JURNAL BIOLOGI PAPUA
Volume 17, Number 02, pages: 103–111
October 2025

ISSN 2086-3314
E-ISSN 2503-0450
DOI: 10.31957/jbp.4107
http://ejournal.uncen.ac.id/index.php/JBP

Pollen Foraging Activity of Stingless Bee (*Heterotrigona itama*) in Managed Colonies at the Adat Imbo Putui Forest, Kampar Regency

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Received: 1 August 2025 – Accepted: 25 September 2025

ABSTRACT

Stingless bees are commonly found in Indonesia, either living naturally or managed in cultivation systems. The main factor determining the success of stingless bee farming is the availability and abundance of plants as food sources. This study aimed to determine the number and timing of foraging activities of stingless bees (*Heterotrigona itama*) for pollen, the influence of environmental factors on the foraging activities of *H. itama* for pollen, and the types of plants that have the potential to serve as pollen sources. The foraging activity of *H. itama* was directly observed from 06:00 to 18:00. The environmental parameters measured included temperature, humidity, and light intensity. The survey of potential pollen source plants was conducted around the managed colony boxes and within a 200-meter radius from the colony boxes. The results showed that *H. itama* foraging activity peaked at 11:00 (bees leaving the nest), 10:00 (bees returning to the nest without carrying pollen), and 11:00 (bees returning with pollen). Spearman correlation analysis indicated that pollen foraging activity was influenced by light intensity. The potential for pollen source plants around the study site was relatively abundant, with 37 plant species identified.

Key words: activity, *Heterotrigona itama*, environment, pollen, bee feed source.

INTRODUCTION

Stingless bees (Hymenoptera: Meliponini) are eusocial insects that live in colonies. These bees are commonly found in Indonesia, either living naturally or managed through cultivation (Trianto & Purwanto, 2020; Trianto *et al.*, 2023). In their natural habitats, these bees build nests in tree cavities, rock crevices, bamboo, or other materials that provide enclosed spaces with small openings as nest entrances. Stingless bees are more commonly found in tropical regions with hot climates compared to subtropical regions with four seasons (Putra *et al.*, 2016). Stingless bees are easy to cultivate because they do not sting, are relatively docile, and their propagation and maintenance are not difficult. Stingless bee farming has recently begun to receive attention as an effort to develop local potential to support the availability of food sources and to improve colony productivity, including in Riau. The Adat Imbo Putui Forest (HAIP), a customary forest, is an area with great potential for the development of stingless bee farming, as it provides abundant food sources derived from native forest plants. Based on surveys and interviews, it was found that local forest managers have already initiated the cultivation of stingless bees (*Heterotrigona*

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itama). However, the production of honey, propolis, and bee pollen from these managed colonies has not yet reached its optimum level, and so far, their utilization has been limited mainly to honey.

The daily activity of stingless bees entering and exiting their nests serves to protect the nest from predators, remove waste, and forage for food. Foraging activity influences the colony weight and its production yield, including honey, bee pollen, and propolis (Erwan *et al*., 2020; Prastiyo *et al*., 2023). Foraging behavior characteristics vary among bee species, influenced by both biotic and abiotic factors such as individual body size, weather conditions, and the resources being explored (Silva *et al*., 2019). Forager activity generally begins to decline at 08:00, with the largest quantity of pollen collected between 09:00 and 11:00 (Jaapar *et al*., 2018).

The main factor determining the success of stingless bee farming is the availability and abundance of plants as food sources. This is because colony development and productivity are highly dependent on the availability of food, namely nectar and pollen produced by plants (Supiandi *et al*., 2023). Plant species that are frequently visited by stingless bees include acacia (*Acacia mangium*), downy rose myrtle (*Rhodomyrtus tomentosa*), rubber (*Hevea brasiliensis*), bilimbi (*Averrhoa carambola*), coral vine (*Antigonon*), sensitive plant (*Mimosa pudica*), coconut (*Cocos nucifera*), palm (*Dypsis lutescens*), cashew (*Anacardium occidentale*), cacao (*Theobroma cacao*), guava (*Psidium guajava*), and jackfruit (*Artocarpus heterophyllus*) (Alpian *et al*., 2022; Erwan *et al*., 2022).

