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Flight activity of stingless bees *Tetragonisca angustula* (Hymenoptera: Apidae: Meliponini) during in the year

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Abstract

Malerbo-Souza D, Halak A. 2016. Flight activity of stingless bees *Tetragonisca angustula* (Hymenoptera: Apidae: Meliponini) during in the year. Entomotropica 31(39): 319-331.

The aim of this experiment was to study the external activity of *Tetragonisca angustula* through out the year and its relation with air temperature and relative humidity. Material was collected in the Centro Universitário Moura Lacerda, Ribeirão Preto, SP. Once a month, for twelve months, an assessment was made by recording the number of bees entering the colonies with nectar or with pollen in corbiculae between 7:00 a.m. and 6:00 p.m., during 10 minutes each time (hour). There were significant differences in external activity of *T. angustula* along the 12 months of observation. Bees entering without loads of pollen were most numerous in March 2008 and least in July 2007. Bees entering with loads of pollen peaked in February 2008 and showed lowest activity level in July 2007. *T. angustula* is very sensitive to air temperature. External activity without loads of pollen starts with 17.8 ˚C with activity peaks between 25.0 and 35.3 ˚C. Bees entering with loads of pollen needed higher temperature (19.6 ˚C) for beginning external activity, and showed peaks between 23.7 and 34.4 ˚C. Relative humidity is not a limiting factor for the foraging behavior of *T. angustula.* Frequencies for bees entering nests without loads of pollen was 86.3 %, for bees with pollen 13.7 %.

Additional key words: Climatic factors, external activity, nectar, pollen, pollination ecology

Resumen

Malerbo-Souza D, Halak A. 2016. Actividad de vuelo de las abejas sin aguijón *Tetragonisca angustula* (Hymenoptera: Apidae: Meliponini) durante el año. Entomotropica 31(39): 319-331.

El objetivo de este estudio fue registrar la actividad externa de *Tetragonisca angustula* a lo largo del año y su relación con la temperatura del aire y la humedad relativa. Las observaciones se realizaron en el Centro Universitario Moura Lacerda, Ribeirão Preto, Brasil. Una vez al mes, durante 12 meses, se realizó una evaluación mediante el registro del número de abejas que entran al nido con o sin carga en las corbículas, entre las 7:00 am y las 6:00 pm, durante 10 minutos en cada oportunidad (hora). Se observaron diferencias significativas en la actividad externa de *T. angustula* a lo largo de los 12 meses de evaluación. El número de abejas entrando sin carga de polen fue mayor en marzo de 2008 y menor en julio de 2007. El número de las que entran con carga de polen fue mayor en febrero de 2008 y menor en julio de 2007. *T. angustula* es muy sensible a la temperatura. El inicio de la actividad externa sin carga de polen se produce con una temperatura de 17,8 ˚C, con picos de actividad entre 25,0 ˚C y 35,3 ˚C. Las abejas que entran con carga de polen requieren de una temperatura más alta (19,6 ˚C) y muestran picos de actividad entre 23,7 ˚C y 34,4 ˚C. La humedad relativa no es un factor limitante para el comportamiento de forrajeo de *T. angustula*. La actividad de las abejas fue mayor para la recolección de néctar (86,3 %) en comparación con la recolección de polen (13,7 %).

Palabras clave adicionales: Actividad externa, ecología de la polinización, factores climáticos, néctar, polen.

Introduction

Stingless bees are the most diverse group of social bees and are distributed across the tropical and subtropical regions of the world (Michener 1974). Camargo and Pedro (2007) consider 391 valid species to be adscribed to the stingless bees of the neotropical region.

The large number of species implies high complexity and behavioral diversity as well as ecological importance in pollination of native plant species and agricultural crops. Hence, the interest in studying stingless bees increased considerably over the last 50 years (Imperatriz-Fonseca et al. 2012). Due to their less problematic defensive behavior compared to honeybees (*Apis mellifera*), the simple handling and considerable amount of honey and pollen stocked, breeding of these bees has aroused increasingly popular interest (Nogueira-Neto 1997).

