Jurnal Ilmu Produksi dan Teknologi Hasil Peternakan **Vol. 08 No. 2 Juni 2020, Hlm: 67-71**
ISSN 2303-2227 eISSN 2615-594X DOI: https://doi.org/10.29244/jipthp.8.2.67-71
Accredited by National Journal Accreditation No. 30/E/KPT/2019 Available online at https://journal.ipb.ac.id/index.php/ipthp/index

The Influence of Environmental Factors on the Activity and Propolis Production of Tetragonula laeviceps

Pengaruh Faktor Lingkungan terhadap Aktivitas dan Produksi Propolis Tetragonula laeviceps

H. Salatnaya[1*], W. D. Widodo[2], Winarno[3], & A. M. Fuah[3]
[1]Study program of Agrotechnology, Banau Tertiary Institute of Agricultural Enterprise, West Halmahera
[2]Departement of Agronomy and Horticulture, Faculty of Agriculture, IPB University
[3]Department of Animal Production and Technology, Faculty of Animal Science, IPB University
Jl. Ir. Soekarno, Kompleks BBI Palawija. Acango-Jailolo, Halmahera Barat, Indonesia
Jl. Agatis, Kampus IPB Darmaga Bogor 16680, Indonesia
*Corresponding author: hearty.salatnaya@gmail.com
(Received 06-02-2020; Revised 20-03-2020; Accepted 24-04-2020)

ABSTRACT

The Environment is one of the factors influencing the development and productivity of the bee colony. Favourable environment will significantly support bee productivity. The factors which influence the bees activity include temperature, humidity, light intensity, wind speed, rainfall, and food availability. The aims of this study are to know the influence of environmental factors on activity and propolis production of stingless bees. This study used six colonies of Tetragonula laeviceps into two different locations, monoculture and polyculture nutmeg farm. The method used is a direct observation of the activities and propolis production of stingless bee and analyzed by t-test. The study results of T. laeviceps in monoculture and polyculture farms showed that the activity of the bees was influenced by environmental factors influencing propolis production. The activities would start when the temperatures ranged from 22-23 °C, humidity 70-88%, and light intensity 183-4344 lux. The peak activity of the bees occurred at the temperatures of 26-28 °C, humidity 55-71%, and light intensity 46.875-91.347 lux. The propolis produced by T. laeviceps was 27.79 g in the monoculture farm and 48.80 g in the polyculture farm. The significant difference was predominantly due to the environmental factors.

Keywords: environment, activity, propolis

ABSTRAK

Lingkungan merupakan salah satu faktor yang menentukan perkembangan dan produktivitas koloni lebah. Lingkungan yang optimal dan kondusif akan mendukung produktivitas lebah. Faktor-faktor yang berpengaruh terhadap aktivitas lebah adalah temperatur, kelembaban udara, intensitas cahaya matahari, kecepatan angin, curah hujan dan ketersediaan pakan. Tujuan penelitian ini adalah untuk mengetahui pengaruh faktor lingkungan terhadap aktivitas dan produksi propolis pada lebah tanpa sengat. Penelitian menggunakan enam koloni lebah Tetragonula laeviceps yang ditempatkan pada dua lokasi yang berbeda, yaitu perkebunan pala monokultur dan polikultur. Metode yang digunakan adalah pengamatan langsung terhadap aktivitas lebah dan produksi propolis dan dianalisis menggunakan uji t. Hasil pengamatan yang dilakukan pada *T. laviceps* di kebun monokultur dan polikultur menunjukkan bahwa lingkungan mempengaruhi aktivitas keluar-masuk lebah yang mempengaruhi produksi propolis. Aktivitas lebah dimulai pada saat suhu berkisar antara 22-23 °C, kelembaban 70-88%, dan intensitas cahaya 183-4344 lux. Jumlah aktivitas lebah yang tertinggi terjadi pada saat suhu mencapai 26-28 °C, kelembaban 55-71%, dan intensitas cahaya 46.875-91.347 lux. Lingkungan juga mempengaruhi jumlah propolis yang dihasilkan. Propolis yang dihasilkan adalah 27,79 g pada kebun monokultur dan 48,80 g pada kebun polikultur. Perbedaan yang signifikan terutama disebabkan oleh faktor lingkungan.

