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Stingless Bee-Nutmeg Plant (*Myristica fragrans* Houtt) Integration and Its Sustainability in West Halmahera Regency

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ABSTRACT

The integration of stingless bees and nutmeg trees, as well as its sustainability, has received limited attention in the literature. Therefore, this study aimed to analyze the characteristics of stingless bee production and assess its sustainability in West Halmahera Regency. Meliponiculture was integrated into two types of nutmeg gardens (A and B) based on different ecological characteristics, with each consisting of 9 colonies. Garden B had more diverse vegetation than Garden A. Data were analyzed using means and t-tests for productivity, i.e., colony growth, honey, pollen, and propolis production, and a SWOT analysis was conducted to develop sustainability strategies. The results showed that the average colony weight gain in Garden B was 85.56 ± 67.59 grams, higher than in Garden A (14.50 ± 80.40 grams). Based on the t-test results, colony growth in Garden A was not significantly different (P > 0.05), whereas in Garden B it was significantly different (P < 0.05). Honey production was lower in Garden A (247 g) than in Garden B (320 g). Garden B produced more pollen (638 grams) than Garden A (174 grams). Propolis production in Garden B, 133 grams, was much lower than in Garden A, 185 grams. Eight major strategies were identified for sustaining the stingless bee-nutmeg plant integration in West Halmahera.

Keywords: Nutmeg, Stingless bee, Sustainability, West Halmahera

ABSTRAK

Integrasi antara lebah tanpa sengat (stingless bees) dan tanaman pala, serta keberlanjutannya, masih mendapat perhatian yang terbatas dalam literatur ilmiah. Oleh karena itu, penelitian ini bertujuan untuk menganalisis karakteristik produksi lebah tanpa sengat dan keberlanjutannya di Kabupaten Halmahera Barat. Meliponikultur diintegrasikan dengan tanaman pala di dua tipe kebun pala (A dan B), berdasarkan karakteristik ekologi yang berbeda dengan masing-masing terdiri dari 9 koloni. Kebun B memiliki vegetasi yang bervariasi dibandingkan Kebun A. Data dianalisis menggunakan uji rata-rata dan uji-t untuk produktivitas, yaitu perkembangan koloni, produksi madu, polen, dan propolis, serta analisis SWOT untuk mengembangkan strategi keberlanjutan. Hasil penelitian menunjukkan rata-rata pertumbuhan koloni di Kebun B adalah 85.56 ± 67.59 gram, lebih tinggi dari Kebun A (14.50 ± 80.40 gram). Menurut hasil uji-t, pertumbuhan koloni di Kebun A tidak berbeda nyata (P > 0,05), sedangkan di Kebun B berbeda nyata (P < 0,05). Dibandingkan dengan Kebun B (320 gram), Kebun A (247 gram) kurang produktif dalam menghasilkan madu. Kebun B menghasilkan lebih banyak polen (638 gram) dibandingkan Kebun A (174 gram). Produksi propolis di Kebun B, 133 gram, lebih rendah dibandingkan Kebun A, 185 gram. Ada delapan strategi utama untuk mempertahankan integrasi lebah tanpa sengat-tanaman pala di Halmahera Barat.

Kata kunci: Pala, Lebah Tanpa Sengat, Keberlanjutan, Halmahera Barat

INTRODUCTION

Stingless bees (SB) are social insects living in tropical and subtropical areas, especially in the wild. They collect nectar and pollen from flowers to feed on and simultaneously pollinate the plants. Stingless bees are generalist pollinators who visit many flowers (Widhiono *et al.* 2016) and are efficient honey producers (Fadhilah & Rizkika, 2015; Jalil & Shuib, 2014). The body size of SB is smaller than that of the Tribe Apini, resulting in less honey production. However, the honey they produce has a higher selling value and is beneficial for health (Chuttong *et al.* 2015; Salatnaya *et al.* 2023).

