Enhances production of coffee (Coffea robusta): the role of pollinator, forages potency, and honey production from stingless bee Tetragonula sp. in Central Lombok, Indonesia

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Enhances production of coffee (*Coffea robusta*): the role of pollinator, forages potency, and honey production from stingless bee *Tetragonula* sp. in Central Lombok, Indonesia

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Abstract

The bees are roles as an agent of pollinator to improve the productivity of plants. This study were purposes to enhancing coffee production (*Coffea robusta*) by roles of stingless bee *Tetragonula* sp. as pollinator agent, forages potency, and honey production. This study has been conducted in coffee plantation in Lantan, Central Lombok, Indonesia. Several parameters were measured such as the number of bunches and flowers, production of nectar and pollen, sucrose nectar content, production of coffee, production of honey, honey stomach volume, and pollen weight. The results showed that the different of observation time influencing the number of bunches, flowers, production of nectar and pollen, sucrose nectar content ($p<0.01$). The number of bunches was ranged from 58.2 to 144.9 bunches/tree, number of flowers 36.3 to 58.7 flowers/bunches and 2,362.5 to 8.250.6 flowers/tree. Furthermore, the nectar production 9.16 to 33.85 g/tree, pollen production 1.72 to 5.95 g/tree, sucrose nectar content 20.6 to 35.0%. Estimation of coffee production before pollinated by *Tetragonula* sp. was 1,230.8 kg/ha, but after pollinated by *Tetragonula* was increased became 3,605.7 kg/ha (49.1%). Fruit production before pollinated by *Tetragonula* sp. was 2,127.2 fruit/tree, but after pollinated by *Tetragonula* sp. was increased became 8,309.2 fruit/tree (59.2%). Production of honey from *Tetragonula* sp. was 3.74 g/hive/5 months and in *Apis cerana* was 301.4 g/hive/months. It can be concluded that the *Tetragonula* sp. as an agent of pollinator can enhancing the production of coffee and indirectly also increasing the biodiversity of coffee.

Keywords: *Biodiversity, coffee flowers, nectar, pollination, pollen*

Introduction

The coffee plantation area in Indonesia every year is decreased where in 2017 Government Estates has an area 23.63 thousand hectares and decreased in 2018 became 19.92 thousand hectares and in 2019 is decreased became 14.5 thousand hectares. Furthermore, Private Estates also decreased where in 2017 has an area 23.19 thousand hectares and decreased in 2018 became 22.25 thousand hectares, and in 2019 decreased became 9.71 thousand hectares. The decreased of coffee plantation area is caused by the land conversion in several provinces. However, in Smallholders Estates is increased in 2017 1.192 million hectares, then increased in 2018 became 1.210 million hectares and in 2019 increased became 1.215 million hectares. The decreased of coffee plantation area is impacted on decrease in coffee production. The production of coffee in Indonesia from year of 2017 to 2019 is fluctuating where the production of coffee in 2017 year is 30.29 thousand ton and decreased to 28.14 thousand in 2018 (deceased 7.1%) and in 2019 decreased became 10.01 thousand ton (BPS-Statistics Indonesia 2019). In

in West Nusa Tenggara Province, Indonesia showed that smallholders coffee area in 2016 is 12,256 ha with coffee production is 4,641 tons (BPS-Statistics Indonesia 2017) and in 2017 is decreased became 11,978 ha with coffee production is 4,865 tons (BPS-Statistics Indonesia 2018) and in 2018 is decreased became 11,942 ha with coffee production 5.037 tons (BPS-Statistics Indonesia 2019).

