SPECIAL ISSUE: *5th INTERNATIONAL SYMPOSIUM ON INSECTS (ISOI2023), "UNVEILING THE HIDDEN PROSPECT OF INSECTS", 11-13 SEPTEMBER 2023*

Serangga 2024, 29(2): 40-49. *Fahimee et al.*

https://doi.org/10.17576/serangga-2024-2902-04

FANNING BEHAVIOR OF STINGLESS BEE, *Heterotrigona itama* (COCKERELL, 1918) (HYMENOPTERA: APIDAE)

Fahimee Jaapar[1*], Zulidzham Mohd Sani[1] & Salmah Yaakop[2]
[1]Agrobiodiversity and Environmental Centre,
MARDI Headquarters,
43400 Serdang, Selangor, Malaysia
[2]Centre for Insect Systematics,
Department of Biological Science and Biotechnology,
Faculty of Science and Technology,
Universiti Kebangsaan Malaysia,
43600 Bangi, Selangor, Malaysia
*Corresponding author: *miesre@mardi.gov.my*

Received: 13 May 2024; Accepted: 17 June 2024

ABSTRACT

The increase of temperature shows a negative impact on the behavior of the insects live in colonies, including the stingless bees. The stingless bees employ the fanning behavior as the best method to remove excess heat within colonies. The objective of this study was to investigate the fanning behavior of the *Heterotrigona itama* (Cockerell) in relation to regulate inner temperature and relative humidity. This study was conducted from January 2023 to May 2023 using three colonies. The fanning behavior of *H. itama* has been observed from 0800H until 1700H for 5 minutes per hour per 3 days for 5 months with camera recorder. There were significant differences between time and fanning behavior ($F_{9,449}$ = 34.96, $P>0.005$) from 0800H to 1700H. In addition, the frequency of fanning behavior increased when the temperature hit on 28ºC±SD and stop when the temperature below 27ºC±SD and showed a significant difference ($F_{70,449}$ = 42.59, $P>0.005$). Furthermore, changes of humidity also stimulate the fanning behavior of *H. itama* and showed a significant different ($F_{41,449}$ = 36.83, $P>0.05$). Besides that, the fanning behavior started with aggregation of workers at the entrance and the leader site at the top of the entrance to stimulate other workers to fan the hives according to the changes of the temperature. The fanning behavior occurred during the hot season to reduce the temperature inside the colony, while stabilizing the humidity inside the colony during the raining seasons.

Keywords: Temperature, heat control, thermoregulation, relative humidity, involucrum

ABSTRAK

Peningkatan suhu memberikan kesan yang negatif kepada kelakuan serangga yang berkoloni termasuk lebah kelulut. Bagi menangani suhu yang tinggi di dalam koloni, lebah kelulut akan menjalankan aktiviti kipasan bagi mengeluarkan suhu yang panas. Objektif kajian ini adalah untuk menilai kelakuan kipasan bagi spesies *Heterotrigona itama* (Cockerell) dengan perubahan cuaca. Kajian telah dijalankan pada Januari 2023 sehingga Mei 2023 menggunakan tiga koloni. Kelakuan kipasan bagi *H. itama* telah dicerap dari jam 0800 sehingga 1700. Terdapat perbezaan yang bererti bagi masa dan kelakuan kipasan ($F_{9,449}$ = 34.96, *P>0.005*) dari jam 0800 sehingga 1700. Selain itu juga, kekerapan bagi kelakuan kipasan meningkat apabila suhu mencapai 28ºC±SD dan berhenti apabila suhu di bawah 27ºC±SD dan memberikan perbezaan yang bererti ($F_{70,449}$ = 42.59, *P>0.005*). Selain itu juga, perubahan kepada kelembapan relatif turut meransang kelakuan kipasan dan menunjukkan perbezaan yang bererti ($F_{41,449}$ = 36.83, *P>0.05*). Kelakuan kipasan ini bermula dengan terdapat sekumpulan lebah pekerja berkumpul dan kebiasaannya akan diketuai oleh seekor lebah pekerja yang berada di bahagian atas pintu masuk. Kelakuan ini akan berlaku apabila suhu dan kelembapan relatif turun atau meningkat. Secara keseluruhannya, kelakuan kipasan ini terjadi lebih kerap pada musim panas bagi menurunkan suhu di dalam koloni dan menstabilkan kelembapan relatif.