Kata kunci: lingkungan, Trigona, propolis

INTRODUCTION

Stingless bee is a cold-blooded insect and sensitive to changes in environmental temperatures (Junior *et al.* 2010). Flying activity of this bee is influenced by the condition of the inside colony and the environment (Hilario *et al.* 2000). Environmental conditions and colony activity have a significant relationship. The factors of the environment that influence the activities of the bees are temperature, relative humidity, season, and light intensity, rainfall (Asiah *et al.* 2015; Maia-Silva *et al.* 2015; Sung *et al.* 2011).

Previous research for three species of stingless bees shows that while they were exposed to cold conditions, the workers will consume syrup, but in the high temperature, the workers consumed water. The workers also fanning the nest and regurgitating drops of water on the floor of the box. Adults bee and pupae has greater mortality at low temperatures than at high temperatures. The workers will die while the temperature between 1.7 – 5 ^{o}C and total lethal temperature between -5 – 2 ^{o}C, while minimum mortality at a temperature between 25 – 40 ^{o}C. The pupae mortality was high below 25 ^{o}C and more than 33 ^{o}C, while the total lethal temperature between 2 – 5 ^{o}C (Macias-Macias *et al.* 2011).

Temperature affects the production of propolis because bees use it to isolate and protect their nest from environmental factors. Temperature always influences the amount of propolis collected by worker bees (Gojmerac 1983). Jager (2001) and Gojmerac (1983) stated, that the rise in temperature made plant resins and wax became soft and allows bees to process them. On a very hot day, bees began to work earlier in the morning, but at very low temperatures in the morning, bees would not collect resin. According to Krell (1996), propolis collection would be more active at the beginning of the rainy season, because bees prepared their nests for the winter. Bees isolated their hive from the external environment and regulated the temperature inside it, making it often hard to set up.

Stingless bee produced excellent propolis which was often used as a natural medicine that is very beneficial for human health and endurance. Propolis was actually the gum collected by bees from different shoots of plants, including from the plants that were broken, where the plant sap was then mixed with enzymes found in their salivary glands which was used to protect their hive from the contamination by bacteria, viruses and fungi (Ghisalberti 1979; Gojmerac 1983; Marcucci 1995; Popova *et al.* 2005; Chen *et al.* 2008).

MATERIALS AND METHODS

The material used in this study was six colonies of *Tetragonula laeviceps*, which consisted of one queen, a few drones, and hundreds workers. The six colonies were placed in two different ecosystems (monoculture and polyculture). The number of the plants found in the monoculture location was 437 nutmeg trees (*Myristica fragrans* Houtt). The types of crops on the polyculture land comprised 10 nutmeg trees, 1 lamtoro tree, 1 jengkol tree, 1 lychee tree, 2 mango trees, 4 rambutan trees, 2 jambu air trees, 3 pineapple trees, 1 passionfruit tree, 2 guava trees, 1 tree, 3 durian trees, 5 papaya trees, 41 banana trees, 1 mangosteen tree and 3 jackfruit trees.

Each colony consisted of hundreds bees placed on a sengon wooden stup measuring 25x15x15 cm^3 and the stup was written a number on it. Then each stup was weighted as an empty colony. Next, the colonies from bamboo were moved into stups by moving the entire egg nests and food supplies into the stups. After that, the entrances were covered with the propolis obtained from the old nest entrances. The stups already containing colonies were weighed to find out their initial weights before they were placed in the old places for 3 days so that the colonies would not fly away. After that, the stups were put on the places that had been prepared in the study area.

The research was conducted through direct obsevations to the daily activities of *T. laeviceps.* colonies which were kept in two different farms to produce propolis repeatedly. The parameters measured in this study were:

a. The colony activities indicated by the number of bees went in and out to find food by way of counting the colony activities in and out for 5 minutes beginning from 6:00 to 17:00 pm every day.
b. The propolis produced by T. *laeviceps* within a period of 3 months. The nest harvested was weighed, and the honey, pollen and propolis were separated. Each propolis harvest was weighed.

