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ANALYSIS OF COLONY DEVELOPMENT OF *Trigona* sp. IN INTEGRATED SUSTAINABLE FOOD HOUSING AREA CENTRAL LOMBOK

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Abstract: The Sustainable Food House Area or Kawasan Rumah Pangan Lestari (*KRPL)* integrated with *Trigona sp*. bee cultivation can be an alternative livelihood to improve the community's economy. This study aims to analyze the development of bee colonies in *KRPL* in terms of the number of pollen and honey pots produced. The type of this research is descriptive qualitative. The study was conducted from October-November 2020. The samples used were 14 colonies, categorized as strong colonies, medium colonies, and weak colonies. The increase in the number of empty pots, honey pots, and pollen pots was observed every three days. Environmental factors such as temperature, humidity, light intensity, and the activity of the Trigona bees were also observed. The results showed that the average temperature at *KRPL* was 29.80 °C, with an average humidity of 69.62% and a light intensity of 22610 lux. Most of the increase in the highest total number of pots occurred in strong colonies. The number of empty pots, honey pots, and pollen pots increased on different days. In the last week of the observation, most of the colonies did not increase the number of pots. The development of *Trigona sp*. bee colonies in *KRPL* is considered slow even though the environmental conditions there are normal. Cultivation of *Trigona sp*. in *KRPL* should use strong colonies rather than medium and weak colonies.

Keywords: *Trigona* sp., *Colony Development, Honey pot, and pollen pot*

INTRODUCTION

Global Climate Change has recently become an increasingly great global problem. The rising air temperatures, melting of polar ice caps, rising sea levels, changing of rainfall patterns, floods, and storms, and the increasing number of natural disasters are evidence of climate change [1].

Climate change will impact humans and ecosystems, such as the decline in forest function, the number of fish, and agricultural lands [2]. Poor community groups mainly depend on these ecosystems for their livelihoods. They will find it challenging to meet their daily needs as the declining quality and quantity of natural resources decline. They will find it difficult to leave the house to earn a living in extreme weather affecting the family food security.

The Ministry of Agriculture has initiated the use of yardland through the development of the Sustainable Food House Area (*KRPL*). *KRPL* was implemented in 2011, then became the beginning of *KRPL* development in various locations, including West Nusa Tenggara (NTB) [3]. *KRPL* is one of the agricultural models developed on limited land to produce food. *KRPL* can grow various plants from vegetables, fruits, medicinal plants, and ornamental plants [4]. It can support the needs of people's daily life. The rest product can also be sold. Therefore, the household food needs can be fulfilled even can improve a family economy. The existence of *KRPL* will also be able to provide more optimal benefits for a community, especially if combined with *Trigona sp*.

Trigona sp. cultivation can be used as an alternative livelihood for a community for some benefits. Besides producing honey, *Trigona sp*. also produces propolis and bee pollen products that can be sold [5]. The results show that propolis can function as an antibacterial as it contains flavonoid compounds [6]. *Trigona sp*. is also one of the most effective pollinators (pollinating agents), which indirectly provides benefits in increasing plant productivity [7].

Trigona sp. cultivation is easy and inexpensive [8]. It does not have a stinger, is not an aggressive insect, and is resistant to disturbance [5]. *Trigona* bees are also easy to adapt to new environments, relatively resistant to pests and diseases, do not have a famine, and have a variety of food sources [9].

One of the implementations of *KRPL* in NTB is located in Mertak Tombok Village, Praya District, Central Lombok Regency. It is overgrown with various types of vegetables, fruits, and flowering plants. The area is also one of the places where *Trigona sp*. bees are cultivated. Different plants there can be a source of bee food. *Trigona sp*. will indirectly help plants pollinate. As the *Trigona sp*. cultivation in *KRPL* is still relatively new, it is necessary to conduct a study on the development of *Trigona sp*. bee colonies cultivated in *KRPL*.

RESEARCH METHODS

The descriptive qualitative research was conducted for 40 days, from mid-October to late November 2020. The population was 14 colonies of *Trigona sp*. imported from North Lombok Regency. The research sample used was the same as the total population or referred to as total sampling.