The flight activity or external activity is measured by counting the number of bees that leave or enter the colonies, with or without apparent materials (Hilário et al. 2007). However, this activity has been most studied in honeybees (Ellis et al. 2003, Huang and Seeley 2003, Danka and Beaman 2007, Malerbo-Souza and Silva 2011) and bumblebees (Morse 1982, Spaethe and Weidinmüller 2002).

In stingless bees, several factors can influence flight activity, mainly climatic factors such as temperature, light intensity, relative humidity, rainfall and wind (Souza et al. 2006, Malerbo-Souza and Silva 2011). In addition, other factors can affect flight activity, such as the internal conditions of the colony (Fidalgo and Kleinert 2007), the division of tasks (Nunes-Silva 2007), the size and physiology of bees (Imperatriz-Fonseca et al. 1985, Teixeira and Campos 2005), the internal timing of bees (Hilário et al. 2003), the reproductive diapause (Pick and Blochtein 2002), the reward calorie of nectar (Roubik and Buchmann 1984), the availability of flowers in nature (Pierrot and Sclindwein 2003) or in greenhouses (Bruijn and Sommeijer 1997), and seasonality (Cortopassi-Laurino et al. 2007).

Tetragonisca angustula (Hymenoptera: Apidae) measure approximately 5 mm, has golden color and may occupy various places for nesting, such as holes in walls, stones and hollow trunks of trees which positively influence the evolutionary success of the species. This bee is considered one of the most adaptable species (Silveira et al. 2002).

Knowledge about the flight activity of stingless bees are important both for the preservation of these organisms and hence the ecosystem, as well as for the management of these species used for economic purposes, such as pollination of crops. In Brazil, *T. angustula* is a known pollinator of strawberries (*Fragaria x ananassa*) cultivated in greenhouses (Calvete et al. 2005)

However, there is little information available concerning external activity of these bees in the course of the year, namely in different seasons. Given these characteristics, the aim of this work was to study the external activity of stingless bees *T. angustula* correlated with climatic data through the year in Ribeirão Preto, Brazil.

Material and Methods

This study was carried out between July 2007 and June 2008 at the meliponary of the University Center Moura Lacerda (Campus), in Ribeirão Preto, Brazil. This meliponary was composed of three colonies of stingless bees *Tetragonisca angustula* and is close to an apiary with six hives of africanized honeybees *Apis mellifera*. Elevation of Ribeirao Preto is 620 m with the following coordinates: lat 21° 10' 36" S, long 47° 49' 15" W. Local climate is subtropical, with mean annual temperature around 21 °C and anual rainfall of 1 500 mm.

During twelve months (from July 2007 to June 2008), once a month, an evaluation was made of the external activity of stingless bees *T. angustula*, with three replications (three colonies). This

evaluation was performed by counting the number of all bees entering the colonies with and without loads in pollen baskets (corbiculae) according the methodology used by Malerbo-Souza and Silva (2011).

Bees entering with loads of pollen in corbiculae can carry resins, but were counted as bringing loads of pollen only. It was not possible to distinguish between bees bringing nectar, water, or nothing. Bees entering the colony without pollen or resins on the corbiculae were considered to bring nectar.

The data were monitored from 7:00 a.m. to 6:00 p.m. (local time) during 10 minutes per hour, in each colony (7:00 to 7:10 a.m. in first, 7:10 to 7:20 a.m. in second and 7:20 to 7:30 a.m. in third colony and successively until 6:20 to 6:30 p.m.).

The meteorological data (temperature and relative humidity of the air) were obtained from the Meteorological Station of the University Center Moura Lacerda.

All data were statistically analyzed using the program ASSISTAT to compare means when necessary we used the Tukey test at 1 % level of probability. To analyze the external activity of stingless bees throughout the hours and the months regression analysis for orthogonal polynomials was used, thus obtaining the appropriate equations for the observed patterns under the experimental conditions.