Plant species diversity among bee forage plants is essential to ensure food availability throughout the year. Each plant species has different flowering periods, allowing bees to store food in their nests as a reserve during periods of forage scarcity (Tahir *et al*., 2021). To date, no studies have investigated the foraging flight behavior of stingless bees and the plant species serving as pollen sources in the HAIP area. Therefore, this study aimed to examine the flight activities of stingless bees entering and exiting their nests, determine the influence of environmental factors on bee flight activity, and identify potential forage sources around the study site. The findings of this research are important for understanding the foraging activity patterns of stingless bees and for providing a basis for colony management to improve production and support the conservation of plants as bee forage sources.

MATERIALS AND METHODS

Research Period and Location

The research was conducted from 6 to 23 May 2024 at a stingless bee (*H. itama*) farming site in the Adat Imbo Putui Forest (HAIP), Kampar Regency.

Materials and Equipment

The equipment used included a tally counter, camera, and stopwatch. Environmental parameters were measured using a thermohygrometer (for temperature and humidity) and a lux meter (for light intensity). The equipment and materials used for plant data collection included a measuring tape and raffia string.

Procedure

The foraging activity of *H. itama* worker bees was observed directly over a period of three weeks. Observations were conducted on three stingless bee colony boxes with three replications, performed once per week. The observations recorded the number of worker bees exiting the nest (LH), the number of worker bees entering the nest carrying pollen (ECP), and the number of worker bees entering the nest without pollen (EWCP). Worker bees carrying pollen were identified by the presence of yellow material on their corbicula. The entry and exit activity of *H. itama* worker bees was manually counted using a tally counter. The activity was observed hourly for 10 minutes from 06:00 to 18:00. This procedure followed Martin & Batteson (1993).

Pollen source plant data were collected through direct observation by recording all plant species present in each plot. The plots consisted of two plots within the farming area and four plots arranged in the cardinal directions within a 200-meter radius, with each plot measuring 20 × 20 meters. Plant species with potential as pollen sources were identified in the area surrounding the colony boxes up to a radius of 200 meters. Data

Table 1. The flight activity of *H. itama* worker bees.

Times	Box 10			Box 9			Box 16		
	LH	ECP	EWCP	LH	ECP	EWCP	LH	ECP	EWCP
06.00-06.10	84	1	38	75	1	90	78	1	112
07.00-07.10	81	4	87	102	6	185	82	4	139
08.00-08.10	154	7	132	111	8	172	71	5	94
09.00-09.10	176	8	151	103	17	178	83	11	90
10.00-10.10	150	10	136	100	13	207	72	12	81
11.00-11.10	191	18	153	108	14	134	106	21	75
12.00-12.10	166	17	116	73	12	102	81	23	80
13.00-13.10	181	21	130	80	5	86	69	18	68
14.00-14.10	129	10	107	55	4	89	59	11	74
15.00-15.10	103	4	85	72	6	102	54	8	71
16.00-16.10	58	2	67	55	2	104	51	3	75
17.00-17.10	24	1	52	62	1	96	39	2	35
18.00-18.10	3	1	15	1	3	3	6	1	31
Total	1.500	104	1.269	997	92	1.548	851	120	1.025

Notes: LH: Leaving the hive, ECP: Entering carrying pollen, EWCP: Entering the hive without carrying pollen.

Table 2. Measurements of temperature, humidity, and light intensity.