Katakunci: Suhu, kawalan kepanasan, pentermokawalaturan, kelembapan relatif, involukrum

INTRODUCTION

The rise of temperature and relative humidity affected most life on earth including insects. There are several behaviors of insects combating the temperature and relative humidity rises such as thermoregulation (Stabentheiner 2001), hive architecture such as involucrum (Gonzalez et al. 2018) and fanning behavior normally happen in *Apis mellifera* (Kaspar et al. 2018). Thermoregulation is the ability of an organism to maintain the temperature and humidity inside its nest for its existence. This is needed inside the nest due to control the birth rate and avoid premature birth. In some cases, increasing of temperature inside their nest will change their metabolism specifically on their flight muscle.

Fanning behavior in bees happens with an association of bee workers and flapping their wings with synchronize tempo for several time (Peters et al. 2019). Some cases for *A. mellifera*, fanning behavior also as a tool to protect their colony from predators (Yang et al. 2010) and dehydrate their honey (Nicolson et al. 2022). Moreover, *A. mellifera* has been identified species that can control their nest temperature when the external temperature is higher than 40°C (Heinrich 1993). In stingless bees, the fanning behavior also occurs when temperature and humidity increased or decreased. Some of the species collected special resin (Jaapar et al. 2019) to build special structures such as involucrum to control heat from damaging their colony. Species of *Heterotrigona itama* can control humidity compared to temperature in some cases (Fahimee et al. 2021). Furthermore, their abundance in Malaysia, inhabiting from 20 feet from sea level to 4000 feet above sea level (Jaapar et al. 2016) can be a hypothesis this species has the ability to adapt with the surrounding environment.

In stingless bees, decreasing of temperature and relative humidity will affect the brood production and disturb the colony sustainability (Vollet-Neto et al. 2011). However, increasing relative humidity will spark the fungus to distribute inside the colony and will harm the colony itself (Oldroyd & Aanen 2015). Thus, regulating the inside temperature and relative humidity is crucial for maintaining the livelong of colony. Therefore, the main objective of this research was to study the fanning behavior of *H. itama* on regulating of temperature and relative humidity inside the colony.

MATERIALS AND METHODS

Colonies and Site Description

Three colonies of a *H. itama* with similar aged (1-year-old) were set up in Malaysia Agriculture Research and Development Institute (MARDI) Serdang Meliponiculture Farm (2.9818804, 101.69203,16.5) The farm has been placed adjacent to herbal garden and the surrounding area has been planted with agriculture tree such as rambutan (*Nephellium lappaceum*), papaya (*Carica papaya*), mangosteen (*Garcinia mangostana*) and star fruit (*Averrhoa carambola*).

Behavior Observation

The behavior of each colonies was observed and recorded according to (Jaapar et al. 2018). The movement of the individual has been observed and recorded for 5 min per hour between 0800H to 1700H for 3 days per 5 months (January 2023 to May 2023). To assess the fanning behavior, method by Kaspar et al. (2018) with modification has been established for *Heterotrigona itama* in natural environment. A digital single-lens reflex (DSLR) camera (NIKON D810) with a macro lens (100mm) attached has been placed in front of the colony entrance to record the movement and the fanning behavior of stingless bees. In addition, this type of DSLR can record the fanning sound inside the colony. To assess the relative humidity and temperature in relation to fanning behavior, button data loggers (WatchDog B100 2K) were installed behind the colonies.

Data Analysis

The video was brought back to the laboratory and played back to record and measure the behavior. The behavior recorded was a number of fanning incidents (second) per 5 minutes. Temperature and relative humidity data have been extracted from the data logger using SpecWare 9 software. Data of fanning behavior for every month and One-way ANOVA between times of fanning versus temperature and humidity were analyzed using Minitab 17 software.

RESULTS

A total of 2250 minutes has been recorded from January 2023 to May 2023. Within this period, 7069 fanning incidents (second) has been recorded and May 2023 has been found the highest fanning incident followed by April, March, January, and February (Figure 1). Meanwhile, the fanning incident also showed significant differences ($F_{4,449}$, df = 8.14, $P>0.05$) between the months from January to May (Figure 2). This incidence was followed by the mean temperature of January 2023 to May 2023 which was high in May (±30.4ºC) (Figure 3). The fanning behavior started from 1000 H and reached a higher level at 1200 H before decreasing until 1700 H and showed a significant difference in the mean numbers of fanning behavior ($F_{9,449}$, df = 34.96, $P>0.05$) from 0800 H to 1700 H (Figure 4).