To increase the coffee production is required the roles of insect to pollinate their flowers and one of the insects as the best pollinators is honeybees or stingless bees. Coffee flowers are producing a nectar and pollen for honeybees or stingless bees food. Nectar and pollen are used by honeybees or stingless bee to produce honey and bee bread which required for their growth and development in the colonies (Abrol 2011; Agussalim et al 2018). When coffee flower blooming is usually found the honeybees or stingless bees visits the flowers to collect nectar and pollen. Stingless bee species that can be found in Lombok include *Tetragonula* species that can produce honey, bee bread, and propolis (Agus et al 2019; Agussalim et al 2019, 2020, 2021; Erwan et al 2020, 2021). Furthermore, when the bees collecting nectar and pollen as an indirectly, they are services as an agent of pollinator so increased the productivity of coffee. Coffee flowers include in hermaphrodite where they are can performed the self-pollination, but assumed is predominant pollinated by wind, however the cross pollination by the bees can significantly increasing the production of coffee (*Coffea canephora*) (Klein et al 2003; Quezada-Euan 2018; Roubik 2002). In Mexico, the main visitor in coffee flowers is honeybee *Apis mellifera* for about 84% from total of visitors. Furthermore, stingless bee *Trigona corvina* also reported their visit for about 6% from total of visitors (Vergara and Badano, 2009).

Klein et al (2003) reported that the insects are services as pollinator is mostly pollinated by the bees is ranged from 2,038 to 2,269 bees that visiting coffee flowers. Several studied showed that honeybees or stingless bee can improve the productivity of several plants such as number of fruits, weight, length, etc. from various countries (Azmi et al 2016; Bezabih and Gebretsadikan 2014; Calderone 2012; Kishan Tej et al 2017; Layek et al 2021; Putra et al 2014; Rogers et al 2014; Veddeler et al 2008). However, the studied the roles of stingless bee *Tetragonula* sp. as an agent of pollinator in coffee (*Coffea robusta*) in Central Lombok, Indonesia has not studied. This study were purposes to enhancing coffee production (*Coffea robusta*) by roles of stingless bee *Tetragonula* sp. as an agent of pollinator, forages potency from coffee flowers, and evaluate the honey production from *Tetragonula* sp. in Central Lombok, West Nusa Tenggara Province, Indonesia.

Materials and Methods

This study has been conducted in the coffee plantation who manage by communities in forest area (smallholders) in Lantan with located at 600 above sea level, Central Lombok Regency, West Nusa Tenggara Province, Indonesia. One hundred of coffee flowers were wrapped for about 9 months using gauze (size 10 x 10 cm) that have been counted to determine their ability to self-pollination. Afterwards, the coffee fruit amount was counted each wrap. Furthermore, the flowers percentage that became fruit from the treatment without stingless bee pollinated and pollinated by stingless bee was calculated by the equation:
Flowers percentage = (flowers amount per bunch – coffee fruit) x 100%

The flowering characteristic of coffee was obtained by observed from April to November. The nectar production from coffee flowers and the capacity of coffee plantation per hectare for stingless bee meliponiculture. Thirty coffee trees were chosen randomly, and each their tree was counted production per bunch, flowers amount per bunch. Afterwards, the flowers were

taken 4 bunches and was counted flowers amount per bunches randomly. The number of blooming flowers bunches, blooming flowers per bunches, and flowers per coffee tree was counted directly from coffee plant. The colonies of stingless bee *Tetragonula* sp. was used as an agent of pollinator for coffee plants were 20 colonies per hectare of coffee plantation.

Figure 1. Coffee flowers were covered by gauze used in this study

Nectar collecting and their sucrose content

Coffee flowers were covered by gauze (Figure 1) before collected their nectar from 18 coffee bunches and their bunches were at least 50 flowers. Every 2 bunches that blooming flowers were collected their nectar using a glass pipette has been modified (Figure 2A) in the morning (06.00 to 09.00), afternoon (11.00 to 13.00), and evening (16.00 to 18.00) in one day every period of flowers blooming. Afterwards, the nectar was put into Eppendorf tube (Figure 2B) and then analyzed using Luff Schoorl method as described by AOAC (2005). All analyses were performed in triplicates and each in duplo.