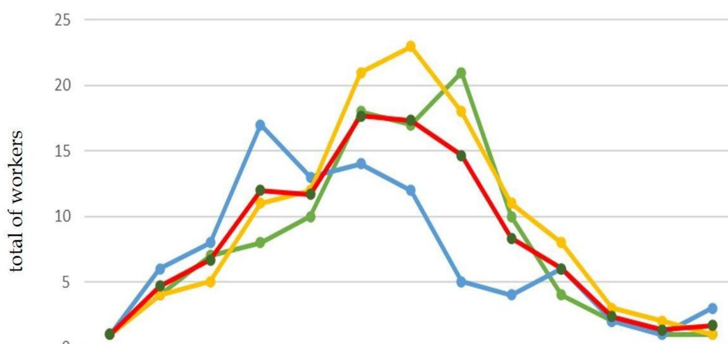
Time	Colony box 10			Colony box 9			Colony box 16		
	T (℃)	H (%)	LI (Lux)	T (℃)	H (%)	LI (Lux)	T (℃)	H (%)	LI (Lux)
06.00-06.10	25-28	81-82	79-115	26-28	78-89	11-427	25-26	87-88	4-50
07.00-07.10	25-28	83-91	801-2623	26-28	84-90	461-725	25-26	88-91	99-315
08.00-08.10	26-27	83-87	2485-4678	27-29	81-90	694-1311	25-27	90-91	447-1010
09.00-09.10	28-30	79-83	5463-8615	27-30	81-90	1081-2476	26-28	87-91	908-1346
10.00-10.10	29-31	74-80	8490-10830	27-30	77-89	1806-2347	27-30	79-89	894-3426
11.00-11.10	30-31	54-71	7725-14420	29-31	76-80	2161-5004	28-29	81-88	2190-1633
12.00-12.10	30-31	53-78	10820-15400	29-31	72-83	1894-3903	28-33	70-83	2066-3580
13.00-13.10	31-32	64-74	6932-64850	29-30	73-84	945-2226	29-31	76-79	2031-3522
14.00-14.10	30-31	66-69	8960-13050	28-32	72-87	611-5294	29-31	75-78	2332-4003
15.00-15.10	31-33	65-69	5183-10510	28-30	72-86	473-1338	29-32	74-82	1755-4905
16.00-16.10	31-32	70-72	4592-9004	28-30	74-80	515-638	29-30	77-81	1489-4983
17.00-17.10	29-31	72-74	1393-2502	28-30	80-88	411-517	29-30	79-85	418-1815
18.00-18.10	28-29	74-80	35-415	27-29	83-85	12-307	28-29	84-89	103-201

Notes: T = temperature, H = humidity, LI = light intensity.

Table 3. Correlation between temperature, humidity, and light intensity with the flight activity of stingless bee *H. itama*.

No	Environmental parameter	Correlation coefficient	Description
1.	Temperature	0,178	Very weak
2.	Humidity	-0,115	Very weak
3.	Light Intensity	0,504	Moderate

Figure 1. *H. itama* bee entering the nest carrying pollen.



	06.00-06.10	07.00-07.10	08.00-08.10	09.00-09.10	10.00-10.10	11.00-11.10	12.00-12.10	13.00-13.10	14.00-14.10	15.00-15.10	16.00-16.10	17.00-17.10	18.00-18.10
box 10	1	4	7	8	10	18	17	21	10	4	2	1	1
box 9	1	6	8	17	13	14	12	5	4	6	2	1	3
box 16	1	4	5	11	12	21	23	18	11	8	3	2	1
LH B10, B9, B16		5	7	12	12	18	17	15	8	6	2	1	2

Figure 2. Daily pollen foraging activity of stingless bee (*H. itama*).

collection on pollen source plants was conducted in each plot, and the determination of pollen source plants was supported by interviews and literature review.