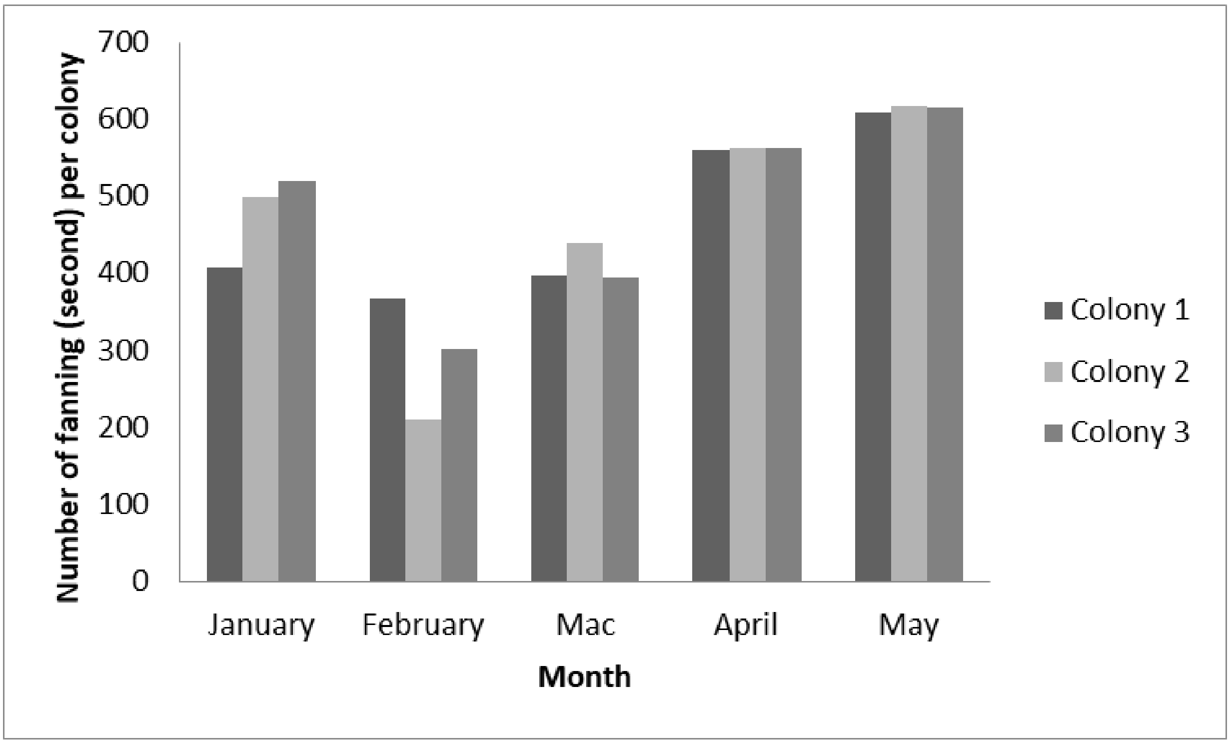

Figure 1 Number of fanning (second) incidents per colony from January 2023 to May 2023