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The column containing the Trigona bee colony was covered with transparent mica plastic. The top of the plastic was given a transparent glass before being covered with a wooden board for easy observation. Installation of plastic and glass on the Trigona *stup* was conducted in the late afternoon to not interfere with Trigona's activities of looking for food.

The variables observed in this study were the numbers of empty pots, honey pots, and pollen pots counted every three days, which were 14 observations. Environmental factors such as temperature, humidity, light intensity, and activity in and out of the nest were also observed. Bee's entering and leaving the hive activities were observed at 08.00-11.00 & 14.00-17.00 with a five-minute observation at each *stup* [10]. Temperature, humidity, and light intensity were measured using a thermohygrometer and lux meter at 08.00-18.00 GMT+8 [11].

The number of empty, honey, and pollen pots data was analyzed descriptively and presented in tabular form. In contrast, the temperature, humidity, light intensity, and activity of bees entering and leaving the hive data were calculated using the average formula by the following calculation [12].

1. Temperature
   Daily temperature:
   $$\bar{x} = \frac{\Sigma\, Total\ temperature\ on\ day{-}n}{Numbers\ of\ temperature\ data}$$
   Monthly temperature:
   $$\bar{x} = \frac{\Sigma\, Average\ daily\ tempature}{Numbers\ of\ days}$$
2. Humidity
3. Daily humidity:
   $$\bar{x} = \frac{\Sigma\, Total\ humidity\ on\ day{-}n}{Numbers\ of\ humidity\ data}$$
   Monthly humidity:
   $$\bar{x} = \frac{\Sigma\, Average\ daily\ humidity}{Numbers\ of\ days}$$
4. Light intensity
   Daily light intensity:
   $$\bar{x} = \frac{\Sigma\, Total\ light\ intensity\ on\ day{-}n}{Numbers\ of\ light\ intensity\ data}$$
   Monthly light intensity:
   $$\bar{x} = \frac{\Sigma\, Average\ daily\ light\ intensity}{Numbers\ of\ days}$$
5. In-and-out activity
   Entering hive activity:
   $$\bar{x} = \frac{\Sigma\, Total\ of\ bees\ entering\ the\ hive}{Numbers\ of\ days}$$
   Leaving hive activity:
   $$\bar{x} = \frac{\Sigma\, Total\ of\ bees\ leaving\ the\ hive}{Numbers\ of\ days}$$

The temperature, humidity, light intensity, and activity of bees entering and leaving the hive data obtained were analyzed quantitatively and qualitatively. It is described by displaying graphs processed using Microsoft Excel 2016 software.

RESULTS AND DISCUSSIONS

The Sustainable Food House Area (*KRPL*) area is located in Mertak Tombok Village, Praya District, Central Lombok Regency with an altitude of 185-230 masl. The total area of Mertak Tombok Village is 322 ha. It has a reasonably fertile soil structure, as seen from the composition of the area of paddy fields which is more dominant (256 ha) compared to dry land (66 ha) [13]. Mertak Tombok Village has the potential for *Trigona sp*. because most of the area is agricultural land.

KRPL is overgrown with various types of nectar and pollen producing plants such as candlenut (*Aleurites moluccana*), cayenne pepper (*Capcisum frutescens*), mahogany (*Swietenia macrophylla*), papaya (*Carica papaya*), banana (*Musa paradiciaca*), eggplant (*Solanum melongena*), tomato (*Solanum lycopersicum*), sapodilla (*Manilkara sapota*), moringa (*Moringa oleifera*), purslane (*Portulaca oleraceae*), tamarind (*Tamarindus indica*), spinach (*Amaranthus viridis*), guava (*Syzygium aquaeum*), lime (*Citrus amblycarpa*), kapok randu (*Ceiba petandra*), kenikir (*Cosmos caudatus*), coffee (*Coffea sp*), manga (*Mangifera indica*), tekokak (*Solanum torvum*), soursop (*Annona muricata*), sunflower (*Helianthus annuus*), kenikir (*Cosmos caudatus*), purslane (*Portulaca oleraceae*), horse whip (*Stachytarpheta cayennensis*), tembelekan flower (*Lantana camara*), pukul delapan flower (*Turnera subulate*), pukul sembilan flower (*Portulaca grandiflora*), tai ayam flower (*Tagetes erecta*), and zinnia (*Zinnia sp*.).