Results and Discussion

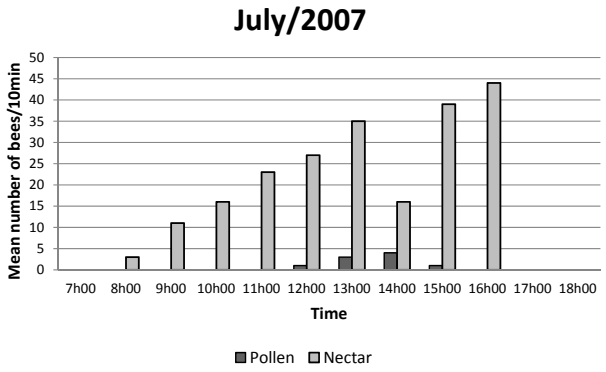
In Winter 2007 (July, August and September), the external activity of *Tetragonisca angustula* occured from 8:00 a.m. to 5:00 p.m. In July 2007 the activity peak for bees entering the colonies bringing nectar was at 4:00 p.m. and for bees with loads of pollen in corbiculae was at 2:00 p.m. , at a temperature ranging from 25.2 to 25.5 ˚C and relative humidity from 62.0 to 64.0 %. In this month a positive correlation with temperature and negative correlation with relative humidity were observed.

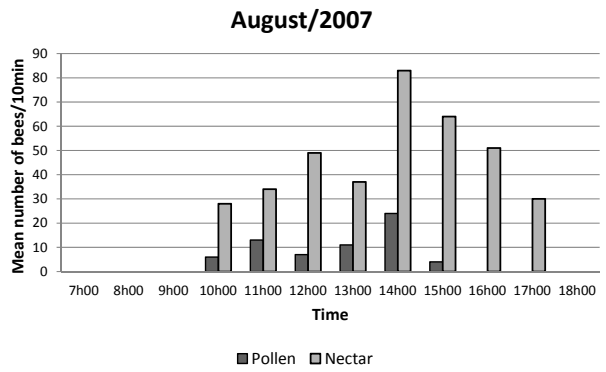
The air temperatures in the mornings in August 2007 were colder (12.4 ˚C at 7:00 a.m.), which influenced the beginning of the external activity of the stingless bees. Activity started later, at 10:00 a.m. with temperature around 20.1 ˚C and extended till 5:00 p.m. at 31.9 ˚C. The relative humidity of the air varied between 36.4 % at 10:00 a.m. and 15.3 % at 5:00 p.m. The bees carrying loads of pollen started external activity at 10:00 a.m. and finished at 3:00 p.m.

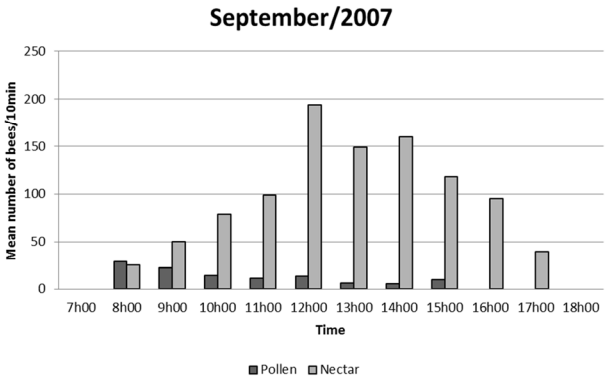
In August 2007 there was an activity peak at 2:00 p.m. both for nectar and for pollen. Already in September 2007 the pattern had changed and the peak for pollen activity occurred in the early morning (8:00 a.m.) and for nectar at noon. In this month the temperature was higher around the activity peak, viz. 31.0 to 32.0 ˚C and the relative humidity was low around 17.0 %.

Figure 1 shows that the stingless bees increased their external activity in austral winter 2007 following an increase of air temperature. July 2007 was also the month with minor air temperatures and minor external activities of stingless bees.

In Spring 2007 (October, November and December) (Figure 2) the external activity of stingless bees was intense, probably associated with the flowering of many plants close to the meliponary, like eucalyptus (*Eucalyptus* sp.), the rope-glory (*Ipomoea hederacea*), the fleur-de-Cardinal (*I. quamoclit*), the kinkan (*Fortunella margarita*) and jatropha (*Jatropha curcas*). The maximum temperature for September and October was 35.0 ˚C. In November the maximum temperature was 30.8 ˚C and higher number of bees entered colonies with loads of pollen. This occurred probabily due to the floral resources that provided nectar and pollen. At the experimental site corn crop (*Zea mays*) is cultivated in large areas every year. This plant is important in providing pollen for different bee