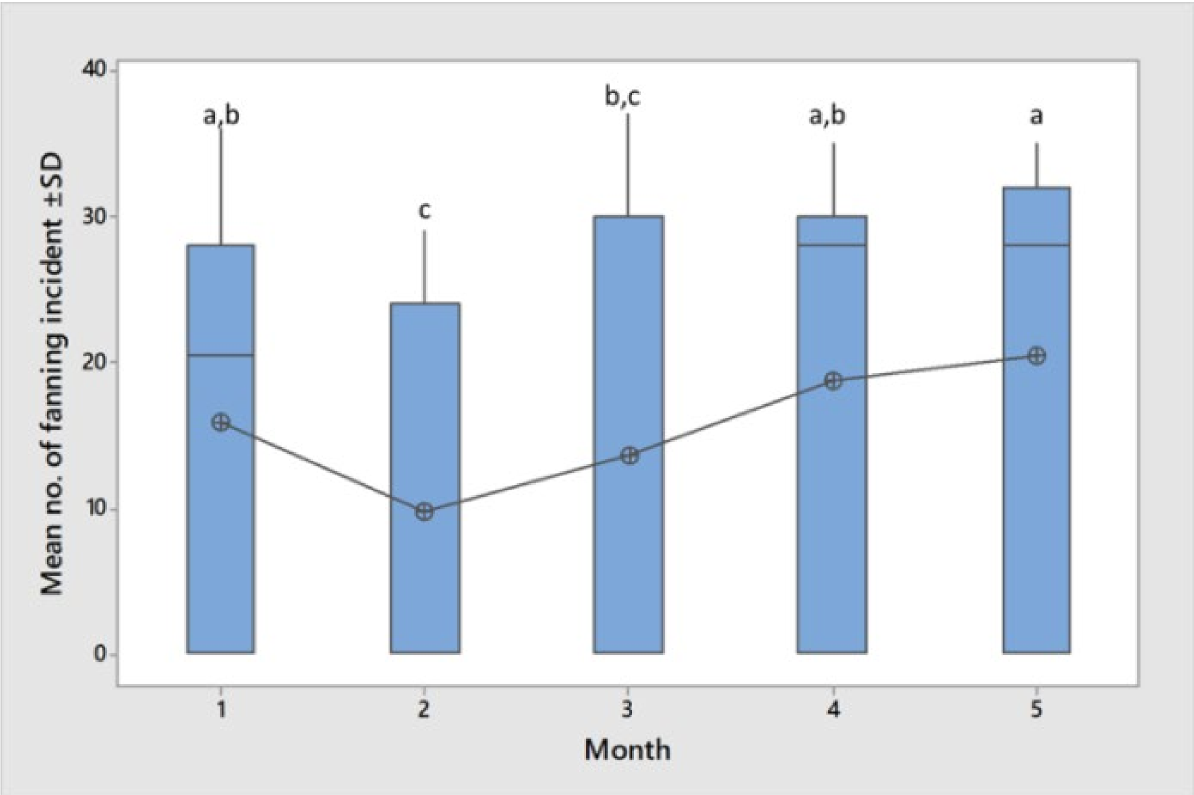

Figure 2. Mean number of fanning incident from January 2023 to May 2023. Letters (a) and (b) indicate whether there are significant differences between month and fanning behavior (Tukey's Test)

