The production of honey and pot-pollen from stingless bee *Tetragonula clypearis* and their contribution to increase the farmers income in West Lombok, Indonesia

Bambang Supeno, Erwan[1] and Agussalim[2]

Faculty of Agriculture, University of Mataram, Jl. Majapahit No. 62, Mataram - 83125, Indonesia
bsupeno59@unram.ac.id
[1] Faculty of Animal Science, University of Mataram, Jl. Majapahit No. 62, Mataram - 83125, Indonesia
[2] Faculty of Animal Science, Universitas Gadjah Mada, Jl. Fauna 3, Bulaksumur, Yogyakarta - 55281, Indonesia

Abstract

Beekeeping in stingless bees is called meliponiculture and the products are produced consists of honey, pot-pollen, and propolis. However, in West Lombok, Indonesia there is lack of information about the contribution of honey and pot-pollen sold on the beekeepers or farmers income. Therefore, the aims of this study were to determine the production of honey and pot-pollen from the stingless bee *Tetragonula clypearis* and their contribution to increase the farmer's income. In this study was used 112 colonies of stingless bee *Tetragonula clypearis* were moved from the bamboo hives to the box hives. All colonies were meliponiculture for about 8 months in the yard and rice field and harvested in two periods namely the first was after four months of meliponiculture and the second was four months after the first harvested. The recent findings showed that the production of honey in the yard was ranging 153.2 to 164.2 ml/hive/4 months and in the rice field was ranging 153.2 to 160.5 ml/hive/4 months. The production of pot-pollen in the yard was ranging 43.3 to 47.6 g/hive/4 months and in the rice field was ranging 43.5 to 44.1 g/hive/4 months. The total production of honey in the yard was 17,776 ml/8 months/56 colonies and in the rice field was 17,556 ml/8 months/56 colonies. The total production of pot-pollen in the yard was 5,093 g/8 months/56 colonies and in the rice field was 4,903 g/8 months/56 colonies. The contribution total of honey and pot-pollen on the farmers income in the yard was USD 503.791 and in the rice field was USD 496.032. It can be concluded that the yard and rice field can be used as the location for meliponiculture of stingless bee *Tetragonula clypearis* to increase the farmer's income based on the products of honey and pot-pollen.

Keywords: *bamboo hives, box hives, meliponiculture, nectar, pollen*

Introduction

Stingless bee species in the world for about 500 species have been identified and maybe more than 100 species have not been studied (Michener 2013). Furthermore, in Indonesia is found a minimum 46 species (*tribe Meliponini*) from genus *Austroplebeia* Moure, *Geniotrigona* Moure, *Heterotrigona* Schwarz, *Homotrigona* Moure, *Lepidotrigona* Schwarz, *Lisotrigona* Moure, *Papuatrigona* Michener and Sakagami, *Pariotrigona* Moure, *Tetragonula* Moure, and *Wallacetrigona* Engel and Rasmussen (Kahono et al 2018). For example in several region in Indonesia have been reported 7 stingless bee species (*Tetragonula laeviceps*, *T. iridipennis, T. biroi, T. sapiens, T. sarawakensis*, *Lepidotrigona terminata*, and *Heterotrigona itama*) from Yogyakarta (Trianto and Purwanto 2020), 6 species (*T. laeviceps, T.* cf. *biroi*, *T. drescheri*, *T. sarawakensis*, *H. itama,* and *L. terminata*) from the industry meliponiculture in West Java Province (Purwanto and Trianto 2021), 5 species (*T. sapiens, T. fuscobalteata, T. clypearis, L. terminata,* and *Wallacetrigona incisa*) from West and South Sulawesi (Sayusti et al 2020), and 3 species (*Tetragonula laeviceps*, *T. aff. fuscobalteata*, and *Heterotrigona itama*) from Belitung (Azizi et al 2020).