Data Analysis

The environmental parameter data were analyzed using Spearman's correlation test to determine the relationships between various environmental factors (air temperature, humidity, and light intensity) and nest entry and exit activities. The analysis was conducted at 1% and 5% significance levels. The correlation between environmental factors and bee activity was interpreted based on Fowler *et al*. (1998) as follows: very weak (0.00–0.19), weak (0.20–0.39), moderate (0.40–0.69), strong (0.70–0.90), and very strong (0.90–1.00).

RESULTS AND DISCUSSION

Foraging Flight Activity of *H. itama* for Pollen

The flight activity of *H. itama* consisted of exiting the nest (LH), entering the nest carrying pollen (ECP), and entering the nest without pollen (EWCP). Based on the observations, the average number of *H. itama* flight activities varied at different hours of the day. The results showed that the number of these activities fluctuated according to the observation time.

The activity of *H. itama* worker bees was observed at a stingless bee farming site in HAIP, which currently has 17 colony boxes. Observations were carried out from 06:00 to 18:00 (Table 1). As the sun began to rise at 06:00, *H. itama* individuals were seen exiting the nest to begin their activities. *H. itama* became active in the morning towards midday as light intensity increased, and their activity declined toward the late afternoon. Previous studies have shown that bee flight activity is more closely related to light intensity, particularly during the initial daily activity period around sunrise (Silva *et al*., 2014). In addition to light intensity, more flowers the primary food source bloom in the morni. Azmi *et al*. (2015) stated that most flowers bloom in the morning and close in the afternoon. The process of pollen collection, such as flight distance, pollen gathering, and pollen handling time, is associated with flower blooming, which predominantly occurs in the morning.

The highest nest-exiting activity (LH) of *H. itama* in the three colonies was recorded between 08:00 and 15:00. Previous studies reported that the peak nest-exiting activity of *H. itama* occurred in the morning (09:00–10:00) and in the afternoon (13:30–14:30) (Suwarno *et al*., 2023). In other species, such as *Tetragonula laeviceps*, pollen foraging activity was relatively high at 08:00, with peak activity observed at 11:00, before declining again in the afternoon (Wulandari *et al*., 2017). The differences in activity patterns may be due to variations in environmental conditions during different working hours, the availability of plant resources during different periods, and differences in the elevation of study sites. The lower activity observed in the early morning and late afternoon could be attributed to lower temperatures and reduced sunlight intensity at the study site. According to Kaluza *et al*. (2016), bee activity is regulated by environmental conditions and species characteristics (such as body size correlated with visual range, mouthpart preferences, foraging time, food storage capacity, and habitat characteristics surrounding the colony).

The average number of *H. itama* workers exiting the nest (LH) and entering the nest without pollen (EWCP) was higher in box 10 compared to boxes 9 and 16 (Table 1). This may be due to the higher sunlight intensity at box 10, as it was located in an open area not shaded by trees. In contrast, boxes 9 and 16 were placed under trees and did not receive direct sunlight. Therefore, the higher nest entry and exit activity in box 10 was likely influenced by its exposure to sunlight.

H. itama bees carrying pollen can be identified by the presence of small pollen pellets on a specialized structure on their hind legs called the corbicula (Figure 1). Based on Figure 2, the peak average number of pollen-carrying worker bees from the three boxes (LH B10, B9, B16) occurred between 09:00 and 13:00. Fitri Ramadani *et al*. (2021) reported that the number of individuals returning to the nest with pollen increased from morning to midday and then gradually decreased in the afternoon. Similarly, Rakshita *et al*. (2022) showed that pollen foraging activity began at 09:00 and was only observed during midday hours.

The activity of *H. itama* entering the nest carrying pollen (ECP) was higher in box 16 than in boxes 10 and 9. The higher MP activity in box 16 may have occurred due to the greater availability of food sources around box 16, including the presence of Israel grass (*Asystasia gangetica*). Although pollen-producing plants were present around boxes 10 and 9, the plants near these colonies were not in bloom at the time, which may have caused *H. itama* to forage further afield. As stated by Pratama *et al*. (2018), the distance and height of food sources also influence the pollen-collecting activity of stingless bees. This is supported by Hidayati *et al*. (2020), who noted that the availability of food sources near the colony is a key factor affecting the foraging activity of stingless bees. In addition to proximity, plants that are not too tall may also be more likely to be visited by stingless bees.