The distribution of SB spans Indonesia, encompassing 46 species from 10 genera. The species are mostly found in Borneo (29 species), followed by Sumatra (23 species), Irian Jaya (9 species), Java (7 species), Sulawesi (3 species), North Moluccas (3 species), Moluccas (2 species), and Timor (1 species) (Kahono *et al.* 2018; Salatnaya *et al.* 2021, 2023). Three species from North Moluccas were discovered by Salatnaya *et al.* (2021) from *Tetragonula*: *Tetragonula clypearis, T. sapiens,* and *T. biroi*. They are occur naturally in forests and nest in tree trunks, broken walls, and under the roofs of residential homes. SB is also found in West Halmahera Regency, living in forests and settlements. The local community has not exploited SB due to insufficient information about its health and economic benefits. According to Salatnaya *et al.* (2019), the beekeeping business in West Halmahera has significant potential because it is supported by the availability of nectar and pollen-producing plants. It is about 128,422.70 ha, or 59.46% of the area of West Halmahera, which is moderately suitable (S2). Salatnaya *et al.* (2021) said there are 77 species of plants, i.e., forage plantations, plantation crops, fruit plantations, vegetable crops, ornamental plants, wild plants, and shrubs, that stingless bees can use to get nectar, pollen, and resin.

Stingless bees are easy to cultivate and do not require large costs (Kahono *et al.* 2018; Salatnaya *et al.* 2023). According to Fadhilah & Rizkika (2015), this species is easily adaptable to various forms and different nesting materials. Bee cultivation, integrating relevant and locally potential plantations, may increase farmers' income. According to Fuah *et al.* (2014), the integration concepts and approaches are efficient, productive, profitable, and sustainable for business. Additionally, the pollination activities of SB will increase the productivity and quality of fruit production (Roubik *et al.* 2018; Salatnaya *et al.* 2023). The plants used by SB in agriculture are horticulture and plantation crops that produce nectar and pollen for their survival, as well as resin-producing plants that are used to build and protect their nests (Jalil & Shuib, 2014; Kahono *et al.* 2018).

Nutmeg is widely known as one of the world's most important spice crops. There are five centers of production in Indonesia, i.e., North Moluccas, Moluccas, North Sulawesi, and West Papua Province. North Moluccas is the largest plantation area (42.716 ha) and produces about 7.937 tons (Jannah *et al.* 2022). Nutmeg is widely planted in West Halmahera (8.638 ha), one of the regencies in North Moluccas, which can produce about 653 tons, based on the data from BPS Kabupaten Halmahera Barat (2024). This plant produces nectar, pollen, and resin that can be used for meliponiculture (Salatnaya *et al.* 2021) because it can flower throughout the year (Seema & Manimekalai, 2023).

Nutmeg plants grow in areas with altitudes ranging from 700 to 4500 m, temperatures ranging from 22 to 34 °C, and rainfall ranging from 2000 to 3500 mm. Nutmeg can grow in any type of soil, but the most preferred type is volcanic soil with a pH of 6.5 to 7.5. Nutmeg plant flowers are usually unisexual, but some trees have both male and female flowers. Female flowers are usually 1 to 3 in number, while male flowers are 1 to 10 in number in a series. Ivory yellow flowers, with most types being dioecious, produce both nectar and pollen. The shape of the stylus flower is small (<2mm) (Salatnaya *et al.* 2021; Seema & Manimekalai 2023; Jose *et al.* 2016; Naeem *et al.* 2016). The productive age of plants ranges from 28 to 70 years, depending on the variety. Fruit is produced only by female and hermaphroditic trees, while male trees and hermaphrodites produce pollen. The plants start flowering at the age of 6 to 8 years and bear fruit regularly every year (throughout the year) with a large harvest season twice a year, namely April and December (Ruhnayat & Martini 2015; Wahyuni & Bermawie 2019). Based on the results of the survey, the people of West Halmahera have carried out the cultivation of nutmeg along with coconut plants through polyculture.