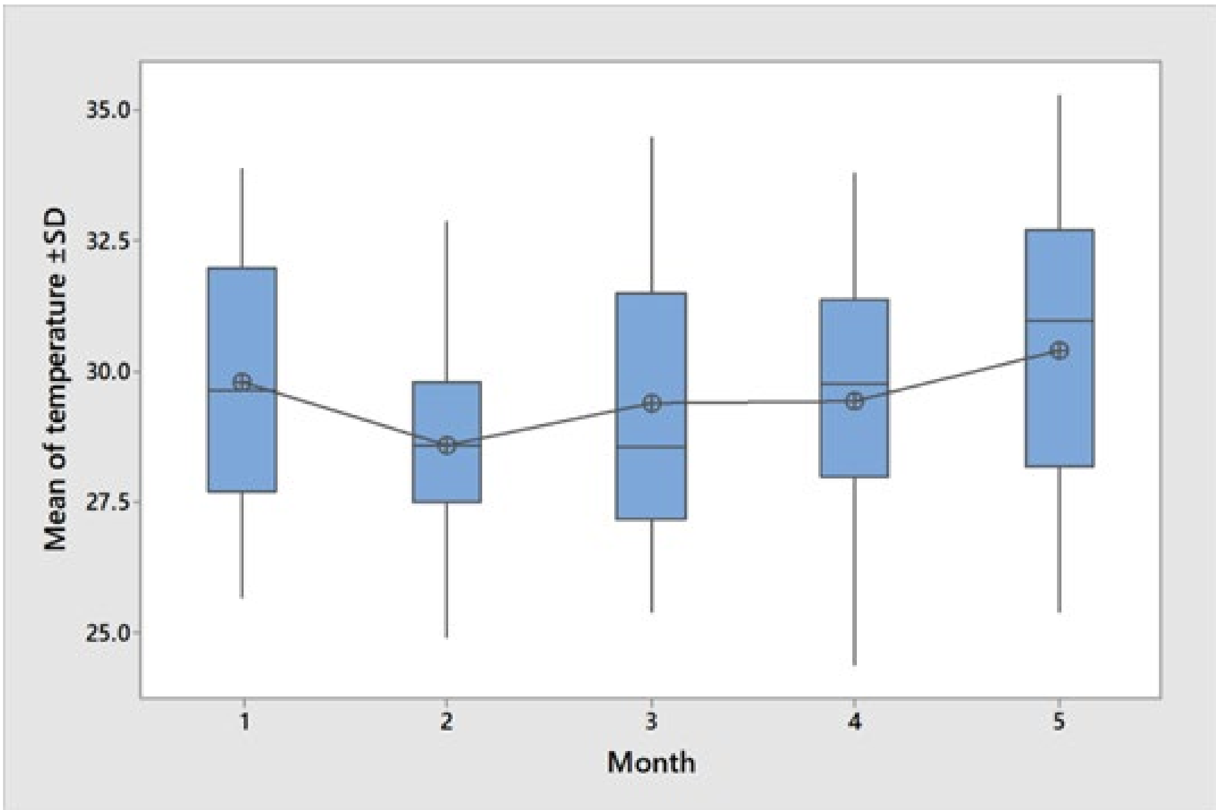

Figure 3 Mean of temperature from January 2023 to May 2023

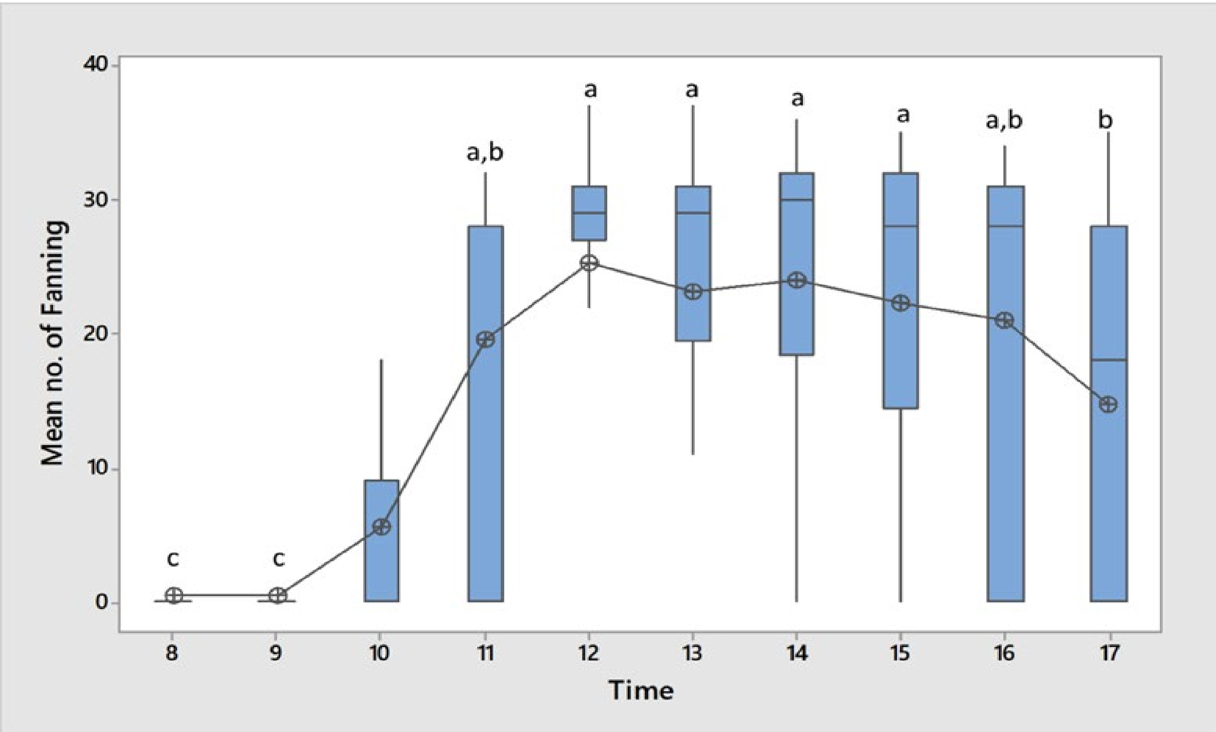

Figure 4. Mean number of fanning behavior from 0800 to 1700. Letters (a) and (b) indicate whether there are significant differences between time and fanning behavior (Tukey's Test)