The data obtained from this study were presented descriptively to show the conditions of the two locations, while productivity data were presented in tables, charts and images. The analysis result was followed up by t test (Walpole 1995) to determine the activity of T. *laeviceps* at two different farms with different plant species (monoculture and polyculture) using a program of Minitab ® 16.1.0.

$$t = \frac{(\bar{x}_1 - \bar{x}_2) - d_0}{\sqrt{\left(\frac{s_1^2}{n_1}\right) + \left(\frac{s_2^2}{n_2}\right)}}$$

$$v = \frac{(s_1^2/n_1 + s_2^2/n_2)^2}{\frac{(s_1^2/n_1)^2}{n_1 - 1} + \frac{(s_2^2/n_2)^2}{n_2 - 1}}$$

σ_1≠ σ_2 and unknown

Description:
x_1= the mean value of the bee population in the monoculture farm
x_2= the mean value of the bee population in the polyculture farm
s_1^2= the variance of the bee population in the monoculture farm
s_2^2= the variance of the bee population in the polyculture farm
n_1= the number of the observations in the monoculture farm
n_2= the number of the observations in the polyoculture farm

RESULTS AND DISCUSSION

Environment and Bees Activities

The influence of environmental factors (temperature, humidity, and light intensity) on T. *laeviceps* activities in the monoculture nutmeg farm can be seen in Table 1 and in the polyculture farm in Table 2. The results of observations on the monoculture and polyculture farms showed that the environment influenced the daily activities of stingless bees went out and bees into the hives.

The worker bees start the activity at 06:00 at both locations. *T. laeviceps* activity in the monoculture farm was initiated when the temperature was 23.08 °C, humidity 70%, and light intensity still low at 183 lux. The number of bees that came out was 4 bees / 5 minutes and the bees that came in 3 bees / 5 minutes. *T. laeviceps* activity in the polyculture farm began when the lowest temperature reached 22.52 °C, humidity 88%, and light intensity 4,344 lux. The number of bees that came out was 6 bees / 5 minutes and went in 5 bees / 5 minutes.

Table 1. Environmental factors and T. *laeviceps* activities in the monoculture nutmeg farm

Hour	Activity		Temperature	Humidity	Light Intensity
	Out	In	(°C)	(%)	(lux)
6:00	4	3	23.08	70	183
7:00	12	12	22.31	70	723
8:00	25	29	23.84	68	1,963
9:00	30	34	24.25	65	6,919
10:00	42	50	25.71	61	6,071
11:00	60	71	26.63	56	16,634
12:00	54	72	27.27	55	91,347
13:00	51	66	27.11	56	33,062
14:00	42	60	26.84	58	5,679
15:00	30	44	26.03	59	2,558
16:00	22	34	25.24	62	1,521
17:00	11	19	24.23	64	542

Source: Primary data

The bee activities increased with the increase in environmental temperature and light intensity, while the humidity decreased. The highest number of bees at monoculture farm that came out was 60 bees / 5 min occurring at a temperature of 26.63 with a humidity of 56%, and a light intensity of 16,634 lux at 11.00. The highest number of incoming bees (72 bees) occurred when the temperature reached 27.27 °C, humidity 55%, and light intensity 91.347 lux at 12.00. The peak activities of stingless bee at polyculture was at 10.00 when the temperature reached 28.02 °C, humidity 71%, and light intensity 46,875 lux with the highest number of bees that came out was 34 bees / 5 minutes and the highest number of incoming was 37 bees/5 minutes. The foraging activity will stop before 18:00 at both locations. This result was supported by Nugroho and Soesilohadi (2015), that temperature and light intensity has a positive correlation, but negative correlation with humidity. The humidity will decrease while the temperature and light intensity was high. Based on Mathiasson *et al.* (2015), forage activity and environmental factors have a significant correlation.

Table 2. Environmental factors and T. *laeviceps* activity in the polyculture farm

Hour	Activity		Temperature	Humidity	Light Intensity
	Out	In	(°C)	(%)	(lux)
6:00	6	5	22.52	88	4,344
7:00	18	18	23.69	92	38,738
8:00	31	34	26.09	82	138,563
9:00	32	34	26.95	75	89,897
10:00	34	37	28.02	71	46,875
11:00	31	33	28.44	69	37,178
12:00	28	32	28.25	70	31,292
13:00	27	31	28.43	70	27,943
14:00	26	29	27.79	73	27,390
15:00	19	25	26.05	76	24,948
16:00	16	22	25.27	80	15,586
17:00	13	19	25.14	83	4,667