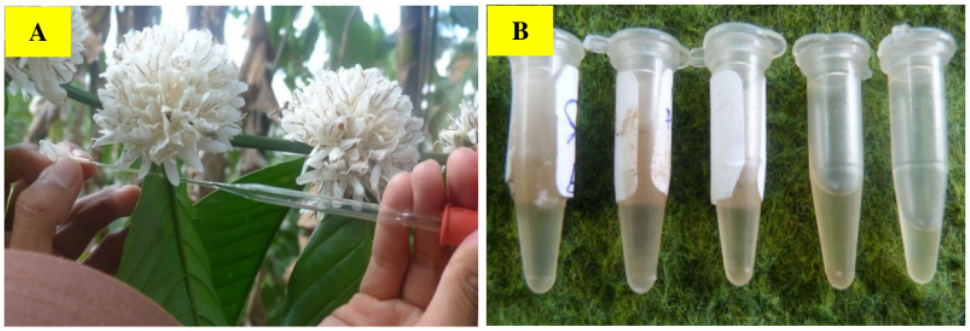

Figure 2. Coffee flowers when collected a nectar (A) and nectar has been collected put in Eppendorf tubes (B)

Production of nectar and pollen of coffee flowers

The production of nectar from coffee flowers were measured from 1,220 flowers and the average each flower was counted. Production of nectar from one flower was measured from one flower sample and sucked by a glass pipette has been modified (Figure 2A) and weighed

by digital scale. For production of nectar per coffee tree was counted from the number of flowers per coffee tree multiplied by production of nectar per flower. The production of nectar per hectare of coffee plantation was counted by the production of nectar per coffee tree multiplied by the number of coffee tree per hectare (coffee trees per hectare were 1,322 trees). The pollen production from coffee flowers were measured from 1,062 flowers and then were counted the average each flower. The production of nectar and pollen each month was counted from the number of flowers per tree multiplied by production of nectar and pollen from each flower and measured during July to October. The total production of nectar and pollen were counted as the production total from July to October. The total production of nectar from coffee flowers was counted from the sum of nectar from 4 month during July to October period and production per hectare of plantation also was counted.

Estimation of coffee production

Estimation of coffee production was counted from the production of coffee per tree multiplied by the number of coffee tree per hectare (coffee trees per hectare of plantation were 1,322 trees) and was counted during May to October each for the flowers covered by gauze (without stingless bee pollinate) and pollinated by stingless bee *Tetragonula* sp. Production of coffee before pollinated by stingless bee was obtained from the data previously have been collected by farmers.

Analysis data

The data of number of bunches, flowers, production of nectar and pollen, and sucrose nectar content were analyzed using by one-way analysis and followed by the Tukey test. The data of total bunches per coffee, flowers per bunches, flowers per coffee and total of production of nectar and pollen per hectares were analyzed by descriptive analysis (Steel et al 1997).

Results and Discussion

Number of bunches and flowers

The results showed that the number of bunches per coffee tree were differ among the observation months. The number of bunches per tree from the higher was 144.9 bunches/tree in September, followed by October was 119.9 bunches/tree, August was 83.2 bunches/tree and the lowest in July was 58.2 bunches/tree ($p<0.01$) (Table 1). This condition, in line with the flower number per coffee tree where in September as the peak of flowering in coffee was 8,250 flowers/ tree, followed by October was 5,534.3 flowers/ tree, August was 3,025.6 flowers/ tree, and decreased in July was 2,362.5 flowers/ tree. In addition, the coffee tree in Lantan, Central Lombok when our studied showed that the flowering was delayed and started in July period though usually flowering was started in May to July periods. Furthermore, the number of flowers per bunches was higher in September was 58.7 flowers/bunch, followed by October was 45.9 flowers/bunch, and decreased in July and August were 39.6 flowers/bunch and 36.3 flowers/bunch, respectively (Table 1).