In Indonesia, stingless bees are created nesting as their habitats are found in the bamboo, sugar palm stalks, tree trunks or wood, in the ground and in the house wall which are producing honey, pot-pollen, and propolis (Agus et al 2021, 2019; Agussalim et al 2019, 2019a, 2020, 2021; Erwan et al 2020, 2021; Sabir et al 2021; Supeno et al 2021). The production of honey and propolis from *Tetragonula* sp. which is meliponiculture in North Lombok, Indonesia have been studied (Agussalim et al 2015; Erwan et al 2020, 2021), *T. laeviceps* in Yogyakarta (Agussalim et al 2020), and *T. laeviceps* in West Java (Abduh et al 2020). However, honey and propolis production from stingless bee *Tetragonula clypearis* in West Lombok (Indonesia) has not been studied. The contribution of meliponiculture stingless bee species by the sold of their products can be increase the beekeepers income have been studied in several country (Abd Razak et al 2016; Aguilar et al 2013; Alves 2013; Ayala et al 2013; Fuenmayor et al 2013; Halcroft et al 2013; Mustafa et al 2018). However, in West Lombok, Indonesia there is lack of information about the contribution of honey and pot-pollen sold on the beekeepers or farmers income. Therefore, the aims of this study were to determine the production of honey and pot-pollen from the stingless bee *Tetragonula clypearis* and their contribution to increase the farmer's income.

Materials and methods

Colony transfer and meliponiculture of stingless bee *Tetragonula clypearis*

This study was conducted in Lembah Sari Village, Batu Layar Sub-district, West Lombok District, Indonesia. The stingless bee *Tetragonula clypearis* as much 112 colonies were obtained around the Lembah Sari Village from the bamboo as their natural habitat. The colony transfer from the bamboo to box hives was performed in the night to avoid stress from the bees according to previous methods (Agussalim 2020; Agussalim et al 2020; Erwan et al 2020, 2021). Briefly, the colonies from the bamboo hive were split by using a machete and all the brood cells were moved to box hives, followed by the bee workers, drones, and queen bee. Furthermore, the box hives entrance was smeared by the propolis from the entrance of the bamboo hives to make it easier for the workers or foragers to identify their

new hive from box hives. Finally, the box hives were placed in bee houses (Photo 1) with the entrance directly to the feed sources, namely nectar and pollen.

The 112 colonies of *Tetragonula clypearis* from the box hives were meliponiculture in the yard and rice field, each 56 colonies (replications) per location. The plant types as the nectar and pollen sources were identified according to method was explained by Agussalim et al (2017, 2018) at a maximum distance of 300 meters. The bee houses with the size 2 × 1.5 × 2.5 meters which were shown in Photo 1. In addition, in front of the box hives were hung of sugar palm pollen to support the protein source and the box hives were used in this study have a size 30 × 20 × 17 cm. The rice field area around the location of meliponiculture was 0.5 ha while in the yard area was 0.1 ha. During the study was performed the rice field was not applicated of pesticides by the farmers.

Photo 1. The bee houses were used to meliponiculture of stingless bee *Tetragonula clypearis* in the yard (left) and rice field (right)

Photo 2. Honey inside the red circle, pot-pollen inside the yellow circle (left) and brood cells (right) of stingless bee *Tetragonula clypearis*

Brood cells number

The brood cells number was described the health condition and development of the stingless bee colonies. The box hives were opened and then brood cells (Photo 2 right) were taken from 112 colonies. Afterwards, the brood cells number were counted for all brood cells by using a hand counter check.

Honey and pot-pollen production

Production of honey and pot-pollen (Photo 2 left) were measured after meliponiculture 4 months for the first harvest and the second harvest after meliponiculture 4 months after the first harvest. Briefly, honey and pot-pollen of the *Tetragonula clypearis* were harvested from the box hives by cutting the honey and pot-pollen pots and were put in the plastic glass. Afterwards, the honey was squeezed to separate honey and propolis, then the clean honey volume was measured by using a measuring cylinder (Agussalim et al 2020). Pot-pollen was separated from propolis by taking the pot-pollen directly to separate propolis and pot-pollen, then the clean pot-pollen was measured by using a digital scale.

Farmer's income

Farmer's income was calculated from the honey and pot-pollen productions which were multiplied by the price of honey and pot-pollen. The farmer's income was compared among the location from yard and rice field to determine the higher of income can be obtained by the beekeepers or farmers.

Analysis data

All data of production of honey and pot-pollen, and brood cells number were analyzed by an independent T-test by using SPSS software (Windows version of SPSS, release 23), while farmer's income was analyzed by descriptive analysis.