Source: Primary data

The results of this study were in line with Kajobe and Echazarreta (2005) which showed that bees searching for food started their activity early in the morning which totaled approximately 5-10 bees. Rodrigues *et al.* (2007) stated, that the activity of bees began at 06.00 with high humidity of about 65%, low light intensity, and the temperature around 22 °C. Flight activity was the highest when the humidity reached 43-65%. The humidity would be relatively constant around 40% at 17.00 until the bees came into their hive and did not have any activity outside the nest. Mathiasson *et al.* (2015) also supported this study, that bees did a lot of activities at a low humidity while the temperature was high. High activities happened at temperatures above 29 °C and the relative humidity was about 70%. The peak activities of stingless bee was at noon.

Several abiotic factors influenced the activity of bees. Temperature had the greatest effect on the activity of bees (Boontop *et al.* 2008). The activities of bees went in and out increased with the increase in temperature, and the maximum activity occurred when the temperature reached 26.5 to 27 °C similar to the finding of Hilario *et al.* (2001) and Danka *et al.* (2006). Bees could not fly when their body temperature dropped below 10 °C. They were powerless to move at a temperature of 5 °C and they freeze at -1.9 °C (Gojmerac 1983). Contera and Nieh (2007) added that at the time of low temperatures, bees searching for food would stay in their nest longer than when the temperature was normal.

Bee activities were also influenced by humidity. The higher humidity, the lower the activity (Boontop *et al.* 2008). High humidity occurs in the morning when it rains, and bees have no outside activity when it rains. Searching for food is hindered by the rain. Morning rain delays the collection of pollen and continuous rain leads to a decrease in search of food, because the intensity of light in the rain also decreases. This results was supported by Hilario *et al.* (2001), who stated that the higher the light intensity, the higher the activity of bees. The peak was at noon before it decreased when the night came. The result of t test to the environmental factors and the activities of the bees showed a significant difference ($P < 0.05$) with a value of 36.5 + 20.9 in the monoculture farm and 25.00 + 8.99 in the polyculture farm.

The weather at both study sites had great influence on the activity of the bees. Rainfall was still quite high until May, so the activity of the bees outside their hive was very limited. The bees preferred staying in their nest when the weather did not support the activities outside the nest. According to Someijer *et al.* (1983), rain hindered the activity of bees to find food. Morning rain will delay the collection of pollen and continuous rain decreased the activity for food hunting.

Propolis Production

The propolis produced by the colonies of *T. laeviceps* kept in the monoculture nutmeg farm and polyculture farm for 13 weeks can be seen in Table 3. It shows that the weight of T. laeviceps raised in the monoculture farm was higher than in the polyculture farm. During the 3-month study the weights of the colonies produced in the monoculture farm and the polyculture farm were 299 g and 170 g respectively. The result of t test showed that the colony development in the monoculture nutmeg farm and in the polyculture farm was significantly different ($P < 0.05$) with a value of 95.5 + 10.8 g in the monoculture nutmeg farm and 61.3 + 11.7 g in the polyculture farm. However, after being harvested, the product of Trigona in the monoculture nutmeg farm was only 21.93% of the colony weight and in the polyculture farm 54.56%.

The colony development could be associated with plant-flowering seasons in the farm and the environment. Nutmeg plant is a plant that blooms throughout the year, but the highest flowering period occurs in April and May. Fortunately, the flowering period coincided with the implementation of the research activities, so that the colony development could be observed. Bees need sufficient food not only for survival but also for the colony development. Seemingly, the amount of food that was collected by bees in the monoculture farm was not much. Consequently, the colony development was not too fast. Additionally, during the observations, the environment was not really supportive due to the weather change, where there was more rain than there was sunny time.

Table 3. Harvest of T. *laeviceps* propolis in the nutmeg monoculture farm and the polyculture farm

Farm	Colony Weight (g)	Harvest Colony (g)	Propolis (g)
Monoculture	299	68	27.79
Polyculture	170	94.77	48.8

Source: Primary data

The colony development could be associated with plant-flowering seasons in the farm and the environment. Nutmeg plant is a plant that blooms throughout the year, but the highest flowering period occurs in April and May. Fortunately, the flowering period coincided with the implementation of the research activities, so that the colony development could be observed. Bees need sufficient food not only for survival but also for the colony development. Seemingly, the amount of food that was collected by bees in the monoculture farm was not much. Consequently, the colony development was not too fast. Additionally, during the observations, the environment was not really supportive due to the weather change, where there was more rain than there was sunny time.