Table 1. The number of blooming flowers bunches, blooming flowers and production of nectar and pollen of coffee flowers during July to October periods

Parameters	Observation months				SEM	*p*
	July	August	September	October		
Number bunches per tree	58.2[d]	83.2[c]	144.9[a]	119.9[b]	4.137	0.000
Number flowers per bunches	39.6[b]	36.3[b]	58.7[a]	45.9[b]	1.659	0.000
Number flowers per tree	2,362.5[d]	3,025.6[c]	8,250.6[a]	5,534.3[b]	300.1	0.000
Production of nectar (g/tree)	9.16[c]	12.79[c]	33.85[a]	23.26[b]	1.237	0.000
Production of pollen (g/tree)	1.72[c]	2.25[c]	5.95[a]	4.10[b]	0.218	0.000

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

The different of number of bunches and flowers from coffee tree each month might be affected the different the ability in each plant to growth and absorb the soil nutrients that used to produce flowers each bunch. Based on number of brunches and flowers per coffee tree indicates have potential as an area for beekeeping of honeybees or meliponiculture of stingless bees. The number of coffee flower per plant in our study was differ with previously studied by Bareke et al (2021) that number of flowers per plant for *Coffea arabica* L. is ranged from 485 to 2330 flowers/plant. Based on Pearson correlation showed that the number of blooming flowers bunches per coffee has a positively correlated with blooming flowers per bunches ($r = 0.256$, $p<0.001$) and number of flowers per coffee ($r = 0.772$, $p<0.001$). In addition, the blooming flowers per bunches has a positively correlated with the number of flowers per coffee ($r = 0.778$, $p<0.001$) (Table 3). Its indicates that the higher of number of numbers of blooming flowers, blooming flowers, and flowers of coffee trees are impact on increased the production of nectar and pollen from coffee trees. Therefore, it can be supporting the availability of honeybees or stingless bees that sustainability to supporting the increase of biodiversity especially coffee tree.

Table 2. The total number of bunches, flowers and total production of nectar and pollen from coffee flowers

Parameters	Total (4 months)	Per hectare (ha)
Number bunches per tree	421.6	-
Number flowers per bunches	180.6	-
Number flowers per tree	19,173	25,352,815
Production of coffee nectar (g)	79.1	104,549
Production of coffee pollen (g)	14.1	18,548

Notes for production of nectar (n = 1,220 flowers) and pollen (n = 1,062 flowers) of coffee flowers and coffee trees were 1,322 trees/ha

The number total of bunches per coffee tree was 421.6 bunches/tree and the number of flowers per bunches was 180.6 flowers/bunches. Furthermore, the number total of flowers per coffee tree was 19,173 flowers/tree, while per hectare of plantation was 25,352,815 flowers/ha (Table 2). It indicates that the coffee plantation was potential to support the nectar and pollen for honeybees or stingless bees. Thus, in future is needed comprehensive study about the production of honey and bee bread from honeybees or stingless bees and the quality of honey or bee bread based on their chemical composition.

Production of nectar and pollen

The results showed that the production of nectar from one coffee flower was 4.12 mg/flower, while the pollen production was 0.73 mg/flower. It indicates that the coffee flowers have the potential as the source of nectar and pollen for honeybees or stingless bees forages. The results showed that the production of nectar and pollen from coffee flowers each month for observe was differ. The production of nectar from coffee flowers was higher in September period was 33.85 g/tree, followed by October was 23.26 g/tree, August was 12.79 g/tree, and decreased in July period was 9.16 g/tree (Table 1). Coffee flowers was produced the nectar for 3 days and depend on climate or season, when the rain season when flowers are started blooming so the flowers just can produce nectar for 2 days. However, in our study was differ with reported by Bareke et al (2021) that the *Coffea arabica* L. coffee produce nectar for 5 days where the production peak of nectar in second 2 day and decreased in third day until to fifth day. The production of pollen from coffee flowers was higher in September period was 5.95 g/month, followed by October was 4.10 g/coffee, in August was 2.25 g/coffee, and decreased in July period was 1.72 g/coffee (Table 1). The total of nectar production for 4 months from one coffee tree was 79.1 g/tree, while the production per hectare of plantation was 104,549 g/ha (Table 2). Based on production of nectar per plant and per hectare plantation indicates that the coffee flowers are the potential nectar source for honeybees or stingless bees. The production of nectar from coffee flowers were positively correlated with the number of blooming flowers bunches ($r = 0.772$, $p<0.01$), blooming flowers ($r = 0.778$, $p<0.01$), and number of flowers ($r = 1.000$, $p<0.01$) (Table 2).