Results and discussion

Honey production

The research finding showed that the production of honey from stingless bee *Tetragonula clypearis* in the yard and rice field for the first and second harvest were did not differ. The honey production in the yard for the first harvest was 164.2 ml/hive/4 months and in the rice field was 160.5 ml/hive/4 months. Furthermore, the honey production in the yard and rice field was similar for the second harvest was 153.2 ml/hive/4 months (Table 1). The honey production from stingless bee *Tetragonula clypearis* was supported by the plant types as the nectar source in the yard such as mango (*Mangifera indica*), coconut (*Cocos nucifera*), sugar palm sap (*Arenga pinnata*), starfruit (*Averrhoa carambola*), cowpea (*Vigna unguiculata* L. Walp.), rambutan (*Nephelium lappaceum*), and water apple (*Syzygium samarangense*), while in the rice field consists of chili (*Capsicum annuum*), eggplant (*Solanum melongena*), and long beans (*Vigna unguiculata* sesquipedalis). Coconut, rambutan, mango, and starfruit are potential nectar sources for honeybee (Agussalim et al 2017, 2018). The honey production among the yard and rice field was similar may be caused by their distance being 400 meters, so *Tetragonula clypearis* can collect nectar from plant flowers in front of their hives and the other location (yard and rice field). This study was supported by Eltz et al (2002) and Nunes-Silva et al (2010) were reported that the stingless bee can be within reach of plant flowers to collect nectar or pollen up to a distance of 600 to 1,000 meters.

Table 1. The average of honey production from stingless bee *Tetragonula clypearis* were meliponiculure in the yard and rice field

Honey production	Meliponiculture locations		SEM	*p*
	Yard	Rice field		
First harvest (ml/hive/4 months)	164.2	160.5	4.14	0.654
Second harvest (ml/hive/4 months)	153.2	153.2	3.60	0.998

The average of honey production from stingless bee *Tetragonula clypearis* in our study was ranging from 153.2 to 164.2 ml/hive/4 months of the meliponiculture was differ to reported by Agussalim et al (2020) from the *Tetragonula laeviceps* ranging from 60 to 263 ml/4 months of meliponiculture with the plant types as the nectar sources consists of calliandra (*Calliandra calothyrsus*), banana (*Musa paradisiaca*), mango (*Mangifera indica*), chicory (*Cichorium intybus*), tamarind (*Tamarindus indica*), sunflowers (*Helianthus annuus*), indigofera (*Indigofera arrecta*), catappa (*Terminalia catappa*), syzygium (*Syzygium polyanthum*), kapok (*Ceiba pentandra*), alfalfa (*Medicago sativa* Linn), starfruit (*Averrhoa carambola*), matoa (*Pometia pinnata*), water apple (*Syzygium samarangense*), bilimbi (*Averrhoa bilimbi*), lemon (*Citrus limon*), guava (*Psidium guajava*), chili (*Capsicum annuum*), caimito (*Chrysophyllum caimito*), canarium (*Canarium luzonicum*), and rambutan (*Nephelium lappaceum*).

Supeno et al (2021) reported that the honey production from stingless *bee Tetrag*onula sp. was meliponiculture in coffee (*Coffea robusta*) plantations as the main nectar source was 5.74 g/hive/5 months. Furthermore, Erwan et al (2020) was also reported that the production of honey from *Tetragonula* sp. which was meliponiculture by using a box hive was 18.72 ml/1 month and in bamboo hive was 9.18 ml/month with the plant types as the nectar sources consists of banana (*Musa paradisiaca*),longan (*Dimocarpus longan*), cashew (*Anacardium occidentale*), mango (*Mangifera indica*), starfruit (*Averrhoa carambola*), sunflowers (*Helianthus annuus*), coconut (*Cocos nucifera*), bilimbi (*Averrhoa bilimbi*), Jamaica cherry (*Muntingia calabura*), calliandra (*Calliandra calothyrsus*), cassava (*Manihot esculenta*), and papaya (*Carica papaya*). Honey production was affected by the availability of nectar from plants, temperature, humidity, worker population, the activity level of the foragers (Agussalim et al 2020; Erwan et al 2020), and the brood cells number. However, the brood cells number in the yard was lower than in the rice field in the first four months, but in the second four months, the brood cells number in the yard was higher than in the rice field (Table 3). The brood cells were hatches that became the workers or drones which had an impact on the increase of the bee population.