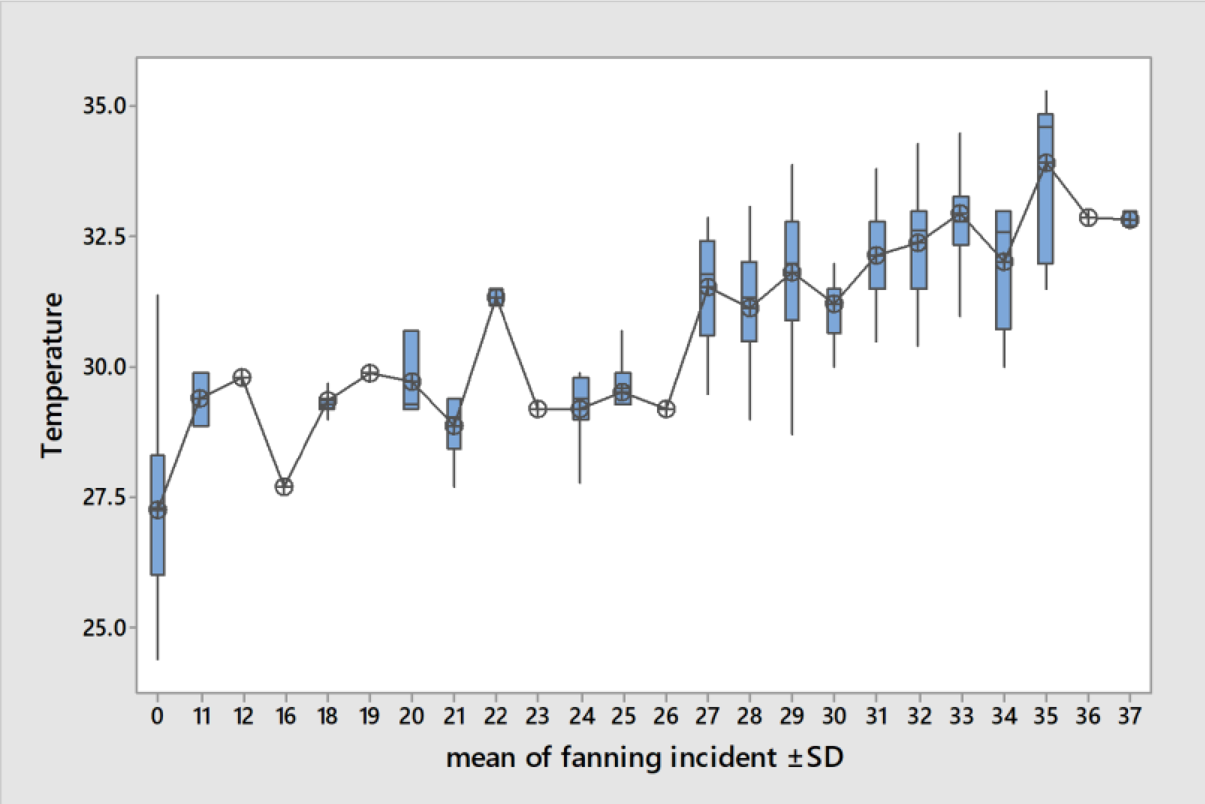

Figure 5 Mean number of fanning behavior in relation to temperature from 0800H to 1700H