In addition to the plants mentioned above, which are potential food sources for *Trigona* bees, there is a water reservoir right behind the bee *stup* that bees can use as a water source. Water availability is one of the important aspects to be considered at the *Trigona* bee cultivation location [14]. Water can be used to regulate the temperature in the nest [15]. Environmental conditions such as temperature, humidity, and light intensity at the *Trigona* bee cultivation location also greatly affect cultivation success.

Increase of Empty Pots, Honey Pots, and Pollen Pots Number

The *Trigona* bees used in this study have different conditions, so the researcher grouped them into three: strong colonies, medium colonies, and weak colonies from the number of food reserves, daughter cells, and individual bees. Delaplane et al. [16] stated that colony strength could be determined by looking at the number of bees, daughter cells, honey, and pollen. *Stups* included in strong colonies were S2, S3, S4, and S9; the medium colonies were S1, S5, S10, S11, S12, and S14; while S6, S7, S8, and S13 were classified into weak colonies.

Most of the strong colonies in *KRPL* showed a high increase in the total number of pots compared to the medium and the weak colonies.

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This may be caused by the stability of strong colonies in maintaining temperature conditions in the hive and having more worker bees looking for and gathering food than the medium and the weak colonies. In addition, Delaplane et al. [16] explained that larger colonies tend to collect more nectar when the availability of nectar is abundant and consume less nectar when the availability of nectar in nature is reduced.

Trigona bees collect nectar and pollen as food reserves for the colony. The food reserves are stored in a storage pot (empty pot) made of *cerumen*. Empty pots that have been built will later be filled with honey or pollen by worker bees.

Table 1 shows that the increase in empty pots varies between each *stup*, where the increase occurred on different days. Some started to build pots on the fourth day of the observation, the seventh day. Some others on the tenth and thirteenth day of the observation, likewise for honey and pollen pots. In the last week of the observation, it was also found that the number of pots, either the empty pots, the honey pots, or the pollen pots did not increase.

Table 1. Increase of empty pots

DAY	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	Total
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	1	0	2	0	0	0	4	1	0	2	2	6
DAY	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**S11**	**S12**	**S13**	**S14**	**Total**
7	2	0	0	0	1	2	5	0	2	4	2	1	4	0	8
10	0	1	6	6	0	2	2	1	0	1	3	0	0	2	9
13	2	23	2	5	4	0	0	0	16	2	0	1	0	0	7
16	0	0	0	0	0	0	0	0	0	0	1	3	0	3	3
19	2	0	0	0	0	2	0	0	0	0	0	0	1	0	3
22	1	16	12	6	0	0	1	0	11	0	3	3	5	1	10
25	0	0	0	0	0	0	3	0	0	3	0	0	0	0	2
28	2	0	1	0	3	3	1	0	0	0	0	0	0	0	5
31	0	0	2	0	0	0	0	0	6	1	1	3	0	0	5
34	0	9	3	0	0	1	0	0	0	0	4	0	0	3	5
37	3	0	4	1	0	0	1	0	4	3	0	2	0	0	7
40	0	4	0	2	0	0	0	0	0	0	0	2	0	0	3
Total	12	53	30	21	8	12	13	1	39	18	15	15	12	11	

Note: The number 0 indicates no increase of empty pots

The increase in the number of pots in each bee colony in *KRPL* was slower than Mathiasson et al. [17], who reported that all bee colonies had built storage pots (empty pots) on the first day of observation, and some pots were filled with honey. Each colony also continues to build and fill new pots and always provides empty pots until the end of the observation. This difference may occur due to differences in the colonies' conditions, where the bee colony used by Mathiasson et al. [17] did not have food reserves in the colony. Thus, each colony immediately built an empty pot as a storage for food reserves to be collected.