Nutmeg plants produce produce both nectar and pollen, which stingless bees utilize to produce honey for their needs and the development of their colony. Nutmeg also produces resins that can produce propolis (Fadhilah & Rizkika, 2015). The various benefits of the integration system applied between stingless bees and nutmeg plantations are important to provide necessary information for the local community and farmers to gain a better understanding of the various local bee species, cultivation methods, and their usage for household cash income. The previous study was used to study *Tetragonula laeviceps* cultivated in monoculture and polyculture nutmeg farms in West Java to know the environmental effect for production (Salatnaya *et al.* 2020b) and their activity (Salatnaya *et al.* 2020a'). However, West Halmahera is characterized by vast nutmeg plantations and various species of stingless bees. The most species found in West Halmahera is *Tetragonula clypearis* (Salatnaya *et al.* 2021). To the best of our knowledge, no previous study has investigated the integration between *Tetragonula clypearis* and nutmeg in West Halmahera, as well as the sustainability. Therefore, it is necessary to research stingless bees integrated with nutmeg (*Myristica fragrans* Houtt) plantations in West Halmahera. This study aims to analyze the characteristics of SB production integrated with nutmeg plants in West Halmahera Regency and its sustainability.

MATERIALS AND METHODS

Materials and Tools

The materials used to calculate stingless bee

production were 18 *Tetragonula clypearis* colonies (Figure 1). The 16 colonies came from *Mione Bee Royal farm*, one of the meliponiculture farms in West Halmahera, and two colonies were found from the bamboo in community areas. The bees were cultivated at two different nutmeg plantation locations in West Halmahera Regency, and each garden used nine colonies, which were separated into three groups. The tools used for cultivation included empty boxes made of tofiri wood, measuring 25 cm x 15 cm x 15 cm, which were used for SB colonies, digital scales, plastic jars, knives, and filters.

Figure 1. Tetragonula clypearis

The ecosystem characteristics of the two nutmeg plantation locations (Garden A and Garden B) differed. The land's surface in Garden A was flat, and the farmers planted nutmeg trees with about nine meters between each tree. Additionally, they planted walnuts, durian, and coconut trees. On the other hand, the land's surface in Garden B was not flat. The plants included nutmeg, coconut trees, mangosteen, lansium trees, rambutan, cempedak, durian, melinjo, snakefruit, and various shrubs. The distance between the nutmeg trees was about four to six meters.

Cultivation Procedure

The bees found in community areas, and *Mione Bee Royal Farm*, were collected and relocated to a predetermined location for temporary cultivation, then transferred into a wooden nest with dimensions of 25 cm x 15 cm x 15 cm. The empty box was weighed to determine its weight. After that, all the colonies (queens, males, workers, and eggs) were moved into the box and weighed to determine the initial weight. The feed (pollen) was also moved into the box so the bees could continue their activities. Propolis from the entrance of the old nest was taken and used at the entrance of the new nest to help the bees recognize the nest faster. After three days, the colonies were moved to the cultivation location and placed around the sites for easy access to floral resources. Cultivation activities were carried out for 1.5 months, assuming SB would have produced honey, pollen, and propolis throughout the period. The box was weighed at the end of the research activity before harvesting was done to determine the final weight. The products (honey, pollen, and propolis) were harvested and weighed to calculate the total production. Finally, the products (honey, pollen, and propolis) that had been weighed were separated and weighed to determine their respective weights.

Data Analysis

The data obtained from the study were analyzed using the average value (mean), standard deviation, and t-test at a 95% confidence level with the SAS 9.4 program. The results of the study were also described descriptively and arranged in the form of tables and figures. The potential characteristics of each garden were described, and cultivation methods and formulation strategies to determine the sustainability of such integration systems were analyzed using SWOT analysis. This research has only one informant because the expert on meliponiculture in West Halmahera is only one person. Therefore, the results will provide the main strategies for meliponiculture business development.

RESULTS AND DISCUSSION

Stingless Bee-Nutmeg Plant Integration

The stingless bees used for cultivation were *Tetragonula clypearis*, commonly found in West Halmahera Regency. The cultivation activity was organized on nutmeg plantations in two different locations (Garden A and Garden B) in West Halmahera Regency. The changes in colony weights are shown in Table 1. Initially, we had 18 colonies used for cultivation, but after a week, one of them in Garden A flew away from the nest, resulting in only 17 colonies being cultivated.