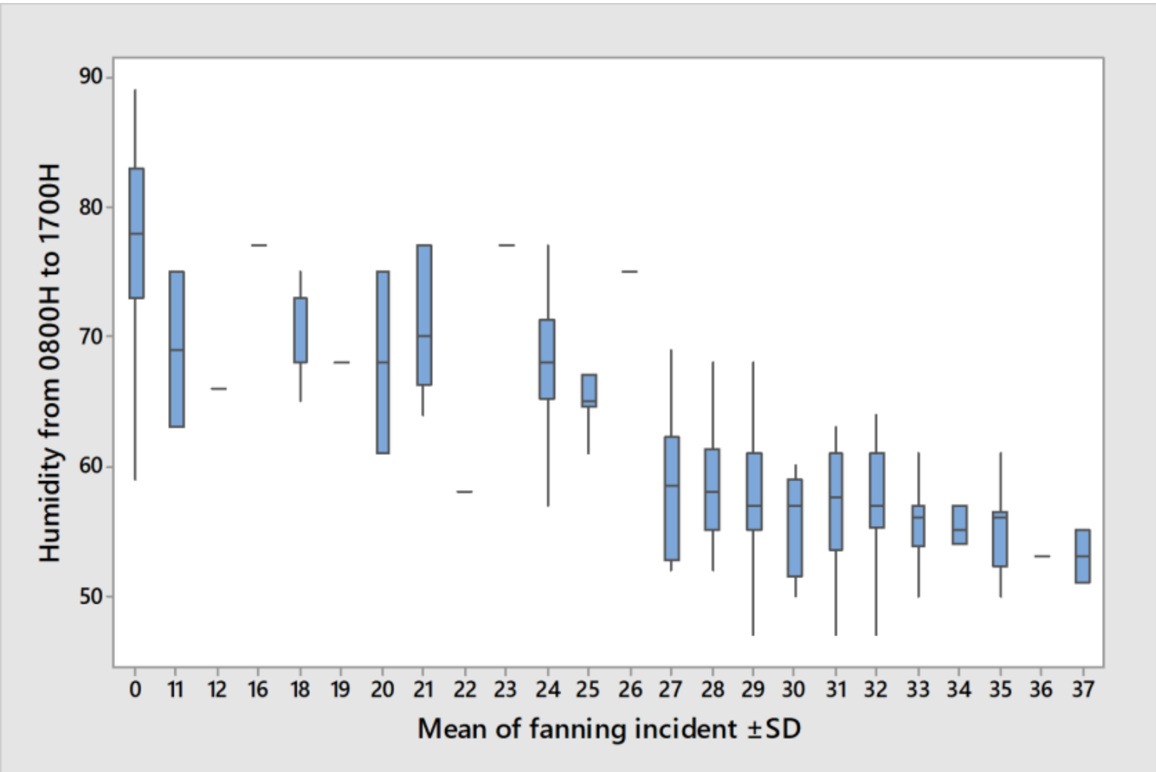

Figure 6. Mean number of fanning behavior in relation to relative humidity

The number of fanning incidents was between 11 incidents (second) to 37 incidents (second) per 5 minutes. One incident of fanning was between one second to three seconds. Meanwhile, the frequency of fanning behavior increased when the outside temperature hit 30ºC and showed significant differences ($F_{70,449}$, $P>0.005$) between rise of temperature and fanning incident (Figure 5). Meanwhile, the humidity also reflected the fanning behavior with increased when the relative humidity was below 50% and showed a significant difference ($F_{41,449}$, df :36.83, $P>0.005$) from 0800H to 1700H. From the observation, the fanning behavior started with aggregation of workers at the entrance and the leader site at the top of the entrance to stimulate other workers to fan the hives according to the changes of the temperature and relative humidity.

DISCUSSION

Changes in microclimate such as a rise in temperature will affect brood production in the colony (Vollet-Neto et al. 2011). Moreover, the prolonged hot temperature will cause premature birth and decrease the size of individuals inside the colony (Pereboom & Biesmeijer 2003). Then, there are needed to stingless bees control their colony temperature to avoid colony absconding or death. In the world of bees, workers normally collect water from dew or water drops and then cover the combs or colony with their proboscis to avoid overheating in the nest (Schmaranzer 2000). Meanwhile, increasing relative humidity has a relationship with fungal growth (Paludo et al. 2018). Even though the high humidity will increase the microbial interaction in the colony, sometimes the mass growth of fungal has a bad effect on colony development (De Paula et al. 2021).

Based on our result in Figure 2, there are more incidents of fanning from Mac to May 2023. This result has a similar trend to the weather pattern in Malaysia which is warmer from April to June every year (Tangang et al. 2007) and supported by our result in Figure 3. Thus, the number of fanning incidents was increasing influenced by an increase in temperature. As a small organism, their mechanism to tolerate changes of the environment is great such as a decrease in temperature will affect their foraging and movement (Campos et al. 2010). However, in stingless bees, the cavity or involucrum structure has the ability to control the temperature to heat the brood chamber to sustain the production of workers (Halcroft et al. 2013). From the observation, the fanning behavior occurred with echo sounds and prolonged between 1s to 3s.

Figure 4 shows that there is no fanning incident in the early morning. Fanning incidents started at 1000H until 1700H, and the highest number of fanning incidents was at 1200H. This result was stimulated by the high mean temperature at 1200H in Malaysia (Suparta & Yatim 2019). Whereby, increasing temperature will increase fanning behavior such as in Figure 5 vice versa with relative humidity in Figure 6. There is evidence that relative humidity was the critical factor in stingless bee's colony to sustain (Menezes et al. 2013). Furthermore, increasing of temperature also will affect brood production in the colony (Vollet-Neto et al. 2011). In Malaysia, during the rainy seasons, the foraging behavior is slightly low and the brood production is increased (Jaapar et al. 2018).

CONCLUSION

The finding of fanning behavior in *H. itama* can be a reason why this species is abundance and ubiquitous in Malaysia. Their adaptation to changes in relative humidity and temperature makes their existence prolonged and can be domesticated as a pollinator in all weather conditions. Thus, this species can be a candidate as a pollinator under greenhouse with their specialty to mitigate the climate.

ACKNOWLEDGEMENT

The authors would like to thank the farmers of meliponiculture for supporting this research.

AUTHOR DECLARATIONS

Funding Statement
The authors acknowledged the financial support from the MARDI RMK 12 project with grant number PRS505.

Conflict of Interest
The authors declare that they have no conflict of interest.

Ethics Declarations
No ethical issues are required for this research.

Data Availability Statement
This manuscript has no associated data.

Author's Contributions
FJ was the researcher, collected, analysed the data, and wrote the first draft of the manuscript. ZMS collected the data and SY revised and wrote the manuscript.

REFERENCES

Campos F., Gois, G. & Carneiro, G. 2010. Colonial thermoregulation in stingless bees (Hymenoptera, Apidae, Meliponini). *Pubvet* 4(24): 1-8.

De Paula, G.T., Menezes, C., Pupo, M.T. & Rosa, C.A. 2021. Stingless bees and microbial interactions. *CurrentOpinion in InsectSscience* 44: 41-47.