Table 3. Pearson correlation numbers of blooming flowers bunches per coffee, blooming flowers per bunches, flowers per coffee, production of nectar and pollen from coffee flowers.

	Production of nectar	Production of pollen	Blooming flowers bunches	Blooming flowers	Flowers
Production of nectar	1				
Production of pollen	1.000**	1			
Blooming flowers bunches	0.772**	0.772**	1		
Blooming flowers	0.778**	0.778**	0.256**	1	
Flowers	1.000**	1.000**	0.772**	0.778**	1

**Indicates significant at p<0.001 (2-tailed)

Production of nectar from one of coffee flower in our study was differ with reported by Manila-fajardo and Cervancia (2020) for *Coffea liberica* var. *liberica* is ranged from 4.22 to 14.43 μL. Furthermore, production of nectar per coffee *Coffea arabica* L. flowers in 07.00 to 18.00 hours is ranged from 2.5 to 6.6 μL (Bareke et al 2021). The production of nectar from coffee flowers is affected by coffee cultivars, plant age, season or climate (include temperature, humidity), and availability of soil nutrients and their ability to absorb of soil nutrients.

The production of pollen from coffee flowers was higher in September period was 5.95 g/month, followed by October was 4.10 g/coffee, in August was 2.25 g/coffee, and decreased in July period was 1.72 g/coffee (Table 1). Furthermore, the production of nectar for one coffee tree was 14.1 g/4 months and the total production of pollen from one hectare plantation was 18,548 g/ha. It indicates that the availability of coffee pollen can support for beekeeping or meliponiculture and to increasing the coffee production by cross pollination from pollen each coffee plant. The production of pollen from coffee flowers were positively correlated with the number of blooming flowers bunches ($r = 0.772$, $p<0.01$), blooming flowers ($r = 0.778$,

p<0.01), and number of flowers (r = 1.000, p<0.01) (Table 3). The production total of pollen from coffee flowers was 14.1 g/tree, while per hectare of plantation was produce 18,854 g/ha of pollen. It indicates that the coffee flowers have the potential to produce of pollen as the honeybees or stingless bees food.

Sucrose nectar content

The results showed that the sucrose nectar content from coffee flowers were differ among the time to collecting in the morning, afternoon, and evening for first, second, and third days collecting, respectively. In the first day, the sucrose nectar content in the morning (23.3%) and afternoon (23.3%) were similar and higher than sucrose nectar content in evening was 23.2% (p<0.01). Furthermore, in the morning (24.4%) and afternoon (24.4) were similar and lower than nectar sucrose content in evening was 27.1% for second day and the third day was higher in afternoon was 35.0%, followed by evening was 29.0%, and the lowest in morning was 20.6% (p<0.01) (Table 4).

Table 4. Sucrose nectar content from coffee flowers in various time and day of observe

Observe Days	Time collection			SEM	*p*
	Morning (%)	Afternoon (%)	Evening (%)		
First (%)	23.3^{ay}	23.3^{az}	23.2^{bz}	0.022	0.007
Second (%)	24.4^{bx}	24.4^{by}	27.1^{ay}	0.441	0.000
Third (%)	20.6^{cz}	35.0^{ax}	29.0^{bx}	2.082	0.000
SEM	0.561	1.863	0.848		
p	0.000	0.000	0.000		

^{a,b} *Different superscripts within rows indicate differences at p<0.05*
^{x,y,z} *Different superscripts within columns indicate differences at p<0.05*