The average weight of colonies in Garden A at the beginning of cultivation was 115.5 grams, but at harvest, the average final weight reached 130 grams. Colonies in Garden A experienced an increase of 14.50 ± 80.40 grams in weight. On the other hand, colonies in Garden B had an average initial weight of 118.56 grams. At harvest, there was a weight gain of 85.56 ± 67.59 grams, resulting in an average weight of 204.11 grams, higher than in Garden A. The land surface does not affect the nutmeg plantation, because the elevation of both locations was under 100 m asl. Garden A has an elevation 29,86 m asl, while Garden B is 18,13 -19,57 m asl. The farmer in Garden A planted the nutmeg based on the requirement. Between the nutmeg trees, they planted coconut trees to protect them from the wind, while Garden B planted various trees between the nutmeg trees. This

Table 1. Development of the weight of Tetragonula clypearis colonies in the nutmeg plantation

Location	Average Weight of Colony (gr)		Mean	SD
	Initial	Final		
Garden A	115.5	130	14.5	80.4
Garden B	118.56	204.11	85.56	67.59

Source: Research Data

condition likely contributed to higher colony productivity of stingless bees. The difference in production was likely due to other flowering plants near the cultivation area of Garden B, which provided additional weight to the colonies compared to Garden A.

The t-test results showed that the development of colonies in Garden A was not significantly different ($P > 0.05$), whereas in Garden B, it was significantly different ($P < 0.05$). Kahono *et al.* (2018) and Salatnaya *et al.* (2023) further state that food sources throughout the year support bee breeding, increasing productivity. Additionally, Jalil (2018) said that plants are the main necessity in the life of stingless bees because Salatnaya *et al.* (2023) said that they collect pollen and nectar as their food as well as resin to build and protect their nest. The size of the main stingless bee species in Indonesia is small, so it will affect the flight range. The size of the stingless bee influenced the type of flowers they visited. It always visited small flowers (Salatnaya *et al.* 2021) like nutmeg's flower.

The development of stingless bee colonies was in line with the production of honey, pollen, and propolis. The results indicated that the total products produced by colonies in Garden A (606 grams) were lower than the total products in Garden B (1091 grams) (Table 2).

The highest product obtained from Garden A was honey, totaling 47 grams with an average production per colony of 30.88 ± 37.99 grams. However, this was still less than the amount obtained from Garden B, which yielded 320 grams with an average production per colony of 35.55 ± 13.01 grams. Meanwhile, Garden B produced more pollen, reaching 638 grams (70.89 ± 43.75 grams per colony), compared to Garden A, which only produced 174 grams (30.88 ± 37.99 grams per colony).

Propolis was collected after the honey extraction because the honey bag was made of propolis. Garden A produced 185 grams of propolis (23.13 ± 13.58 grams per colony), more than Garden B, which only produced 133 grams (14.77 ± 6.10 grams per colony). This difference was presumably due to the behavior of bees in Garden A, where they produced propolis at the top of the nest to seal the entrance, protecting it from disturbances such as rainwater, predators, or humans. In contrast, this behavior was not observed in Garden B, likely because of the absence of such disturbances experienced in Garden A.

According to Salatnaya *et al.* (2023) and Kahono *et al.* (2018), the honey produced by stingless bees was lower than that of honeybees, depending on the bee species, vegetation, and handling methods. The solution was to multiply the colonies to get higher production. Heard (2016) adds that bees collect pollen to use as food for bee larvae, workers, and queens because it contains protein. Singh (2016) stated that pollen is essential for colony development, so farmers typically do not harvest too much. Maia-Silva *et al.* (2015) reported that stingless bees would immediately collect pollen if there was an increase in the availability of pollen sources, resulting in the bees' creation of additional new brood cells. According to Maia-Silva *et al.* (2016), the availability of sufficient pollen in the vicinity of bee cultivation is a determining factor for colony growth. Roubik *et al.* (2018), Salatnaya *et al.* (2021), and Salatnaya *et al.* (2023), state that stingless bees also collect resins from plants to use as nest-building materials and for nest protection from predators and diseases. The feeder is also a mixture of wax and resin. Singh (2016) notes that propolis is another important product from stingless bees and is typically harvested after honey extraction.