Pot-pollen production

Pollen collected by the foragers is stored in the pots, where pollen is mixed by honey and bee secretion, then fermented by a lactic acid to preserve it (Bogdanov 2017). The research findings showed that the pot-pollen production in the yard and rice field for the first and second harvest were similar. The production of pot-pollen in the yard for the first harvest was 43.3 g/hive/4 months and in the rice field was 43.5 g/hive/4 months. Furthermore, the production of pot-pollen in the yard for the second harvest was 47.6 g/hive/4 months and in the rice field was 44.1 g/hive/4 months (Table 2).

Table 2. The average of pot-pollen production from stingless bee *Tetragonula clypearis* were meliponiculure in the yard and rice field

Pot-pollen production	Meliponiculture locations		SEM	*p*
	Yard	Rice field		
First harvest (g/hive/4 months)	43.3	43.5	1.52	0.967
Second harvest (g/hive/4 months)	47.6	44.1	1.58	0.269

The pot-pollen production of *Tetragonula clypearis* was supported by the plant types as the pollen sources in the yard consists of sugar palm (*Arenga pinnata*), coconut (*Cocos nucifera*), cowpea (*Vigna unguiculata* L. Walp.), and water apple (*Syzygium samarangense*), while in the rice field such as paddy (*Oryza sativa*), maize (*Zea mays*), chile (*Capsicum annuum*), eggplant (*Solanum melongena*), and long beans (*Vigna unguiculata* sesquipedalis). Coconut and maize are potential pollen sources for honeybees (Agus et al 2019; Agussalim et al 2017, 2018). The distance of the bee houses in the yard and rice field was 400 meters which was impact on the foragers from *Tetragonula clypearis* can also collect pollen from the yard and rice field. This finding was supported by Eltz et al (2002) and Nunes-Silva et al (2010) were reported that the stingless bee foragers can be within reach of the plant flowers to collect nectar and pollen up to a distance of 600 to 1,000 meters. The average of pot-pollen production in our study was ranging from 43.3 to 47.6 g/4 months/colony was differ to reported by Agus et al (2019) that the pot-pollen production of stingless bee *T. laeviceps* was ranging from 1.02 to 4.56 g/2 months of the meliponiculture with the plant types as the pollen sources consists of coconut, banana, spinach, Mexican creeper, acacia,

paddy, pomelo, maize, and stink beans. Production of pot-pollen was affected by the availability of pollen from plant flowers, the population of foragers, the activity of the foragers to collect pollen, and the environmental condition (temperature, humidity, and season). In addition, also was affected by the brood cells number which were impacted on the increase of the bee population.

Brood cells number

The research finding showed that the different location for meliponiculture was highly significant on the brood cells number of stingless bee *Tetragonula clypearis* ($p<0.01$). The brood cells number of stingless bee *Tetragonula clypearis* which was meliponiculture in the yard was 2,731 cells/hive/4 months was lower than brood cells number in the rice field was 3,112 cells/hive/4 months for the first four months. Furthermore, the brood cells number in the yard was 3,121 cells/hive/4 months was higher than brood cells number in the rice field was 2,739 cells/hive/4 months for second four months (Table 3). The brood cells are hatches that become the workers when the eggs were fertilized and unfertilized eggs were hatches become the drones. The brood cells number was affected by the availability of pollen from plant flowers as the raw material to produce royal jelly as the queen bee feed. Thus, was impacted on the productivity of the queen bee to produce more eggs as the workers, drones, and candidate of queen bee (Jarau et al 2009; Sakagami 1982).

