihood security of communities, especially beekeepers in North Lombok Regency, West Nusa Tenggara Province, Indonesia. Thus, in the future is required advanced study about the roles of stingless bees meliponiculture on the income of beekeepers and poverty alleviation in communities.

Conclusions

- The exit activity of hives from stingless bee *Tetragonula* sp. foragers in the boxes hive was ranged from 29.3 to 50.1 heads/5 minutes and was ranged from 25.3 to 36.6 heads/5 minutes for bamboos hive
- The honey pots number from stingless bee *Tetragonula* sp. in boxes hive after meliponiculture one-month were 18.1 pots (big pot), 25.8 pots (medium pot), 26.8 pots (small pot), and 8.27 pots (big pot), 16.3 (medium pot), and 17.6 pots (small pot) for bamboos hive
- The honey volume of stingless bee *Tetragonula* sp. from boxes hive in each pot were 0.37 ml (big pot), 0.28 ml (medium pot), 0.18 ml (small pot), and 0.32 ml (big pot), 0.25 ml (medium pot), and 0.14 ml (small pot) for bamboos hive
- The honey production of stingless bee *Tetragonula* sp. after meliponiculture one-month in boxes hive were 6.68 ml (big pot), 7.22 ml (medium pot), 4.82 ml (small pot) and 2.65 ml (big pot), 4.07 ml (medium pot), and 2.46 ml (small pot) for bamboos hive.

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