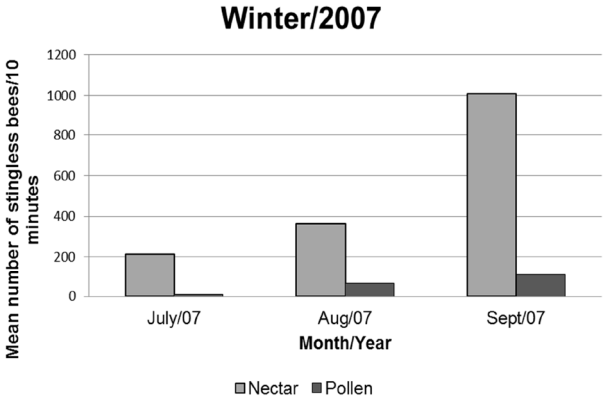
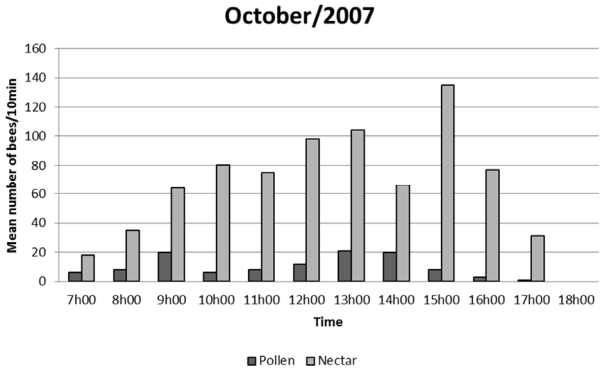
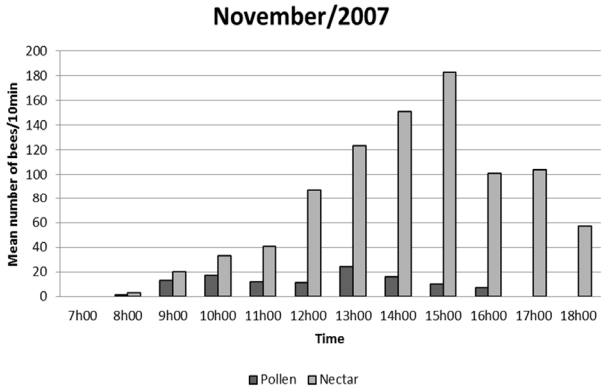
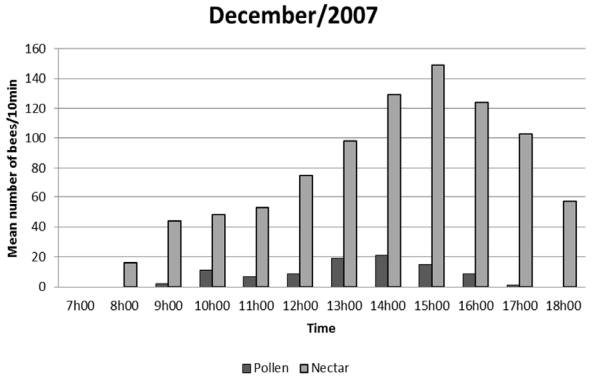


Figure 1. Mean number of stingless bees *Tetragonisca angustula* entering in colonies carrying pollen and nectar from July to September 2007 and in winter 2007.







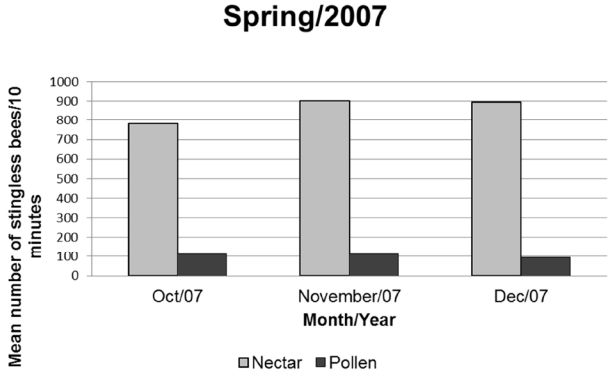


Figure 2. Mean number of stingless bees *Tetragonisca angustula* entering in colonies with pollen and nectar from October to December 2007 and in spring 2007.

species in the surroundings (Malerbo-Souza and Silva 2011). However, corn provides only pollen for floral visitors.