In addition to differences in the colonies used, other things that might explain the difference in the number of honey and pollen pots are differences in weather conditions and the colony's needs. As stated by Erwan et al. [18], the activity of searching for nectar, pollen, and water depends on weather conditions and the colony's needs. The colony's needs mean the number of members and the age of the colony [19]. When the air temperature increases, the energy needed to fly looking for food will be even greater [18]. Bees can consider the amount of energy brought back to the colony (in the form of nectar) with the amount of energy spent foraging for food [20].

In contrast to the increase in the number of empty pots and honey pots, the amount of pollen collected by bees was positively correlated with daughter cells [21]. This is supported by research conducted by Pankiw, et al. [22] that the pheromones produced by larvae stimulate the behavior of bees in collecting pollen, as seen from the number of worker bees that collect pollen in colonies that are given additional larvae compared to colonies where all larvae have been removed. However, it is different from the study conducted by Eckert et al. [23] that the increase of worker bees collecting pollen was higher in small colonies than large colonies until it reached the same level in large colonies.

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Table 2. Increase of honey pots

DAY	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	Total
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	3	8	6	5	1	1	2	0	3	5	4	6	6	2	13
7	0	8	4	4	0	0	0	0	0	4	0	0	0	0	4
10	0	0	0	8	0	0	2	0	0	0	0	0	0	0	2
13	1	0	1	0	0	0	6	0	0	0	0	0	0	0	3
16	0	0	4	5	1	5	2	0	2	0	2	0	0	1	8
19	2	0	7	5	1	2	5	1	0	0	1	0	0	1	9
22	6	5	6	17	0	8	1	0	13	5	1	0	0	0	10
25	4	0	6	3	0	0	0	0	9	0	3	0	0	0	5
28	5	10	1	9	0	2	3	0	19	4	0	0	0	6	9
31	3	3	0	0	0	0	0	0	0	4	0	0	0	0	3
34	5	8	3	1	0	2	0	0	7	0	2	0	0	0	7
37	0	0	0	0	0	1	2	0	0	0	0	0	0	0	2
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	29	42	38	57	3	21	23	1	53	22	13	6	6	10	

Note: The number 0 indicates that there is no increase in honey pot

Table 3. Increase of pollen pots

DAY	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	Total
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	5	4	0	5	9	0	0	0	3	0	0	0	0	3	6
7	0	0	9	4	0	0	0	0	0	0	0	0	0	4	3
10	4	9	3	8	4	0	0	0	0	2	0	0	0	2	7
13	3	18	27	0	0	9	5	0	0	28	10	0	1	3	9
16	6	8	0	5	6	6	2	0	2	11	5	3	1	3	12
19	5	0	5	5	1	9	0	0	0	11	4	3	0	1	9
22	7	54	7	17	0	2	1	0	13	5	3	5	0	2	11
25	1	5	5	3	6	3	3	0	9	0	0	4	0	0	8
28	1	0	0	9	0	0	2	0	19	3	1	0	0	0	6
31	0	6	4	0	0	1	0	0	0	0	1	0	0	1	4
34	0	0	0	1	0	0	0	0	7	4	0	0	0	0	3
37	0	14	3	0	0	0	0	0	0	2	0	1	0	0	4
40	0	5	0	0	0	0	0	0	0	4	0	0	0	0	2
Total	32	123	63	57	26	30	13	0	53	70	24	16	2	19	

Note: The number 0 indicates that there is no increase in pollen pot

The difference in the increase in the number of pollen pots at the *stup* at the study site may also be more related to the availability of pollen in the flowers. As seen on the 10th and 19th days of the observation, the total increase in the number of pollen pots on these two days experienced a fairly rapid increase (104 and 116 pollen pots) compared to the previous days, which a large number of flowers could cause blooms on those days, especially sunflowers which contain a lot of pollen. Control mechanisms in bee colonies are very complex, so the amount of pollen collected by a colony is potentially influenced by more than one variable, such as worker bee population size, number of larvae, surrounding vegetation, weather conditions, etc. [21]. The bee's foraging effort also depends on the number of empty food storage spaces in the colony [24].