The different days to collecting nectar from coffee flowers are impact on the different of sucrose nectar content. The sucrose nectar content of coffee flowers when collected in the morning was higher in second day was 24.4%, followed by first day was 23.3%, and the lowest in third day was 20.6% (p<0.01). In the afternoon the sucrose nectar content was higher in third day was 35.0%, followed by second day was 24.4%, and the lowest in first day was 23.3% (p<0.01). Furthermore, in the evening the higher sucrose nectar content was in third day was 29.0, followed by second day was 27.1%, and the lowest in first day was 23.2% (p<0.01) (Table 4). The sucrose nectar content in our study was differ with previously reported by Manila-fajardo and Cervancia (2020) for *Coffea liberica* var. *liberica* where the mean of calorie content based on sucrose nectar content is ranged from 0.87 to 2.98 cal/μL. Furthermore, Bareke et al (2021) reported that the sugar content from *Coffea arabica* L. coffee nectar is ranged from 2.8 to 4.6 mg/flower/day.

Production of coffee

The results showed that the production of coffee before pollinated by the stingless bee *Tetragonula* sp. was 1,230.8 kg/ha, but after pollinated by *Tetragonula* sp. was increased 49.1% became 3,605.7 kg/ha from previously production. In addition, the fruit production before pollinated by *Tetragonula* sp. was 2,127.2 fruit/tree, but after pollinated by *Tetragonula* sp. was increased 59.2% became 8,309.2 fruit/tree from previously production. It indicates that the involvement of stingless bee *Tetragonula* sp. as an agent of pollinator can improve the productivity of coffee especially coffee production per hectare and fruit production per tree,

however other parameters have not studied such as fruit weight, fruit production per bunches, and the involvement of other insects as the pollinator. Veddeler et al (2008) reported that the bee visiting to the coffee flowers (*Coffea arabica*) increased coffee yield until 80% and 800% in net revenues. Furthermore, Calderone (2012) reported that the honey bees is increased production 28.9% from plants total as an indirectly depend on the pollinators. These results showed that the diversity of bee species is more effective and productive to enhances the productivity of perennial crops by pollination services (Rogers et al 2014).

Table 5. Estimation of coffee production before and after pollinated by stingless bee *Tetragonula* sp. during May to October period

Parameters	Before pollinated by bees	After pollinated by bees	Total	Amount increasing (kg)	Percentage increasing (%)
Coffee production (kg/ha)	1,230.8	3,605.7	4,836.5	2,374.9	49.1
Fruit production (fruit/tree)	2,127.2	8,309.2	10,436.4	6,182.0	59.2

This study in line with reported by Bezabih and Gebretsadikan (2014) that the onion 50% is pollinated by honeybee *Apis mellifera* L. and increased onion production was 41.2%, seeds 1,000 mass was 25%, and percentage of germination was 68%. Furthermore, Azmi et al (2016) reported that the chili pollinated by stingless bee *Heterotrigona itama* and hand cross pollination is resulted longer, heavier, and greater of seed number per fruit than chilies self-pollinated. Furthermore, Putra et al (2014) reported that the tomato flowers that pollinated by honey bee *Apis cerana* more efficient (80.3%) than pollinated by stingless bee *Trigona iridipennis* (70.2%), however weight and size of tomato fruit is similar. Kishan Tej et al (2017) reported that the stingless bee *Tetragonula iridipennis* Smith used as the pollinator in greenhouse can be increased the production attributes of cucumber (fruit length, girth, weight, fruit number per plant, and production per plant) than control (without stingless bee as the pollinator). Furthermore, Layek et al (2021) reported that the open pollination added stingless bee and honeybee can increased watermelon fruit set is 14% for *Tetragonula iridipennis* and 17 for *Apis mellifera* compared to open pollination and geitonogamy. In addition, open pollination added by stingless bee and honeybee increased the quality of watermelon (length, girth, and weight of fruits) than open pollination and geitonogamy, however is lower compared to cross pollination using hand.