Sustainability of Stingless Bee-Nutmeg Plant Integration

The analysis of production capacity and sustainability of stingless bee-nutmeg plant integration in West Halmahera Regency was based on a SWOT analysis. The formulation of strengths and weaknesses (internal factors) and opportunities and threats (external factors) was carried out based on the study's results (Tables 3 and 4).

All the data were analyzed based on IFAS (Internal Factor Analysis Summary) and EFAS (External Factor Analysis Summary). Experts on stingless bees scored the data. Table 5 shows the results of IFAS scoring (Strengths and Weaknesses). Scoring ranged from 0.0 (unimportant) to 1.0 (essential), representing the average of expert responses. Based on Table 5, the total score of Strengths was subtracted from the total score of Weaknesses to obtain the score of the X-axis. Similarly, the total score of Opportunities was subtracted from the total score of Threats to get the score of the Y-axis. The score of the X-axis was 2.1, and the Y-axis was 1.85. The result, as shown in Figure 2, indicated that the strategy was in Quadrant 1, implying that meliponiculture had the potential to develop in West Halmahera Regency. The strategy was progressive, suggesting that if meliponiculture were to develop, it would benefit farmers' incomes, and the business would sustain itself because West Halmahera possesses abundant natural resources and climate to support it (Table 6).

Stingless bees are widely found in West Halmahera but have not been cultivated yet because local communities have limited knowledge the function of this insect. Many people still destroy nests because they consider them harmful. The presence of stingless bees in West Halmahera was first recorded by Salatnaya *et al.* (2021). They come from the genus *Tetragonula*, namely *Tetragonula clypearis,*

Table 2. Production of 18 colonies of Tetragonula clypearis in nutmeg plantation

Location	Colony Weight	Product (gr)			Total Products (gr)
	(gr)	Honey	Pollen	Propolis	
Garden A	434	247	174	185	606
Garden B	746	320	638	133	1091

Source: Research Data

Table 3. Internal factors

Internal Factors			
Strengths		Weaknesses	
S1	The great potential and availability of nutmeg plantations in West Halmahera	W1	Honey production remained low.
S2	Culturally, the community is accustomed to cultivating nutmeg plants.	W2	Community members are unaware of the potential of stingless bees as producers of honey and propolis, as well as the potential of local plants to increase bee production.
S3	Nutmeg plants bloom and flower all year round.	W3	There is no farmer group that has been involved in cultivating stingless bees.
S4	One of the mission statements of the West Halmahera Regency Government is "Increasing and developing the utilization of natural resource potential optimally." The policy will support meliponiculture.	W4	There is no regency government program related to the development of stingless beekeeping.
S5	The geographical location is suitable for the development of nutmeg plants and stingless bees.	W5	There are no regional regulations regarding stingless bees.
		W6	Nutmeg plants are cultivated in polyculture.

Table 4. External factors

External Factors			
Opportunities		Threats	
O1	Indonesia still imports honey due to its low production.	T1	Some community members frequently damage the hives of stingless bees.
O2	The Indonesian government has launched campaigns promoting honey consumption.	T2	Infrastructure and transportation are insufficient to support beekeeping.
O3	West Halmahera Regency has higher education institution that could serve as the centre for education on beekeeping activities and development.	T3	Competition from other regions.
O4	Bee products are priced high.	T4	Pesticides used for agricultural activities could decrease the quality of bee products.
O5	There is high demand for bee products from customers with medium to high economic status.	T5	The competitive quality of bee products in the market.

Tetragonula sapiens, and *Tetragonula biroi*. The most common is *Tetragonula clypearis*. Based on Salatnaya *et al.* (2022), the community consumed honey but did not know how to cultivate it, whereas the bees produced honey and propolis.

