Temporal and climatological influences on flight activity in the stingless bee *Trigona hyalinata* (Apidae, Meliponini)

Influências temporais e climatológicas na atividade de vôo de abelhas-sem-ferrão Trigona hyalinata *(Apidae, Meliponini)*

Felipe A. León Contrera[*]
Vera Lúcia Imperatriz-Fonseca[*]
James C. Nieh[**]

Abstract

Temporal fluctuations in climate play an important role in bee foraging and pollination. Documenting these influences therefore provides useful baseline information for the effects of climate change on Neotropical pollinators. In this study we analyzed the influence of time of the day, temperature, relative humidity and barometric pressure on flight activity of a stingless bee species not previously studied, *Trigona hyalinata*. In this species, flight activity was negatively correlated with time of day and temperature and positively correlated with relative humidity and barometric pressure. The significance of these results and the potential importance of biotic and abiotic variables are discussed.

Keywords: flight activity, stingless bees, climate, temporal patterns, *Trigona*.

[*] Laboratório de Abelhas, Departamento de Ecologia, Instituto de Biociências, Universidade de São Paulo. Rua do Matão, Travessa 14, n. 321, CEP 05508-900. São Paulo - SP, Brasil. E-mail: falc@ib.usp.br.
[**] Division of Biological Sciences, Section of Ecology, Behavior, and Evolution, University of California San Diego. Mail Code 0116, La Jolla CA 92093-0116, USA.

Resumo

As flutuações climáticas têm um papel importante no forrageio de abelhas e na polinização. A documentação dessas influências fornece informações básicas úteis sobre o efeito das mudanças climáticas nos polinizadores Neotropicais. Neste estudo analisamos a influência da hora do dia, temperatura, umidade relativa e pressão barométrica na atividade de vôo de uma abelha-sem-ferrão que ainda não havia sido estudada, a *Trigona hyalinata*. Nessa espécie, a atividade de vôo foi correlacionada negativamente com a hora do dia e a temperatura e, positivamente com a umidade relativa e a pressão barométrica. A significância desses resultados e a importância potencial das variáveis bióticas e abióticas são discutidas.

Palavras-chave: atividade de vôo, abelhas-sem-ferrão, clima, padrões temporais, *Trigona*

Introduction

In social insects, foraging activity and thus pollination are influenced by climatic conditions (KLEINERT-GIOVANNINI; IMPERATRIZ-FONSECA, 1986; ROUBIK, 1989). In light of climate changes such as global warming (WHITTAKER, 2001), it has become increasingly important to obtain baseline data on the relationship between climate and the foraging activity of keystone species such as stingless bees, one of the most important native Neotropical pollinators (HEARD, 1999). Flight activity is well correlated with foraging activity and has been generally used to measure foraging activity by several investigators, thereby providing a useful metric for comparisons (ROUBIK, 1989).

In social insects, flight activity is influenced by several factors, particularly meteorological conditions. The influence of weather on the flight activity of Meliponini bees (MICHENER, 2000) has been studied, and seasonal variations have been found in flight activity as well as correlations have been found between flight activity and weather variables, especially temperature and luminosity (KLEINERT-GIOVANNINI, 1982; IMPERATRIZ-FONSECA *et al.*, 1985; KLEINERT-GIOVANNINI; IMPERATRIZ-FONSECA, 1986; HEARD; HENDRIKZ, 1993; HILÁRIO *et al.*, 2000).

In this note we made preliminary observations about the influence of weather on the flight activity of a stingless bee that has been not previously studied, *Trigona hyalinata*. We also discuss the importance of documenting the influences that climate has on flight behavior (ROUBIK, 1989) in relation to climate change, a fact that influences several aspects of insect biology and may have an effect on stingless bees.

Material and methods

Study site and colony

The study was performed at a farm (Fazenda Aretuzina) near the town of São Simão, São Paulo State, Brazil (21°26'390"S, 47°34'810"W). This location is an agricultural region surrounded by patches of native flora (Cerrado forest) where bees foraged. We used one colony of *T. hyalinata* in these experiments. The *T. hyalinata* colony studied is natural to the region where we made our observations and it was left in its natural nest, located at the top of 4 m high electricity tower.

