Design of system for setting the temperature and monitoring bees in and out the hive

Supandi¹, F Arkan¹*, R F Gusa¹,², M Jumnahdi¹, R Kurniawan¹
¹Department of Electrical Engineering, Faculty of Engineering, Universitas Bangka Belitung, Indonesia
²Research Center for Energy and Information Technology, Universitas Bangka Belitung, Indonesia

*E-mail: fardhanarkan1909@gmail.com

Abstract. Trigona bee is one genus of bee without the sting producing honey and propolis. Activities in and out of the nest are activities to protect the nest from enemy attacks, remove dirt from the nest and most importantly forage. Foraging activities will affect the weight of the bee colony and its products, namely honey, bee pollen, and propolis. Temperature and humidity around the hive are important factors for trigona bees to move. This study aims to monitor temperature, humidity, light intensity, the volume of propolis, and the activity of bees in and out of the hive via a smartphone, to determine the effect of temperature, humidity, and light intensity on the activity of bees in and out of the hive. The average yield of bee activity in and out of the hive by controlling the temperature of the activity of bees in and out of the hive was 155 bees, a temperature of 29.64°C, and humidity of 89.15%. Nest temperature regulation has a significant effect on the activity of bees in and out of the hive. The activity of bees in and out of the hive is high in the morning around 07:00-10:00 at lower temperatures and higher humidity than the time of day or evening. The light intensity around the hive did not significantly affect the activity of bees in and out of the hive.

1. Introduction
Trigona bee is one genus of bee without the sting producing honey and propolis. In Indonesia, the term trigona is quite diverse, among others beeswax, lanceng, or klanceng (in Javanese); teweul (Sundanese); gala-gala or galo-galo (West Sumatra); and ketape or kammu (South Sulawesi). To distinguish it from honey produced from sting bees, Apis for example, honey without the sting of Indonesia is often dubbed honey lanceng [1].

Trigona bees nest in tree cavities, crevices in logs and cracks in building stones [2]. Trigona generally build their nests at an altitude of 2-4 meters above the ground. The entrance and exit of the nest is a tube made of blackish resin. The internal structure of kelulut nests consists of daughter cells, honey cells, and pollen cells[3].

Activities in and out of the nest are activities to protect the nest from enemy attacks, remove dirt from the nest and most importantly forage. Foraging activities will affect the weight of the bee colony and its products, namely honey, bee pollen and propolis. Understanding the activity of bees is needed because it is related to productivity so that it is very good to be used in bee farming [4]. The flight activity of bees is influenced by colony and environmental conditions [5]. Temperature and humidity around the hive are important factors for trigona bees to do activities [6]. The temperature that is too low can cause colony death, while the temperature that is too high makes the worker bees only focus on looking for water instead of producing propolis [7]. At extreme temperatures above 35°C it can...
encourage trigona bees to migrate hives [8]. Therefore modification of the nest is needed so that the high temperature does not exceed 33°C and does not reduce the quality of propolis[9].

The instrumentation system in the honeycomb is in the form of monitoring and temperature regulation to ensure the health condition of the colony to maintain temperature stability in the hive and the use of the TCRT5000 sensor to detect the activity of trigona bees in and out of the hive while the infrared sensor is to detect the condition of the propolis box in the hive. The use of the DHT22 sensor, TCRT5000 sensor, Infrared sensor, and LDR sensor installed in a nest makes the nest conditions can be known simultaneously via a smartphone. Smartphones play a role in displaying sensor readings, namely temperature, humidity, bees in and out of the hive, and the condition of the propolis box.

2. Methods

The design of the hive is made in the shape of a box, there is a cover for the hive, a propolis box, a main box, and a bee in and out hole. The overall process of the electronic circuit starts from the DHT22 sensor, TCRT5000 sensor, LDR sensor, and Infrared sensor. The temperature setting works if the temperature is below 28°C, the lights and fans are ON, if the temperature range is above 28°C and below 35°C, the lights and fans are OFF, if the temperature is above 35°C the lights are OFF and the fan is ON. The sensor sends analog and digital signals to Arduino, Arduino acts as a microcontroller that sends sensor data to NodeMCU, NodeMCU is connected to WiFi and then NodeMCU sends data to the Blynk server. Sensor readings are displayed on the smartphone.

Figure 1. Nest Design

Figure 2. System Design Diagram
3. Results and Discussions

3.1. Display Application Blynk

![Figure 3. Display of Blynk Application on Smartphones](image)

In Figure 3, there is an application display where there is a notification widget that functions to notify you that the lights are working (ON), the lights don't work (OFF) and the fans are working (ON). There are also 4 Led widgets, namely the condition of the propolis box ¼, the condition of the propolis box ½, the condition of the propolis box ¾, and the condition of the propolis box full which functions to indicate that the condition of the propolis box starts to fill if the led widget does not turn on indicating that the propolis volume is still empty. The LCD widget displays a reading of light intensity and the number of bees entering and leaving the hive. There are also 2 gauge widgets that display the DHT22 sensor readings, namely temperature, and humidity.

3.2. Comparison With Temperature Settings and Without Temperature Settings.
The following is a graph of the results of hourly monitoring of hive temperature and humidity carried out in beehives with temperature regulation and without temperature regulation in May and June 2020:

![Figure 4. Comparison Results of Temperature with Temperature Settings and without Temperature Settings](image)
Comparison of the results without temperature regulation and with temperature regulation, namely when the temperature is low in the rainy season. In nests with temperature regulation, the temperature will be more stable than nests without temperature regulation in the rainy season. The average results are from May and June 2020 with a temperature setting of 29.64°C and a humidity of 89.15%, while without regulation, namely a temperature of 28.59°C and a humidity of 84.67%. Species from Meliponini did not leave the nest before the temperature reached 19°C, but Melipona scutellaris exited the nest at 24°C and Frieseomelitta doederleini left the nest at 27°C[10].