The presence of the queen in each bee colony cultivated in KRPL was also observed. In all colonies, the presence of the queen was confirmed except in colony S8. The increase in the total number of pots in the S8 colony was very low compared to other colonies, which were only two pots during the

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observation. This may be due to the queen's absence in the colony during the study, and there were no signs of re-queening until the end of the observation. This result is different from the study conducted by Mathiasson et al. [17], who reported that even though colonies did not have a queen, the colonies still showed an increase in the number of honey pots and pollen pots. This difference may be due to the S8 colony being an unhealthy colony. A healthy colony is characterized by an increased number of eggs, honey pots and pollen pots, and the color of the hive looks fresh and not dull [9].

Nest construction on the stup also experienced a difference. Each stup showed an increase in egg area in each colony, except for S8 and S12. The absence of an increase in the number of eggs in S8 was caused by the absence of a queen in the colony. Meanwhile, in S12 it may be due to the absence of an increase in the number of honey pots on the seventh day until the end of the observation. Lack of feed can cause the bee colony to be weak (the number of worker bees, food reserves, and royal jelly decreases), causing the queen's productivity to be very slow due to reduced food supply [18].

The Relationship between Temperature, Humidity and Light Intensity with the Increase in the Total Number of Pots

The average daily temperature at KRPL is 29.80°C with a range of 26.72-32.74°C, average humidity of 69.62% in 50-88.21%, and a light intensity of 22610 lux with a capacity of 296 -59564 lux. These results are normal environmental factors for the development of Trigona bees. Trigona bees can adapt well in all habitat conditions [7]. Trigona can live near agricultural land, peat swamp forests [25], or even mangrove forests [26].

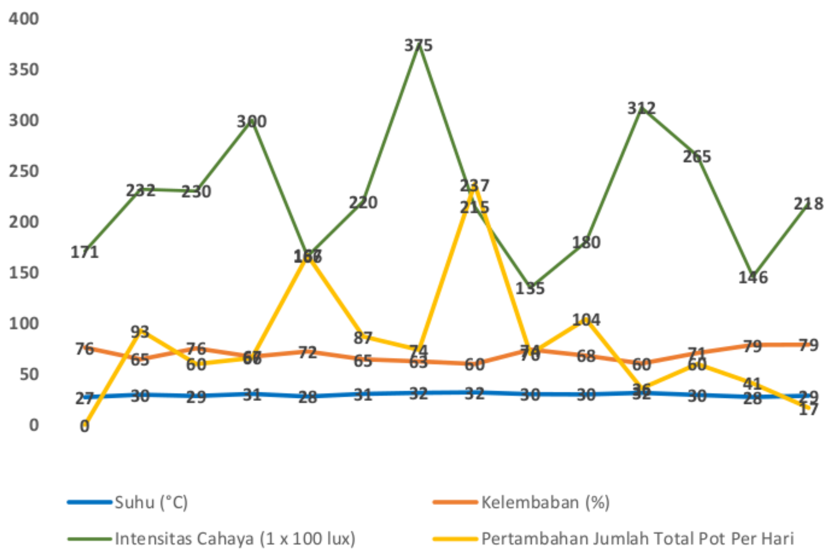

Figure 1. The Relationship between Temperature, Humidity and Light Intensity with the Increase in the Total Number of Pots

Environmental conditions, such as temperature, humidity, and light intensity at KRPL are different in each observation, as shown in Figure 1. However, it can be seen that there is an increase in the total number of pots in each observation. The high increase in the number of pots occurred in environmental conditions with an average daily temperature of 32°C, 60% humidity, and light intensity of 21500 lux. Meanwhile, a low increase in the total number of pots occurred at a temperature of 29°C, with a humidity of 79% and a light intensity of 17100 lux. These results are from several studies that reported that a comfortable and optimal environmental condition for Trigona bees to produce products ranged from a temperature of 26-35°C with a humidity of 46-60% [10], and a light intensity of 20000 lux [27].