Data collection

The experiments were conducted during 9-13 August 2002. We counted the number of bees leaving the nest for periods of 5 minutes during each hour, using a portable weather station (Kestrel 4000 model NK0840) to measure weather conditions: temperature (°C), humidity (%), and barometric pressure (mPa). We started observations at 9:00 am and finished them at 5:00 pm. We stayed at a reasonable distance from the colony (around 4 meters), since this species is highly territorial and aggressive (NOGUEIRA-NETO, 1997). We used binoculars to observe the entrance and count the number of bees leaving the nest. At the end of each day, we downloaded this data into a laptop PC computer.

Statistical analysis

Statistical analyses were carried out using Microsoft Excel and Statistica 6.0 software. We correlated the environmental conditions and time of the day with flight activity. using the Pearson's Product-Moment Correlation index *r* (ZAR. 1999).

Results

Flight activity in *T. hyalinata* was significantly influenced by weather conditions and by the time of day. The flight activity of workers correlated with the time of day, temperature, relative humidity and barometric pressure is shown in Figure 1 and correlation indices of flight activity with weather conditions are summarized in Table 1. Flight activity in *T. hyalinata* was more intense at the beginning of morning. diminishing from 10:00 am to 2:00 pm. and increasing again after 2:00 pm (Figure 1a). Flight activity was more intense in the range of 22-26°C (with a low point on flight activity at 24°C). decreasing at lower and higher temperatures (Figure 1b). Barometric pressure and relative humidity were positively correlated with flight activity in this species (Figures 1c and 1d).

Table 1. Pearson's correlations coefficients for flight activity and environmental variables in *Trigona hyalinata*.

	T. hyalinata flight activity
Time of day	-0.58*
Temp (°C)	-0.39*
RH (%)	0.48*
Pressure (mPa)	0.53*

N=62; * = P<0.05

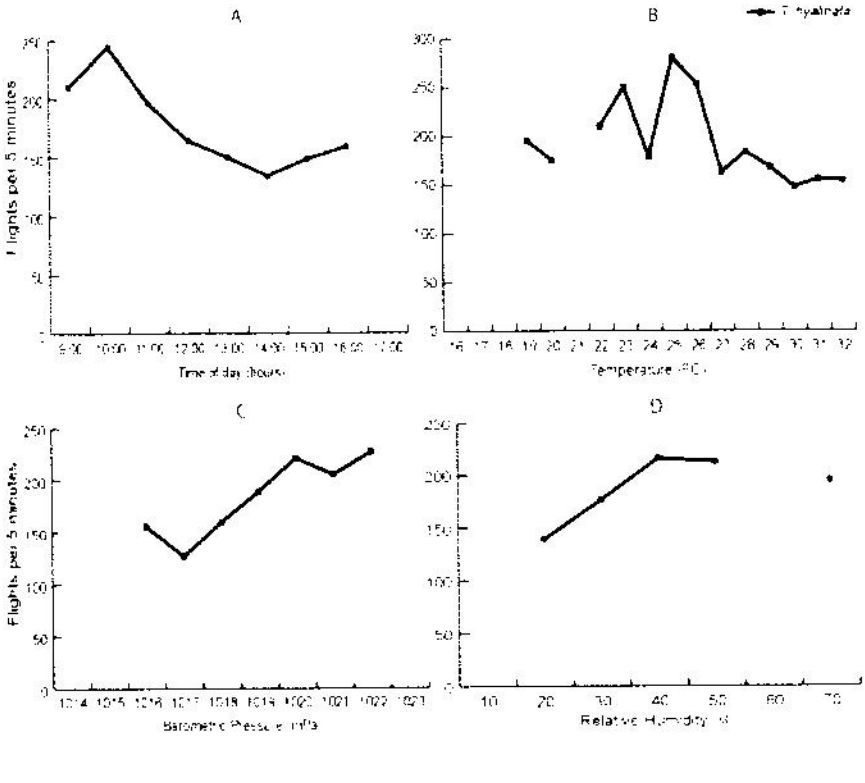

Figure 1. Flight activity of *Trigona hyalinata* related to time of day (a). ambient temperature (b), barometric pressure (c) and relative humidity (d).