The cultivation of stingless bees is known as meliponiculture. Meliponiculture has an economic benefit because it will provide additional income to the farmers. The price of honey from stingless bees is high, and the bees produce propolis that can be sold at a high price. On the other hand, it also helps the farmers to increase their crop production, because stingless bees are good pollinators. If the farmers want to produce honey and propolis, they can integrate stingless bees with the crops. The farmers in West Halmahera had a farmers' group, but did not cultivate stingless bees or use them to pollinate their crops. One of the potential crops that support meliponiculture in West Halmahera is nutmeg because it bloom and flowering all year round. The landscape and environmental of West Halmahera are suitable to cultivate nutmeg and stingless bees. One challenge is that nutmeg is cultivated under agroforestry systems because farmers mix the nutmeg with coconut, durian, banana, etc. So, the harvested honey cannot be considered monofloral nutmeg honey. West Halmahera has an opportunities to develop meliponiculture because Indonesia still imports honey. Even West Halmahera does not have regulation to support meliponiculture, but they had an agriculture enterprise institute to support the government in developing meliponiculture.

Meliponiculture was done in many cities in Indonesia, such as Kalimantan, Sulawesi, Java, and Ambon (Kahono *et al.* 2018; Salatnaya *et al.* 2023). West Halmahera had the potential to develop meliponiculture because about 128,422.70 ha (99 %) were adaptable for stingless bees. Bee forage is an important factor because the bees need nectar and pollen as food (Salatnaya *et al.* 2019). The development of meliponiculture is supported by the flowering season. Nutmeg is one of the crops that bloom all year, and it is a native plant. Nutmeg produces nectar and pollen, as well as resin that bees can use (Salatnaya *et al.* 2019, 2021). The highest demand in West Halmahera is from agriculture, but the government does not have a regulation to support meliponiculture (BPPPD, 2021). Based on BPS (2024), West Halmahera had 8.638 ha used for nutmeg plantation, and most of the community were farmers. The temperature in West Halmahera is around 30 °C – 34 °C also supports

Table 5. IFAS and EFAS scoring

No	Strength	Score	Level	Total
1	The great potential and availability of nutmeg plantations in West Halmahera	0.05	4	0.2
2	Culturally, the community is accustomed to cultivating nutmeg plants.	0.05	3	0.15
3	Nutmeg plants bloom and flower all year round.	0.5	4	2
4	One of the mission statements of the West Halmahera Regency Government is "Increasing and developing the utilization of natural resource potential optimally." The policy will support the meliponiculture.	0.05	3	0.15
5	The geographical location is suitable for the development of nutmeg plants and stingless bees.	0.05	3	0.15
6	The climate supports nutmeg plant cultivation and beekeeping.	0.3	4	1.2
	TOTAL	1		3.85
No	Weaknesses	Score	Level	Total
1	Honey production remained low.	0.5	2	1
2	Community members are unaware of the potential of stingless bees as producers of honey and propolis, as well as the potential of local plants to increase bee production.	0.25	2	0.5
3	There is no farmer group that has been involved in cultivating stingless bees.	0.05	1	0.05
4	There is no regency government program related to the development of stingless beekeeping.	0.05	1	0.05
5	There are no regional regulations regarding stingless bees.	0.05	1	0.05
6	Nutmeg plants are cultivated in polyculture.	0.1	1	0.1
	TOTAL	1	8	1.75
No	Opportunities	Score	Level	Total
1	Indonesia still imports honey due to its low production.	0.3	4	1.2
2	The Indonesian government has launched campaigns promoting honey consumption.	0.05	3	0.15
3	West Halmahera Regency has higher education institution that could serve as the center for education on beekeeping activities and development.	0.2	3	0.6
4	Bee products are priced high.	0.15	4	0.6
5	There is high demand for bee products from customers with medium to high economic status.	0.3	4	1.2
	TOTAL	1	18	3.75
No	Threats	Score	Level	Total
1	Some community members frequently damage the hives of stingless bees.	0.3	2	0.6
2	Infrastructure and transportation are insufficient to support beekeeping.	0.05	1	0.05
3	Competition from other regions.	0.3	2	0.6
4	Pesticides used for agricultural activities could decrease the quality of bee products.	0.3	2	0.6
5	The competitive quality of bee products in the market.	0.05	1	0.05
	TOTAL	1	8	1.9

meliponiculture, because of the flight activities of the bees from 22 °C – 34 °C (Salatnaya *et al.* 2019), and supports the cultivation of nutmeg.