Effect of environmental factors on the flight activity of *H. itama*

The flight activity of *H. itama* can be influenced by environmental conditions such as

Table 4. Potential plants as sources of pollen in the Adat Imbo Putui Forest, Kampar Regency.

No	Local names	Species	Totals (Individu)
1	Ubar	*Syzgium grande*	38
2	Bintangur	*Calophyllum inophyllum*	21
3	Tampui	*Baccaurea kunstleri*	4
4	Medang daun kecil	*Cinnamomum cinereum*	12
5	Aro	*Ficus fistulosa*	1
6	Mempening	*Quercus ewickii*	6
7	Senduduk bulu	*Clidemia hirta*	76
8	Pudu	*Artocarpus kemando*	3
9	Rumput israel	*Asystasia gangetica*	88
10	Karet	*Hevea brasiliensis*	1
11	Ridan	*Nephelium maingayi*	2
12	Bajakah kait-kait	*Uncaria acida*	2
13	Senduduk	*Melastoma malabathricum*	10
14	Rengas	*Gluta renghas*	3
15	Nasi nasi	*Syzygium zeylanicum*	5
16	Palange	*Aporosa aurita*	18
17	Kuras	*Dryobalanops oblongifolia*	5
18	Ilalang	*Imperata cylindrica*	15
19	Putri malu sp 1	*Mimosa pudica*	12
20	Jengkol	*Pithecellobium lobatum*	3
21	Belimbing	*Averrhoa carambola*	3
22	Meranti	*Shorea sp.*	4
23	Santostermon	*Xanthostemon novoguineensis*	1
24	Manggis	*Garcinia mangostama*	6
25	Ambacang	*Mangifera foetida*	1
26	Mahang	*Maccaranga triloba*	1
27	Kaliandra	*Calliandra calothyrsus*	1
28	Durian	*Durio zibethinus*	1
29	Air mata pengantin	*Antigonon leptopus*	1
30	Geronggang	*Cratoxylon arborescens*	3
31	Marapuyan	*Rhodamnia rubescens*	10
32	Pasak bumi	*Eurycoma longifolia*	1
33	Bandotan	*Ageratum conyzoides*	28
34	Meniran	*Phyllanthus urinaria*	20
35	Putri malu sp 2	*Mimosa pigra*	3
36	Pulai	*Alstonia scholaris*	1
37	Kelapa sawit	*Elaeis guineensis*	16

temperature, light intensity, and humidity. The measured environmental parameters during the observation period are presented in Table 2 below.

Based on Table 2, during 06:00–06:10 the temperature ranged from 25 to 28°C and the humidity ranged from 78% to 88%, with worker bees actively entering and exiting the nest (as shown in Table 1). Observations of *H. itama* flight activity around the nest showed that the bees were quite active at the nest entrance in the morning.

Before starting their activities, the bees were seen gathering in front of the nest entrance. According to Erwan *et al*. (2020), bees gather in front of the nest to warm their bodies before flying. Supratman (2018) reported that *Trigona* sp. can survive at temperatures of 22.8–32.8°C and humidity levels of 69–85%. This indicates that the bees are able to adapt to environmental conditions and that these factors do not affect their activity as long as they can tolerate the temperature range. Achyani and Wicandra (2019) stated that stingless bees are highly adaptable to environmental and temperature conditions, so these factors do not significantly affect their foraging activity.