With regards to the relationship between time of day and weather variables, temperature initially increased with time. decreasing at the end of the day (polynomial regression: Temp = -42.70 + 236.64x - 196.25x^2, $P<0.05$). Relative humidity followed the inverse relationship (polynomial regression: RH = 271.63 -796.20x + 65241x^2, $P<0.05$) while barometric pressure (linear regression: BP = 1025.92 – 12.88x, r=-0.59, $P<0.05$) decreased with time. Temperature and relative humidity were inversely correlated (RH = 89.76 – 2.00x, r=-0.64, $P<0.05$). as well as the variables temperature and barometric pressure (BP = 1026.02 – 0.28x, r=-0.50, $P<0.05$). The variables barometric pressure and relative humidity were positively correlated (BP = 1017.49 + 0.03x, r=0.18, $P<0.05$).

Discussion

Our preliminary results showed that climatic factors and time of the day influences flight activity in this species of stingless bee. In *T. hyalinata*, flight activity was significantly influenced by the time of day, temperature, relative humidity and barometric pressure. These results are similar than those found in *T. carbonaria* (HEARD: HENDRIKZ, 1993). The temperature threshold at which flight activity began in *T. hyalinata* was approximately 19°C, similar to *T. carbonaria*, which initiated flight activity at temperatures greater than 18°C (HEARD: HENDRIKZ, 1993).

In *T. hyalinata*, when temperature exceeded 26°C and humidity was below 40%, external activity decreased but did not stop, similar to the Australian bee *T. carbonaria* (HEARD: HENDRIKZ, 1993). Pereboom and Biesmeijer (2003) have hypothesized that the color and size of stingless bees may influence flight activity levels at higher temperatures. *Trigona hyalinata* bees are small and dark, approximately 5 mm in body length (see photograph in NIEH *et al.*, 2003), and live in a warm and relatively dry environment (Cerrado ecosystem). Dark bees in general can have problems with dehydration and with individual thermoregulation in warm areas (PEREBOOM; BIESMEIJER, 2003), thus a small size can compensate this potential constraint for foraging and external activity (a smaller size results in a smaller area for fluid loss). It is unknown how the balance between size and pigmentation act together upon thermoregulation in *T. hyalinata*, but these characteristics may impose general constraints on flight activity (PEREBOOM; BIESMEIJER, 2003). More studies on heat absorbance in stingless bees of different sizes and colors are necessary to give a deeper understanding on this phenomenon.

Trigona hyalinata forages in large groups, competing and extirpating other bees from food sources (NIEH *et al.*, 2003). Thus the overall efficiency resulting from mass foraging at lower temperatures may compensate for the decreased foraging activity at higher temperatures. Even with diminishing activity at greater temperatures and low humidity, an average of 150 bees left the nest each 5 minutes.

In addition to temperature, other factors may also be important for flight activity in this species. For example, luminosity and wind speed also influence meliponine flight activity (IMPERATRIZ-FONSECA *et al.*, 1985; KLEINERT-GIOVANNINI; IMPERATRIZ-FONSECA, 1986; HEARD; HENDRIKZ, 1993; PEREBOOM; BIESMEIJER, 2003). We plan to examine

the effect of these variables in future studies, as well as to do a greater period of data collection, which will allow us to obtain more conclusive data of the influences of weather and climatological variables on the flight activity of this stingless bee species. With global warming, several effects on insect biology have been documented (WHITTAKER, 2001). In stingless bees little is known about the influence of general temperature increases on its biology, but it is already known that adverse weather conditions affects stingless bee flight activity (KLEINERT-GIOVANNINI, 1982; SCHWARTZ; LAROCA, 1999). More knowledge on the climatic preferences of stingless bees is required in order to understand the effect of global warming and the temperature increasing on the behavior and physiology of stingless bees, one of the most important pollinators in the Neotropics (HEARD, 1999). Thus, the long-term collection of baseline data on flight activity levels varying with climatic conditions is therefore an important component to evaluate the effect of climate change on the stingless bee's biology.

Acknowledgements

We would like to thank Paulo Nogueira-Neto for kindly allowing us to stay at the Fazenda Aretuzina and use his research facilities and bees. We would also like to thank Juliana Rangel, Lilian S. Barreto and Ryan R. Yoon for fieldwork assistance, Juvenal Nascimento Flor for help with transportation, Dr. Astrid Kleinert, MSc. Sérgio Dias Hilário and two anonymous referees for valuable comments on this manuscript. Financial support came from FAPESP 02/00582-5 of Brazil to F.A.L.C. and NSF Grant 0316697 to J.C.N.

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