The colony development in the polyculture farm was less than in the monoculture farm, but the monoculture farm was higher in production, because during the study, the flowering season of the plant in the polyculture farm only occurred for certain types of plants, namely 10 nutmeg trees, 1 lamtoro tree, 3 jackfruit trees, 3 pineapple trees, 5 papaya trees, and 2 guava trees. It was assumed that the reason why bees were hoarding food was that the number of flowering plants was not many. According to Siregar *et al.* (2011), stingless bee needed an environment with vegetation that provided pollen and nectar naturally, in order to multiply and produce a variety of bee products, such as honey, pollen and propolis.

Activities of social insects in tropical areas were high in the morning, when the collection of pollen is higher than nectar, as also stated by Roubik (1989). According to Junior *et al.* (2010), bees collected pollen in the morning until noon. The frequency of bees returning to the nest by bringing nectar or water increases during the day in the summer. Throughout the rainy season, the activity of collecting nectar was done more frequently in the morning and early afternoon. Wallace and Lee (2010) stated that the collection of propolis was only a small part of the entire activities carried out by the bees. The bees returning to the nest bringing resin during the peak activity was only 10%. Jager (2001) stated, that propolis production would increased if there was a gap that was open and the light came into their nest, because the incoming light would stimulated bees to collected propolis to seal their hive.

Temperature affects the production of propolis because bees used propolis to isolate and protect their nest from the environmental factors. Temperature always affects the amount of resin collected by worker bees. The rise in temperature makes plant resins and wax become soft and allows bees to process. According to Krell (1996), resin collection would be more active at the beginning of the rainy season, when the bees prepare their nest for the winter.

CONCLUSION

Environmental factors (temperature, humidity, and light intensity) and time significantly affected the flying activity of *T. laeviceps*. High temperatures, as well as high light intensity, increased the activity of the bees, while high humidity in the monoculture farm decreased the activity of the bees. The propolis produced in the polyculture farms was higher than the monoculture farm.

REFERENCES

Asiah, W. N., A. S. Sajap, N. A. Adam, & M. N. Hamid. 2015. Flight intensity of two species of stingless bees *Heterotrigona itama* and *Geniotrigona thoracica* and its relationship with temperature, light intensity and relative humidity. Serangga. 20(1): 35-42.

Boontop, Y., S. Malaipan, K. Chareansom, & D. Wiwatwittaya. 2008. Diversity of stingless bees (Apidae: Meliponini) in Thong Pha Phum District, Kanchanaburi Province, Thailand. Nat Sci. 42:444-456.

Chen, W. Y. *et al.* 2008. Characterisation of taiwanese propolis collected from different locations and seasons. J Sci Food Agri. 88:412-419.

Chuttong, B., Y. Chanbang, & M. Burgett. 2015. Meliponiculture: Stingless Bee Beekeeping in Thailand. Bee World. 91(2): 41-45.

Contera, F. A. L., & J. C. Nieh. 2007. The effect of ambient temperature on forager sound production and thoracic temperature in the stingless bee, Melipona panamica. Behav Ecol Sociobiol. 61:887-897.

Danka, R. G., H. A. Sylvester & D. Boykin. 2006. Environmental influences on flight activity of USDA-ARS Russian and Italian stocks of honey bees (Hymenoptera: Apidae) during almond pollination. J Econ Entomol. 99:1565-1570.

Ghisalberti, E. L. 1979. Propolis: a review. Bee World. 60: 59-84.

Gojmerac, W. L. 1983. Bee, Beekeeping, Honey and Pollination. AVI, Westport.

Hilario, S. D., V. L. Imperatriz-Fonseca, & M. P. Kleinert A de. 2000. Flight activity and colony strength in the stingless bee Melipona bicolor bicolor (Apidae, Meliponinae). Rev Bras Biol. 60:299-306.