In October 2007, at times of higher activity, number of bees entering the colonies with nectar and pollen was higher, at temperatures between 25 to 35 ˚C and with a relative humidity between 28.0 to 64.0 %. In November and December 2007 this variation was lower, viz. 27.0 to 31.0 ˚C and 46.0 to 55.0 % for relative humidity, respectively.

In Summer 2008 (January, February and March), variation in temperatures was between 22.0 to 30.0 ˚C and in relative humidity between 45.0 to 86.0 %. External activity was intense between 10:00 a.m. to 4:00 p.m., for nectar between 1:00 to 2:00 p.m. and for pollen between 10:00 a.m. to 1:00 p.m. (Figure 3).

In Autumn 2008 (April, May and June), temperatures were lower, viz. around 26.0 to 23.0 ˚C during the hottest hours of the day and higher external activity was observed at this hours, too. The relative humidity was lower ranging from 21.0 a 52.0 %. In April, May and June 2008 the highest external activity for nectar and pollen was recorded at 1:00 p.m. with exception of June where the highest number of bees entering with loads of pollen was at 4:00 p.m. Once more, the number of bees entering the colonies with nectar was influenced by air temperature, while relative humidity had no influence on the external activity of the bees.

In this season, *T. angustula* started external activity later between 9:00 to 10:00 a.m. as showed in Figure 4. which means, that air temperature influence these bees at the beginning of external activity of collecting nectar, pollen, water and resins.

In Autumn 2008 we observed that the external activity increased over the months from April to June even with temperatures being very similar between months in this year. The differences observed are probably due to differences in the floral resources available.

Table 1 shows that the minimum temperature for starting external activity for nectaring was 17.8 ˚C and relative humidity was 36.4 %, the maximum was 24.6 ˚C and 94.7 % with average of 20.9 ˚C and 76.7 % respectively. At the peak of activity the temperature and relative humidity minima were 25.0 ˚C and 17.1 %, respectively, the maxima were 35.3 ˚C and 64.9 % and the average was 29.2 ˚C to 45.5 % respectively.

For bees with loads of pollen, minimum air temperature and relative humidity for beginning of activity were 19.6 ˚C and 36.4 %, the maximum was 24.6 ˚C and 94.7 %, and the mean value was 21.8 ˚C and 70.6 % respectively. At peak activity, the air temperature and relative humidity minima, maxima and averages were 23.7 % and 17.1 ˚C, 34.4 ˚C and 70.9 % and 27.9 ˚C and 49.4 % respectively. So, even on dry days the external activity of bees did not cease.

Figure 5 shows the mean number of stingless bees *T. angustula* entering colonies with nectar and pollen throughout the experimental period. We observed that external activity of bees carrying nectar increased during the day, until 1:00 p.m. then declined according to the following equation $Y = -X\ 3039.997 + 560.2995 - 21.21603\ X^2$ ($F = 129.2828$ **, $R^2 = 0.8631$), where Y is the number of bees and X is the time of day.

For bees entering with loads of pollen, by Polynomial Regression in time, it was observed that the external activity increased until 1:00 p.m. then declined ($Y = -91.03659\ X + 454.7696 - 3.687687\ X^2$, $F = 54.6016$ **, $R^2 = 0.8712$). Between 12:00 p.m. and 2:00 p.m. there was a period of increased activity for pollen collection.

