

Influence of the thermal environment on the stingless bee foraging activity: a mini-review

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Abstract In tropical environments, stingless bees are an important group of pollinators, helping to maintain plant biodiversity and, consequently, to preserve ecosystems. The foraging activity of these insects is influenced by biotic and abiotic factors. Although air temperature limits activities outside the hive, the natural thermal environment is complex; meteorological variables interact with each other, requiring elaborate thermoregulatory responses from bees. The complexity of the thermal environment has been the subject of recent research on insect thermoregulation. The effects of wind and especially solar radiation should be considered when studying the behavior of stingless bees. In this context, this mini-review aimed to address the main components of the thermal environment that influence the foraging activity of stingless bees.

Keywords: air temperature, daily rhythm, seasonality, solar radiation, thermal challenge, thermoregulation

Introduction

Pollinators, essential to the balance of ecosystems, have been undergoing a global decline, accompanied by the decline of plant species with which they maintain a relationship of dependence (Potts et al 2010). In Brazil, there is hard evidence that habitat loss, invasion of exotic species and climate change have been reducing native bee populations (Giannini et al 2012). These social insects are widely distributed in tropical regions (Cortopassi-Laurino et al 2006), acting as pollinating agents and assisting in the maintenance of plant biodiversity of ecosystems (Slaa et al 2006). In addition, they are effective pollinators of numerous agricultural crops (Giannini et al 2015).

Climate changes that have been occurring in the last decades and those projected for the next decades have provided extreme conditions for animal survival (Abecia et al

2017; Rashamol et al 2018), negatively affecting their performance and health.

In social bees, the foraging activity rhythm occurs according to weather conditions, especially temperature (Roubik 1989; Oliveira et al 2012; Jaapar et al 2018). However, although the air temperature is the main meteorological variable influencing the behavior and thermal status of foraging bees, studies have shown the importance of other abiotic factors in insect thermal dynamics, especially solar radiation (Figure 1; Kovac et al 2010; Stabentheiner et al 2012).

Based on this thermally challenging scenario that stingless bees face in a highly variable environment, this mini-review aimed to address the main components of the thermal environment that influence the foraging activity of stingless bees.

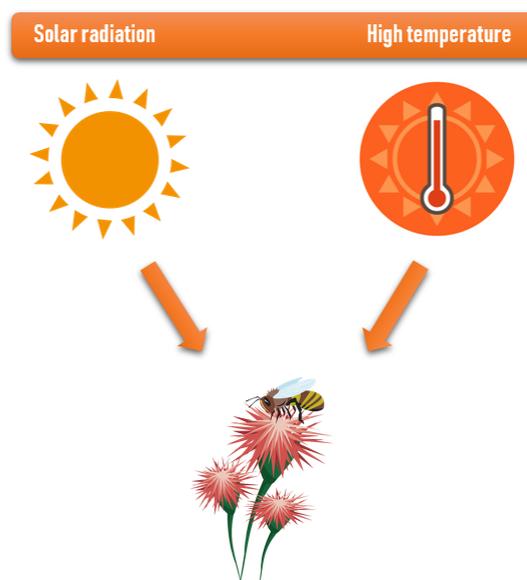


Figure 1 Main components of the thermal environment that cause changes in the stingless bees foraging.

Temperature

Although their body temperature is influenced by the thermal environment inside and outside the hive, social bees are not thermoconformists. One of the behavioral adaptations of *Melipona subnitida*, for example, main native species of the Brazilian semi-arid, is the concentration of collecting activities in the temperature range between 22 and 34 °C (Maia-Silva et al 2015). Environmental temperatures above 34 °C are tolerated when these stingless bees have water to perform evaporative cooling (Ferreira and Hrnčir 2012), keeping their body temperature below the lethal temperature (48,0 °C), even when exposed to effective temperatures up to 50 °C during foraging (Hrnčir et al 2015).