Table 3. The brood cells number of stingless bee *Tetragonula clypearis* were meliponiculure in the yard and rice field

Brood cells number	Meliponiculture locations		SEM	*p*
	Yard	Rice field		
First four months (cells/hive/4 months)	2,731[b]	3,112[a]	69.3	0.005
Second four months (cells/hive/4 months)	3,121[a]	2,739[b]	66.7	0.004

[a,b] *Different superscripts within rows indicate differences at $p<0.01$*

Farmer's income

The research findings showed that the total of honey production from stingless bee *Tetragonula clypearis* in the yard was 17,776 ml/8 months and in the rice field was 17,556 ml/8 months were obtained from 56 colonies. Furthermore, the total of pot-pollen production of stingless bee *Tetragonula clypearis* in the yard was 5,093 g/8 months and in the rice field was 4,903 g/8 months were obtained from 56 colonies (Table 4). Honey and pot-pollen are usually sold by the beekeepers when they are harvested in small and large quantities. In our study, the total production of honey from stingless bee *Tetragonula clypearis* was contributed to the farmers' income of USD 432.914 from the yard and in the rice field was USD 427.800. In addition, the pot-pollen production also was contributed to the farmers' income of USD 70.877 in the yard and in the rice field of USD 68.233 from 8 months of meliponiculture. The total of farmer's income from honey and pot-pollen was USD 503.791 from the yard and USD 496.032 from the rice field as the location of meliponiculture. Alves (2013) reported that Rio Grande do Norte-Paulo Menezes is one of the largest suppliers of honey from stingless bees to supermarkets and is sold at BR$ 60.00 per gallon compared to honey from *Apis mellifera* which is BR$ 5.00 per gallon. Furthermore, in 2004, Menezes produced 300 liters of honey and was sold to supermarkets with an income of BR$ 18,000 per year or BR$ 1,500 per month.

Table 4. The total production of honey and pot-pollen and their contribution to farmers income were meliponiculure in the yard and rice field

Parameters	Meliponiculture locations	
	Yard	Rice field
Total production of honey (ml/8 months/56 colonies)	17,776	17,556
Total production of pot-pollen (g/8 months/56 colonies)	5,093	4,903
Farmers income from honey (price was USD 0.024/ml)	432.914	427.800
Farmers income from pot-pollen (price was USD 0.014/g)	70.877	68.233
Total farmers income from honey and pot-pollen (USD)	503.791	496.032

Our study indicates that the meliponiculture of stingless bee *Tetragonula clypearis* to produce honey and pot-pollen can be contribute to increase the farmers income, especially the farmers in the rice field. In the rice field, the stingless bee *Tetragonula clypearis* can play a role as the pollinator agent of several plants which are planted by the farmers to increase the productivity of agricultural plants. Partap (2011) explained that the cross pollination which is involved the honeybees or stingless bees as the pollinator agent can lead to increasing agricultural productivity, environment conservation and maintenance of biodiversity, improvement of the soil conservative and soil fertility. Thus, which had an impact on the increase farmers income and food security and improved livelihoods.

Currently, the meliponiculture of the stingless bee species in West Lombok and North Lombok have been practiced by the communities generally as an additional income and beekeepers as the main income. Abd Razak et al (2016) reported that the meliponiculture of stingless bees can be used as an additional income for the rubber smallholders in Malaysia, because the rubber is the nectar extrafloral source for stingless bees as the raw material to produce honey. Mustafa et al (2018) explained that several stingless bee products like honey and propolis have helped promote the beekeepers as entrepreneurs and provided an additional income for the community, where they are contributing an additional income of RM 833 for honey and RM 1,666 for propolis. However, the beekeepers in West Lombok and North Lombok have not yet sold a propolis and maybe in the future as an additional income when propolis is sold. Generally, the meliponiculture of stingless bees can increase the farmers or beekeepers income by the sold of honey, pot-pollen, and propolis (Abd Razak et al 2016; Aguilar et al 2013; Alves 2013; Ayala et al 2013; Fuenmayor et al 2013; Halcroft et al 2013; Mustafa et al 2018).

Conclusions

- Production of honey from the stingless bee *Tetragonula clypearis* which is meliponiculture in the yard and rice field for the first and second harvest ranging 153.2 to 164.2 ml/hive/4 months and pot-pollen ranging 43.3 to 47.6 g/hive/4 months.
- The total contribution of honey and pot-pollen sold on farmer's income was USD 503.791 in the yard and USD 496.032 in the rice field each from 56 colonies.

- The yard and rice field can be used as the location for meliponiculture of stingless bee *Tetragonula clypearis* to increase the farmer's income and improve livelihoods.

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