Indonesia still imports honey because the production is still low, and there is no data about honey production from stingless bees (Salatnaya *et al.* 2023). West Halmahera had a great opportunity to produce honey because the natural resources will support the meliponiculture (Salatnaya *et al.* 2019; 2021; 2023). It is well established that the honey production of stingless bees is low, the solution based on Salatnaya *et al.* (2023) is increasing the number of colonies to support honey production.

Cultivating stingless bees will increase the farmer's income (Salatnaya *et al.* 2023). The research by Salatnaya *et al.* (2022) showed that the farmers want to cultivate it because they need the additional income. Based on Kek *et al.* (2017), stingless bee produce less amount of honey but the price is higher than Apis, because honey they produced has higher antioxidant properties then Apis. This business is profitable and feasible, with an ROI of 215% and an R/C ratio of 9.23. If the farmer want to cultivate the bees, Salatnaya *et al.* (2023) suggest the farmers need to grow the plantation without pesticides because it will harm the bees' products. They also had to consider access if they wanted to start the business.

Table 6. SWOT analysis

Internal Factors/ External Factors	Strength	Weakness
	1 The great potential and availability of nutmeg plantations in West Halmahera	1 Honey production remained low.
	2 Culturally, the community is accustomed to cultivating nutmeg plants.	2 Community members are unaware of the potential of stingless bees as producers of honey and propolis, as well as the potential of local plants to increase bee production.
	3 Nutmeg plants bloom and flower all year round.	3 There is no farmer group that has been involved in cultivating stingless bees.
	4 One of the mission statements of the West Halmahera Regency Government is "Increasing and developing the utilization of natural resource potential optimally." The policy will support the meliponiculture	4 There is no regency government program related to the development of stingless beekeeping.
	5 The geographical location is suitable for the development of nutmeg plants and stingless bees.	5 There are no regional regulations regarding stingless bees.
	6 The climate supports nutmeg plant cultivation and beekeeping.	6 Nutmeg plants are cultivated in polyculture.

Opportunities	Taking Advantage of Opportunities and Optimizing Power:	Overcoming Weaknesses by Taking Advantage
1 Indonesia still imports honey due to its low production.	1 Optimizing the utilization of natural resources through collaboration between the regency government and universities (S1, S2, S3, S4, S5, S6, O1, O2,03).	1 Developing stingless bee cultivation by utilizing local food plants in West Halmahera (W1, W2, W3, W4, W5, W6, O1. O2, O3).
2 The Indonesian government has launched campaigns promoting honey consumption.	2 Conducting extension programs for farmers and communities about stingless bees and their benefits (S1, S2, S3, S4, S5, S6, O3, O4, O5).	2 Establishing farmer groups to raise stingless bees and increase their income (W1, W2, W3, W4, W5, W6, O3, O4, O5).
3 West Halmahera Regency has higher education institution that could serve as the center for education on beekeeping activities and development.		
4 Bee products are priced high.		
5 There is high demand for bee's products from customers with medium to high economic status.		

Threats	Using Power to Anticipate Challenges / Threats:	Minimizing Weaknesses and Overcoming Challenges / Threats:
1 Some community members frequently damage the hives of stingless bees.	1 The regency government and universities provide information about the hazards of using pesticides for the development of stingless bees (S1, S3, S4, S5, S6, T4).	1 Collaborating with various stakeholders for promotional efforts (W1, W2, W3, W4, W5, W6, T1, T2, T3, T4, T5).
2 Infrastructure and transportation are insufficient to support beekeeping.	2 The regency government assists farmers with product promotion activities (S1, S2, S3, S4, S5, S6, T1, T3, T5).	
3 Competition from other regions.	3 The regency government improves infrastructure and public facilities (S4, S5, T2, T3, T5).	
4 Pesticides used for agricultural activities could decrease the quality of bee products.		
5 The competitive quality of bee products in the market.		