Fahimee, J., Reward, N.F., Sani, Z.M., Nizar, M. & Salmah, Y. 2021. Pentermokalaturan: Penyesuaian lebah kelulut bagi menangani kesan perubahan cuaca. *Buletin Teknologi MARDI* 26(2021): 119-126.

Gonzalez, V.H., Amith, J.D. & Stein, T.J. 2018. Nesting ecology and the cultural importance of stingless bees to speakers of Yoloxóchitl Mixtec, an endangered language in Guerrero, Mexico. *Apidologie* 49: 625-636.

Halcroft, M.T., Haigh, A.M., Holmes, S.P. & Spooner-Hart, R.N. 2013. The thermal environment of nests of the Australian stingless bee, *Austroplebeia australis*. *Insectes Sociaux* 60: 497-506.

Heinrich, B. 1993. *Hot-Headed Honeybees. Strategies and Mechanisms of Thermoregulation*. Heidelberg: Springer Berlin.

Jaapar, M.F., Halim, M., Mispan, M.R., Jajuli, R., Saranum, M.M., Zainuddin, M.Y., Ghazi, R. & Abd-Ghani, I. 2016. The diversity and abundance of stingless bee (Hymenoptera: Meliponini) in Peninsular Malaysia. *Advances in Environmental Biology* 10: 1-8.

Jaapar, M.F., Jajuli, R., Mispan, M.R. & Ghani, I.A. 2018. Foraging behavior of stingless bee *Heterotrigona itama* (Cockerell, 1918) (Hymenoptera: Apidae: Meliponini). *AIP Conference proceedings* 1940: 020037.

Jaapar, M.F., Nasarodin, N.S., Reward, N.F., Jajuli, R. & Abd-Ghani, I. 2019. Notes on resin collected by stingless bees in Taman Tropika Kenyir, Terengganu, Malaysia. *Serangga* 24(2): 81-89.

Kaspar, R.E., Cook, C.N. & Breed, M.D. 2018. Experienced individuals influence the thermoregulatory fanning behaviour in honey bee colonies. *Animal Behaviour* 142: 69-76.

Menezes, C., Vollet-Neto, A. & Fonseca, V.L.I. 2013. An advance in the in vitro rearing of stingless bee queens. *Apidologie* 44: 491-500.

Nicolson, S.W., Human, H. & Pirk, C.W. 2022.Honey bees save energy in honey processing by dehydrating nectar before returning to the nest. *Scientific Reports* 12: 16224.

Oldroyd, B.P. & Aanen, D.K. 2015. Entomology: A bee farming a fungus. *Current Biology* 25: R1072-R1074.

Paludo, C.R., Menezes, C., Silva-Junior, E.A., Vollet-Neto, A., Andrade-Dominguez, A., Pishchany, G., Khadempour, L., Do-Nascimento, F.S., Currie, C.R., Kolter, R., Clardy, J. & Pupo, M.T. 2018. Stingless bee larvae require fungal steroid to pupate. *Scientific Reports* 8: 1122.

Pereboom, J. & Biesmeijer, J. 2003. Thermal constraints for stingless bee foragers: The importance of body size and coloration. *Oecologia* 137: 42-50.

Peters, J.M., Peleg, O. & Mahadevan, L. 2019. Collective ventilation in honeybee nests. *Journal of The Royal Society Interface* 16: 20180561.

Schmaranzer, S. 2000. Thermoregulation of water collecting honey bees (*Apis mellifera*). *Journal of Insect Physiology* 46: 1187-1194.

Stabentheiner, A. 2001. Thermoregulation of dancing bees: thoracic temperature of pollen and nectar foragers in relation to profitability of foraging and colony need. *Journal of Insect Physiology 4*7: 385-392.

Suparta, W. & Yatim, A.N.M. 2019. Characterization of heat waves: A case study for Peninsular Malaysia. *Geographia Technica* 14(1): 146-155.

Tangang, F.T., Juneng, L. & Ahmad, S. 2007. Trend and interannual variability of temperature in Malaysia: 1961–2002. *Theoretical and Applied Climatology* 89: 127-141.

Vollet-Neto, A., Menezes, C. & Imperatriz-Fonseca, V.L. 2011. Brood production increases when artificial heating is provided to colonies of stingless bees. *Journal of Apicultural Research* 50: 242-247.

Yang, M., Radloff, S., Tan, K. & Hepburn, R. 2010. Anti-predator fan-blowing in guard bees, *Apis mellifera capensis* Esch. *Journal of insect behavior* 23: 12-18.