Hilario, S. D., V. L. Imperatriz-Fonseca, & M. P. Kleinert A de. 2001. Responses to climatic factors by foragers of Plebeia pugnax Moure (In Litt.) (Apidae, Meliponinae). Rev Bras Biol. 61:191-196.

Jager, A. J. de. 2001. The Effect Of Increased Propolis Production On The Productivity A Honeybee Farming System. [Dissertation]. Departement Of Agricultural Management. Saasveld George Campus. Port Elizabeth Technikon.

Junior, N. T. F., B. Blochtein, & J. F. de Moraes. 2010. Seasonal flight and resource collection patterns of colonies of the stingless bee Melpona bicolor schencki Gribodo (Apidae, Meliponini) in an Araucaria forest area in southern Brazil. Rev Bras de Entomol. 54:630-636.

Kajobe, R., & C. M. Echazarreta. 2005. Temporal resource portioning and climatological influences on colony flight and foraging of stingless bees (Apidae: Meliponini) in Ugandan tropical forests. Afr. J. Ecol. 43: 267-275.

Krell. 1996. Value added products from beekeeping. Agri Serv Bull 124, Food and Agricultural Organization of the U.N, 409.

Macias-Macias, J. O., J. J. G. Quezada-Euan, F. Contreras-Escareno, J. M. Tapia-Gonzalez, H. Moo-Valle, & R. Ayala. 2011. Comparative temperature tolerance in stingless bee species from tropical and lowlands of Mexico and implications for their conservation (Hymenoptera: Apidae: Meliponini). Apidologie. 42: 679-689.

Maia-Silva, C., M. Hrncir, C. Inês da Silva, & V. L. Imperatriz-Fonseca. 2015. Survival strategies of stingless bees (*Melipona subnitida*) in an unpredictable environment, the Brazilian tropica dry forest. Apidologie. 46: 631-643.

Marcucci, M. C. 1995. Propolis: chemical, biological properties and therapeutic activity. Apidologie. 26:83-99.

Mathiasson, M. E., P. K. Kwapong, D. A. Wubah, & J. A. Wubah. 2015. Early colony development of an equatorial afrotropical stingless bee (Hypotrigona sp.) in a new habitat. JYI. 29(3): 11-17.

Nugroho, R. B., & R. C. H. Soesilohadi. 2015. Foraging activity of worker stingless bee, *Trigona* sp. (Hymenoptera: Apidae) in Gunungkidul. Biomedika. 8(1): 37-41.

Popova, M., S. Silici, O. Kaftanoglu, & V. Bankova. 2003. Antibacterial activity of Turkish propolis and qualitative and quantitative chemical composition. Phytomedicine. 12:221-228.

Rodrigues, M., W. C. Santana, G. S. Freitas, & A. E. E. Soares. 2007. Flight activity of Tetragona clavipes (FABRICUS, 1804) (Hymenoptera, Apidae, Meliponini) at the Sao Paulo University Campus in Ribeirao Preto. Biosci J. 23:118-124.

Roubik, D. W. 1989. Ecology and natural history of tropical bees. Cambridge UK: Cambridge Univ. Press.

Siregar, H. C. H., A. M. Fuah, & Y. Octavianty. 2011. Propolis Madu Multikhasiat. Jakarta: Penebar Swadaya.

Sung, I. H., S. Yamane, S. S. Lu, & K. K. Ho. 2011. Climatological influences on the flight activity of stingless bees (*Lepidotrigona boozana*) and honeybees (*Apis cerana*) in Taiwan (Hymenoptera, Apidae). Sociobiology. 58(3): 835-850

Sommeijer, M. J., G. A. de Rooy, W. Punt, & de Bruijn. 1983. A Comparative Study Foraging Behavior and Pollen Resources of Various Stingless Bees (Hym., Meliponinae) and Honeybees (Hym., Apinae) in Trinidad, West-Indies. Apidologie. 14:205-224.

Walpole, R. E. 1995. Pengantar Statistika. PT. Gramedia Pustaka Utama. Jakarta.

Wallace, H. M., & D. J. Lee. 2010. Resin-foraging by colonies of Trigona sapiens and T.hockingsi (Hymenoptera: APidae, Meliponini) and consequent seed dispersal of Corymbia torelliana (Myrtaceae). Apidologie. 41: 428-435.