Here is a difference between this species of native bee compared to honeybee, namely, *T. angustula* has increased activity for pollen in the afternoon, while the honeybee has higher activity for pollen collection in the early

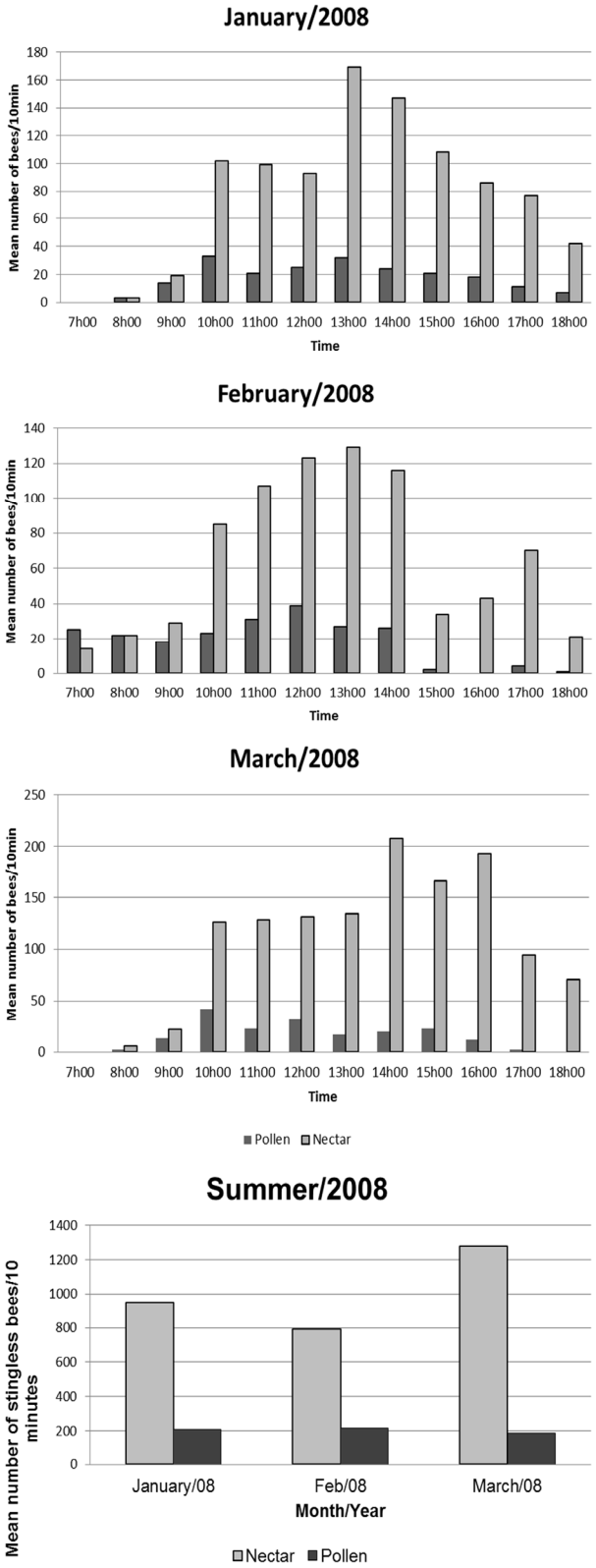


Figure 3. Mean number of stingless bees *Tetragonisca angustula* entering colonies carrying pollen and nectar from January to March 2008, and in summer 2008.