Production of honey, honey stomach volume and pollen weight

The results showed that the honey production from stingless bee *Tetragonula* sp. after 5 months meliponiculture in coffee plantation was 3.74 g//hive (Table 6). Its honey production is described that the stingless bee *Tetragonula* sp. might be the colonies has a started to developed and focused on construct their nest. Supeno and Erwan (2013) reported that the stingless bee *Tetragonula* sp. can produce honey 300 mL/hive for 8 months meliponiculture in North Lombok, Indonesia. Honey production in our study was differ with reported by Agussalim et al (2020) for *Tetragonula laeviceps* after meliponiculture for 4 months is ranged from 60 to 263 ml/hive (79.2 to 328 g/hive). In addition, Erwan et al (2020) reported that the volume of honey pots from *Tetragonula* sp. is ranged from 0.14 to 0.37 mL/pot, total production for 1 month meliponiculture in North Lombok is 9.18 mL/bamboo hive and 18.72 mL/box hive. Production of honey from *Apis cerana* after beekeeping for 5 months was 301.4 g/hive (Table 6) with coffee flowers as the nectar source. This production was differ with previously studied

by Schouten et al (2019) reported that the annual of honey production from *Apis cerana javana* Fabr.) that beekeeping in Java, Bali, Nusa Penida, and Sumbawa is ranged from 0.5 to 5 kg/hive. The different in honey production for each species *Tetragonula* sp. and *Apis cerana* is affected by the different of plant types as the nectar source, activity of foragers to collect nectar, bee species or genetic, and climate condition (temperature and humidity).

Table 6. Production of honey, honey stomach volume, and pollen weight can be collected by honeybee *Apis cerana* and stingless bee *Tetragonula* sp.

Parameters	Weight
Production of honey from *Tetragonula* sp. (g/hive/5 months)	3.74
Production of honey from *Apis cerana* (g/hive/5 months)	301.4
Honey stomach volume from *Tetragonula* sp (g/head) (n = 50 heads)	0.005
Honey stomach volume from *Apis cerana* (g/head) (n = 50 heads)	0.01
Pollen weight transported by *Tetragonula* sp. (g/head) (n = 50 heads)	0.0008
Pollen weight transported by *Apis cerana* (g/head) (n = 50 heads)	0.0027

Honey stomach volume that contains form *Tetragonula* sp. was 0.005 g/head, while in *Apis cerana* was 0.01 g/head. Furthermore, the pollen weight transported by *Tetragonula* sp. after they collected pollen from coffee flowers to hive was 0.0008 g/head, while for *Apis cerana* was 0.0027 g/head. The honey stomach volume that contains nectar from *Apis cerana* was twice bigger than honey stomach volume of *Tetragonula* sp., while pollen weight from corbicula for *Apis cerana* was triples bigger than pollen weight from *Tetragonula* sp. (Table 6). The different of honey stomach volume and pollen weight from corbicula from each bee is caused by the different of bee size of *Apis cerana* was bigger than *Tetragonula* sp. that impact on number of nectar and pollen can be collected by foragers. Furthermore, impacted on flight distance can be reached by *Apis cerana* when collecting nectar and pollen from plant flowers was longer distance than *Tetragonula* sp.

Conclusions

- The role of stingless bee *Tetragonula* sp. as an agent of pollinator can enhancing the production of coffee (*Coffea robusta*) from 1,230.8 kg/ha became 3,605.7 kg/ha or increased 49.1%.
- Production of coffee fruit is increased after pollinated by *Tetragonula* sp. from 2,127.2 fruit/tree became 8,309.2 fruit/tree or increased 59.2%.
- Production of nectar from coffee flowers is 79.1 g/tree/4 months and their production total is 104,549 g/ha.
- Production of pollen from coffee flowers is 14.1 g/tree/4 month and their production total is 18,548 g/ha.
- Production of honey from stingless bee *Tetragonula* sp. is 5.74 mL/hive/4 months and honeybee *Apis cerana* is 300 mL/hive/4 months.
- Stingless bee *Tetragonula* sp. and honeybee *Apis cerana* can be used to increasing the coffee biodiversity.

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