The air temperature varies throughout the day and according to the season. Layek and Karmakar (2018) and Macías-Macías et al (2017) found significant effects of time of day, weather variables and seasonality on the foraging activity of stingless bees *Trigona iridipennis* in India and *Melipona colimana* in Mexico, respectively. In this study by Layek and Karmakar (2018), maximum values of foraging bees were observed between 9:00-11:00 and 15:00-16:00, with maximum activity in spring, attributing these differences to ambient temperature variations and to the availability of floral resources, which are dependent on the time of day and season. Basari et al (2018) and Jaapar et al (2018) showed that foraging activity of stingless bee *Heterotrigona itama* decreases when the air temperature rises near noon.

Additionally, recent studies have also shown that stingless bees can have one or more times when foraging reaches its peak (Barbosa et al 2016; Layek and Karmakar 2017; Basari et al 2018).

At very low temperatures, foraging of *Melipona subnitida* does not occur, even when profitable pollen sources are available (Maia-Silva et al 2014). Pollen collection time for this same bee species is influenced by high temperatures associated with natural resource availability (Maia-Silva et al 2015).

Solar radiation

Another abiotic factor determining the success of foraging activity is global solar radiation because, in an environment of the high solar radiation incidence, such as the Caatinga biome, for example, this environmental factor cannot be neglected. Studies conducted in the semi-arid region of northeastern Brazil found results for global solar radiation levels above 1000 W/m² from 10:00 to 14:00 (Da Silva et al 2010). Oliveira et al (2014) found values between 100 and 800 W/m² at times where bee foraging activity still occurs at a higher intensity (5:30 to 9:00).

Souza-Junior (2019) found similar relationships between the number of foraging bees, environmental temperature and solar radiation (Figure 2), where there was a decrease in the foraging activity when the temperature was above 30.0 °C and when solar radiation exceeds 800 W/m².

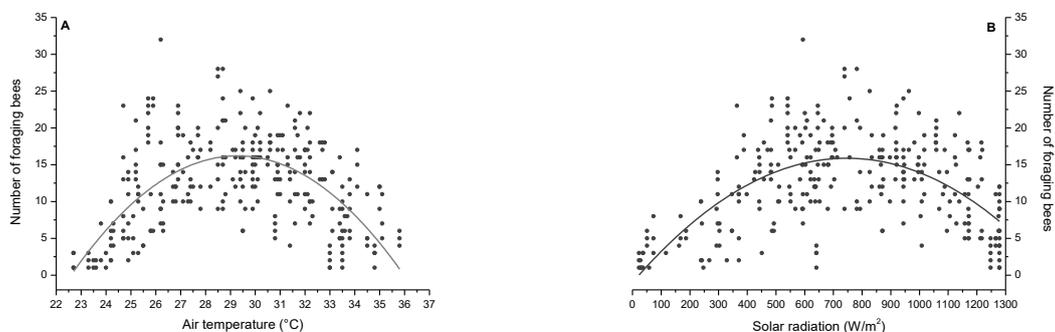


Figure 2 The relationship between the number of *Melipona subnitida* foraging in an artificial feeder according to the air temperature (A) and solar radiation (B). Source: Souza-Junior (2019)

The distance between the beehive and food source

Another factor that directly influences the foraging activity of stingless bees is the distance between the hive and the food source (Basari et al 2018). Foraging preference is given to the floral resources closest to the hive. At greater distances, forage bee recruitment only occurs if the resource is highly profitable for the colony (Nieh and Sánchez 2005). However, when food resources are away from the hives, foraging activity will be expensive for bees (Couvillon et al 2015), as the benefit generated by heat gain through solar

radiation to save endothermic heat (Stabentheiner and Kovac 2014) can be replaced by the problem of body overheating (Willmer and Stone 2004).

Final Considerations

Stingless bees establish complex relationships with their thermal environment. Such complexity goes far beyond the air temperature effects. Often neglected, solar radiation affects the body temperature of bees and their foraging activity in tropical environments.

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