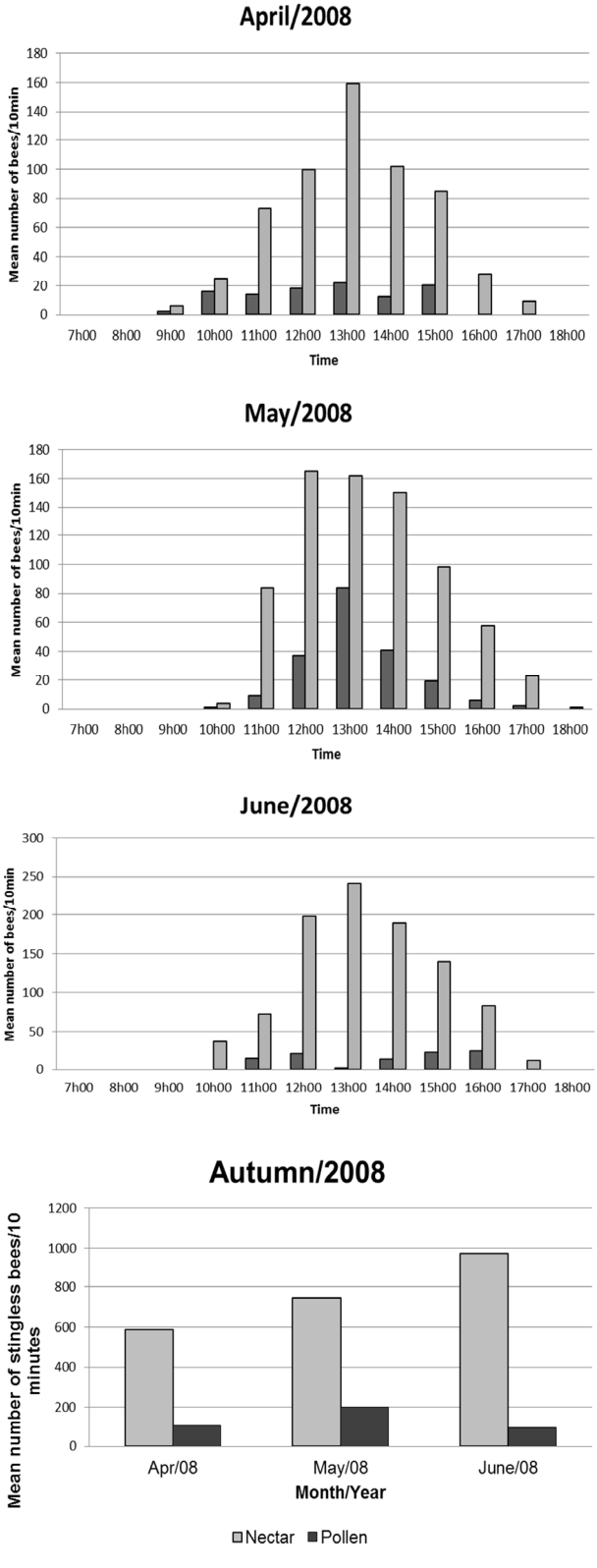


Figure 4. Mean number of stingless bees *Tetragonisca angustula* entering colonies carrying pollen and nectar from April to June 2008 and in autumn 2008.

Table 1. Data of temperature (°C) and relative humidity (%) of 7h to 18h, between the months of July 2007 and June 2008.

Hour/ Period	Temperature (°C)											
	7-Jul	7-Aug	7-Sep	7-Oct	7-Nov	7-Dec	8-Jan	8-Feb	8-Mar	8-Apr	8-May	8-Jun
7h	17.45	12.42	22.36	22.83	19.98	18.29	20.95	20.6	19.16	14.7	13.9	11.02
8h	18.14	15.48	23.7	25.21	21.79	19.42	21.38	22.64	19.57	17.52	14.78	11.47
9h	20.13	20.08	26.53	27.61	23.79	21.6	21.93	24.33	21.92	20.58	17.13	15.68
10h	21.4	24.63	28.79	30.09	26.03	23.84	22.78	25.78	24.54	22.75	20.02	20.13
11h	21.77	28.13	31.16	32.22	27.23	25.34	24.43	27.45	26.95	25.09	22.63	23.16
12h	22.39	29.74	33.19	33.06	28.52	26.36	26.89	28.89	28.83	26.68	25.04	25.6
13h	24.42	30.61	34.54	34.44	29.59	27.57	28.09	29.8	29.7	27.64	26.1	27.64
14h	25.53	31.1	35.17	34.85	30.04	27.82	29.46	30.11	30.1	28.06	26.69	28.21
15h	26.28	31.91	35.62	35.28	30.77	28.31	30.02	31.09	30.64	28.56	27	28.69
16h	25.2	31.98	35.83	35.89	30.65	28.37	30.1	26.92	30.3	28.78	26.22	28.87
17h	20.81	31.95	35.49	35.72	30.51	27.9	29.94	26.64	30.17	27.68	26.89	28.39
18h	18.71	29.4	33.78	34.58	29.7	27.06	29.12	25.74	28.75	26.29	22.92	24.33
Hour/ Period	Relative humidity (%)											
	7-Jul	7-Aug	7-Sep	7-Oct	7-Nov	7-Dec	8-Jan	8-Feb	8-Mar	8-Apr	8-May	8-Jun
7h	93.3	76.2	58.29	75.9	87.8	87.5	91.7	78.7	95.5	95.1	93.9	81.4
8h	92.7	67.55	54.27	63.73	80.2	82.9	89.5	70.4	94.7	88	92.3	80.9
9h	86	51.07	38.55	51.45	71.8	73.4	88.4	64.77	82.8	78.8	85.7	67.89
10h	81	36.37	31.14	45.59	62.22	66.18	85.5	61.88	70.9	71.6	75	51.07
11h	81.8	26.43	25.62	39.49	58.46	64.54	80	57.64	61.57	60.27	65.8	40.15
12h	80.6	20.23	21.14	35.74	54.31	60.5	70.8	53.33	51.8	52.82	56.96	34.18
13h	71.2	19.09	17.88	30.59	48.82	56.56	64.93	50.02	48.43	47.02	52.34	28.54
14h	62.07	17.11	17.53	28.96	47.95	55.48	59.22	48.09	44.91	45.42	47.98	23.5
15h	57.62	15.68	17.46	28.53	46.38	54.73	57.32	45.57	42.46	41.11	44.5	23.01
16h	63.84	14.92	17.04	26.52	43.18	53.75	56.43	67.1	43.13	36.26	47.97	21.41
17h	79.7	15.31	17.42	26.98	44.32	56.02	56.27	71.3	42.11	41.55	44.04	21.54
18h	89.5	19.65	21.34	27.76	47.69	58.67	57.8	68.31	47.33	47.64	60.64	31.5