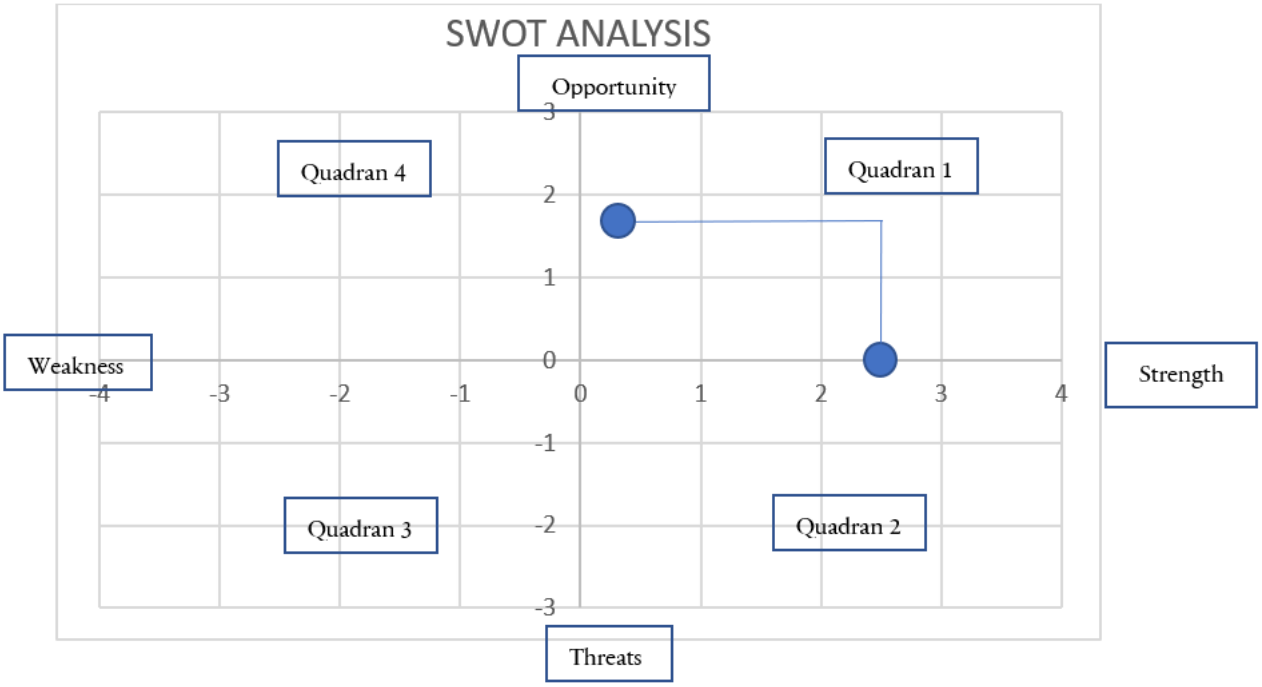

Figure 2. Matrix SWOT Analysis

CONCLUSION

Colony productivity, reflected by colony weight gain of stingless bee colonies in Garden B (746 grams), was higher than in Garden A (434 grams). The most produced products in Garden A were Honey (247 grams), followed by Propolis (185 grams) and Pollen (174 grams). The major products obtained from Garden B were Pollen (638 grams), Honey (320 grams), and Propolis (133 grams). The difference in the productivity of stingless bees between locations was associated with the availability of nectar and pollen at each site.

Strategies for developing and sustaining bee-nutmeg plant integration were progressive because they were in Quadrant 1. The strategies include: Optimizing the use of natural resources through collaboration between the regency government and universities, Conducting extension programs for farmers and communities about stingless bees and their benefits, Developing stingless bee cultivation by utilizing local food plants in West Halmahera, Establishing farmer groups to raise stingless bees and increase their income, Providing information about the dangers of using pesticides for stingless bee development by the regency government and universities, Assisting farmers with product promotion activities by the regency government, Improving infrastructure and public facilities by the regency government, Collaborating with various parties for promotion.

CONFLICT OF INTEREST

We certify that there is no conflict of interest with any financial, personal, or other relationships with other people or organizations related to the material discussed in the manuscript.

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