Based on Figure 6. The average results of bee activity in and out of the hive from May and June 2020 with temperature regulation of the activity of bees in and out of the hive were 155 bees with a temperature of 29.64°C, humidity 89.15%, and light intensity of 779.90 lux. Meanwhile, without temperature regulation, the activity of bees in and out of the hive was 175 bees with a temperature of 28.59°C, humidity 84.67%, and light intensity of 745.55 lux. From the results, the average activity of bees in and out of the hive without temperature regulation, the activity of bees is more than the
temperature regulation of the hive, but with a different average temperature, humidity, and light intensity. The higher the temperature, the activity of the bees will decrease. The highest activity occurs at temperatures reaching 26-28 °C, humidity 55-71%, and light intensity 46,875-91,347 lux [3-8]. Bees are very active in the morning, bees start pollen-collecting activities in the morning when humidity is very high and temperature and light intensity are still moderate [10]. Bees in hot areas will forage in the morning and stop when the sun gets hot and continue before sunset [11].

3.3. Trigona Itama Beehive Volume and Propolis Volume

![Figure 7](image)

**Figure 7.** (a) Trigona Itama's Beehive Volume; (b) Volume of Trigona Itama Bee Propolis

The advantage of moving the colony from natural to artificial hives is that the larger the volume of the hive, the greater the total number of bee sapling cells, honey production, and bee bread [12]. The larger hive volume indicates that the trigona bee colony will utilize space effectively, so that it can be used to place or store more honey pots, bee bread pots and tiller cells, as food reserves [13]. The significant difference in the mean weight of honey in each treatment is thought to be related to the number of populations in the hive [12]. Productive queen bees and the optimal number of worker bees can support the maximum production of tillers and honey [14]. While the drawback is that according to bee farmers, the production of propolis and honey takes a longer time to harvest than using the topping method.

4. Conclusions
Nest temperature regulation has a significant effect on the activity of bees in and out of the hive. Then, Bee activity in and out of hives is high in the morning around 07:00-10:00 at lower temperatures and higher humidity than during the afternoon. In addition, the light intensity around the hive did not significantly affect the activity of bees in and out of the hive.

References
[1] Nascimento DL do and Nascimento FS 2012 Extreme effect of season on the foraging activities and colony productivity of a stingless bee (Melipona asilvai Moure, 1971) in Northeast Brazil H Pub Corp Psyche. Research Article pp 1-6
[2] Hilario SD Imperatriz-Fonseca VL, and Kleinert A de MP 2001 Responses to climatic factors by foragers of Plebeia pugnax Moure (In Litt.) (Apidae, Meliponinae) Rev Bras Biol 61 pp 191-196
[3] Salatnaya H 2012 Productivity of Trigona spp. as a Propolis Producer at Monoculture and Policulture Nutmeg Plantation in East Java, (Bogor: IPB).
[4] Megan H, Robert S, and Anne, D 2013 Pot - Honey A Legacy of Stingless Bees (New York, Heidelberg, Dordrecht. London: Springer) pp 35–72
[5] Fadhila and Rizkika 2015 Potential Business Profit of Bees Without Sting (Depok: PT Trubus Swadaya)
[6] Basrawi A 2017 Preliminary Study on the Thermal Performance of a Ventilated Honey Cassette for Stingless Bees Laboratorium Teknik Meliponini, Fakults Teknik Mesin, Universitas Malaysia Pahang. MATEC Web of Conferences 131 04001
[7] Putra 2014 Structure and Production of Trigona bees spp. In Tubular and Ball-Shaped Nest Biology Department, Faculty of Mathematics and Natural Sciences Udayana University 18 pp 60-64
[8] Hakim 2018 *Production of Propolis from Tetragonula laeviceps Bees Using MOTIVE Nests Equipped with Instrumentation Systems* School of Life Sciences and Technology Bandung Institute of Technology 10 2

[9] Robani 2019 *Flying Activities and Development of the Weight of the Kelulut Bees Colony (Tetragonula laeviceps) on Bogor Darmaga Campus of IPB Silviculture Department Faculty of Forestry Bogor Agricultural Institute*

[10] Hilario SD, Imperatriz-Fonseca VL, and Kleinert A de MP 2001 Responses to climatic factors by foragers of *Plebeia pugnax* Moure (In Litt.) (Apidae, Meliponinae). Rev Bras Biol 61 pp 191-196

[11] Saufi N and Thevan K 2015 Characterization of Nest Structure and Foraging Activity of Stingless Bee, *Geniotrigona thoracica* (Hymenoptera: Apidae, Meliponini). Jurnal Teknologi (Science & Engineering) 77 pp 69-74

[12] Ramadhan E 2016 *Modified Ventilation on Hive Cover of Honey Bee toward Production of Propolis* Department of Animal Production Science and Technology, Faculty of Animal Husbandry, Bogor Agricultural Institute 4 1

[13] Junus M 2011 Effect of age of the queen bee, number of combs incubation, and queen divider against weight gain member of the bee colony A. mellifera Journal of Sciences Animal Husbandry 21 pp 1-10

[14] Gouw M S and Gimenes M 2013 Differences of the daily fight rhythm in two neotropical stingless bees (Hymenoptera: Apidae). Sociobiology 60 pp 183-189

**Acknowledgement**

We gratefully acknowledge the funding from Universitas Bangka Belitung through the RKAKL FT for the publication of this paper.