Tautz [28] stated that bees could function normally at temperatures ranging from 18-35°C. Meanwhile, Ichwan [29] stated that humidity ranging from 60-90% was still suitable for bee breeding. Temperatures above 35°C can encourage Trigona bees to move nests. However, when the temperature is below 18°C, Trigona will warm itself and form hordes to increase the temperature in the nest. Humidity that is too high causes Trigona not to come out to look for food [30]. Thus, even in environmental conditions that are not optimal for

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bees to produce products, Trigona bees cultivated in *KRPL* can still have products because they are still within their tolerance limits.

The Relationship between *Trigona sp.* with Increase in Total Pot Amount

Trigona bees have the same strata as bees in general (queen bees, male bees, and worker bees). The activity of bees entering or leaving the hive is by worker bees. The activity aims to collect raw materials, which will later be processed into products in the form of honey or bee pollen for the sustainability of the colony in the hive. Putra et al. [31] explained that the production of honey and other products by Trigona depends on the number of strata of workers in the colony that is looking for and taking food.

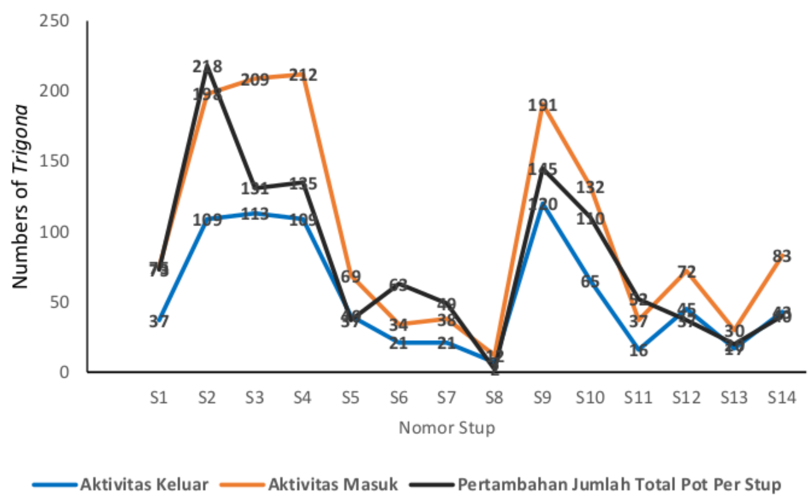

Figure 2. The Relationship between Entering and Leaving the Hive Activities of Trigona's with the Increase in Total Pot

Figure 2 shows that the activity of Trigona bees entering and leaving the hive at KRPL in each colony showed different numbers. High bee activity tends to be followed by an increase in the number of pollen pots and honey pots compared to low bee activity. However, high activity is not always followed by a high increase in the total number of pots as seen in S3 and S4. It indicates that the increase in the total number of pots in the hive is not only influenced by the activity of the bees in gathering food. However, there are other factors that influence it. One of them maybe because of the different food requirements in each colony according to the growth phase. The bee's need for carbohydrates (in the form of honey) varies based on their age and activities. Male bees can consume about 30 mg of carbohydrates per hour in flight, while worker bees consume about 10 mg per hour. Meanwhile, *mutlah* bee larvae need protein (in the form of pollen) to survive [32].

CONCLUSION

Based on the problem formulation, objectives, and observations, it can be concluded that:

1. The development of Trigona sp. bee colonies cultivated in KRPL are slow even though environmental conditions such as temperature, humidity, and light intensity are normal for their development.
2. The factors of temperature, humidity, and light intensity had no significant effect on colony development at the study site because they were within the tolerance range of bee colony development.
3. There is a positive relationship between bee activity and the increase in pollen and honey pots. High bee activity tends to be followed by the rise in the number of pollen pots and honey pots, which are higher than those with low bee activity.

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