The observation results showed that the effect of light intensity on the flight activity of *H. itama* was more significant than that of temperature and humidity. When light intensity ranged from 4 - 427 lux, *H. itama* bees had already started exiting the nest. As light intensity increased to around 500–10,000 lux, the number of *H. itama* bees entering and exiting the nest increased. These findings indicate that the flight activity of *H. itama* depends on sunlight intensity. According to Salatnaya *et al*. (2020), bees begin their activities when light intensity is still low, with peak activity occurring when light intensity is high, and activity declining as light intensity decreases. In general, the start and end of stingless bee flight activity occur at sunrise and sunset. Furthermore, Kwapong *et al*. (2010) stated that this is because bees use sunlight to navigate toward food sources.

The results of Spearman's correlation test showing the relationship between environmental conditions and the flight activity of *H. itama* are presented in Table 3. The Spearman's correlation analysis showed that the relationship between the flight activity of *H. itama* and temperature and humidity had a very weak correlation. A very weak correlation indicates that the flight activity of *H. itama* is not significantly affected by air temperature and humidity. In contrast, the relationship between flight activity and light intensity showed a positive correlation, meaning that flight activity was influenced by light intensity. Observations showed that the number of *H. itama* bees entering and exiting the nest was greater at higher light intensities. Yustia *et al*. (2017) reported that in Indonesia, air temperature generally does not limit stingless bee flight activity, whereas light intensity does.

Potential pollen source plants

A total of 37 plant species from 24 families were identified as potential pollen sources (Table 4). The families found included Fabaceae, Myrtaceae, Phyllanthaceae, Melastomataceae, and Dipterocarpaceae. Fabaceae had the highest number of species, while the largest number of individual plants belonged to Acanthaceae and Melastomataceae. The potential food sources in the area were quite diverse, consisting of forest plants, horticultural plants, and wild plants. The most abundant species were Israel grass (*Asystasia gangetica*), with 88 individuals, and *Clidemia hirta*, with 76 individuals. These two species dominated the area around the colonies, where *A. gangetica* was mostly found near box 16, and *C. hirta* near box 10.

Israel grass (*Asystasia gangetica*) is a herbaceous plant favored by bees. This corresponds with the higher pollen-carrying flight activity of *H. itama* observed at box 16 compared to the other boxes (Figure 2). Sulistiyo *et al*. (2024) stated that herbaceous plants are important for bees because they tend to have shorter growth and flowering periods than tree species, and can bloom at any time.

Other plants, such as coral vine (*Antigonon leptopus*), Xanthostemon (*Xanthostemon novoguineensis*), and Calliandra (*Calliandra calothyrsus*), were also favored by bees. However, these plants were limited in number around the colonies. These species have flower colors that attract bees, such as the red flowers of *A. leptopus*, *C. calothyrsus*, and *X. novoguineensis*. In addition to flower color, species like calliandra are valued because they can bloom throughout the year. The availability of food plants must be considered to ensure that colony needs are met at all times. Sari *et al*. (2019) reported that bee forage plants can be categorized into three groups: plants that flower year-round, seasonal plants, and plants that depend on planting periods.

Stingless bees prefer food sources located close to the colony. This aligns with the plants identified, which were located within 200 meters of the colonies. According to Benedick *et al*. (2021), *H. itama* prefers resources available within a 500-meter radius of the colony, particularly in areas with more diverse and nearby food sources. Therefore, the availability of plants around the colony is a key factor influencing the life and development of bee colonies, particularly the availability of pollen-producing plants as food sources.

CONCLUSION

Based on the results of this research, it can be concluded that the flight activity of *H. itama* varied at different observation hours between 06:00 and 18:10. The peak pollen foraging activity of *H. itama* occurred at 11:00. Light intensity had a greater influence on the flight activity of *H. itama*. The potential pollen source plants around the colonies were quite diverse, with a total of 37 species recorded. Further research is needed on the foraging behavior of *H. itama* during the rainy season to observe differences in activity patterns between the dry and rainy seasons. In addition, pollen collected directly from the pollen pots should be identified to determine the plant species preferred by *H. itama*.

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