morning. Hence, if the activity of honeybee is intense, the stingless bee may have difficulties to find pollen in flowers that have already been visited by honeybee. In adition, most plant species have pollen production concentrated in early morning and nectar throughout the day (Pierrot and Schlindwein 2003).

Comparing the months of the year (Figure 6) it can be observed, that highest external activity was in March 2008 and the lowest activity in July 2007 for stingless bees *T. angustula* entering with nectar. For bees entering with loads of pollen, the highest activity was February 2008 and the lowest activity also in July 2007 showing again that in colder months the activity of these bees was lower. July 2008, the month with minor air temperature and minor external activity showed the influence of seasonality on *T. angustula*.

In general the external activity of stingless bees entering colonies with nectar was positively correlated with air temperature. *T. angustula* started external activity at the hottest hours of the day. Hence, air temperature was the factor, that showed increase in flight activity for this bee. With respect to activity for pollen, there was

Table 2. Maximum, minimum and average of air temperature and relative humidity for external activity start and peak of stingless bees *Tetragonisca angustula* entering colonies with nectar and pollen.

Month	Year	Nectar				Pollen			
		Start activity		Peak activity		Start activity		Peak activity	
		T (°C)	UR (%)	T (°C)	UR (%)	T (°C)	UR (%)	T (°C)	UR (%)
July	2007	18.45	93.3	25.2	63.84	22.39	80.6	25.58	62.07
August	2007	24.63	36.37	31.1	17.11	24.63	36.37	31.1	17.11
September	2007	23.7	54.27	33.19	21.14	23.7	54.27	23.7	54.27
October	2007	22.83	75.9	35.28	28.53	22.83	75.9	34.44	30.59
November	2007	21.79	80.2	30.77	46.38	23.79	71.8	29.59	48.82
December	2007	19.42	82.9	28.31	54.73	21.6	73.4	27.82	55.48
January	2008	21.38	89.5	28.09	64.93	21.38	89.5	28.09	64.93
February	2008	20.6	78.7	29.8	50.02	20.6	78.7	28.89	53.33
March	2008	19.57	94.7	30.1	44.91	19.57	94.7	24.54	70.9
April	2008	20.58	78.8	27.64	47.02	20.58	78.8	27.64	47.02
May	2008	20.02	75	25.04	56.96	20.02	45	26.1	52.34
June	2008	17.82	80.5	26.09	49.95	20.79	67.94	27.53	36.13
Minimum		17.82	36.37	25.04	17.11	19.57	36.37	23.70	17.11
Maximum		24.63	94.70	35.28	64.93	24.63	94.70	34.44	70.90
Mean		20.89	76.67	29.21	45.46	21.82	70.58	27.91	49.41

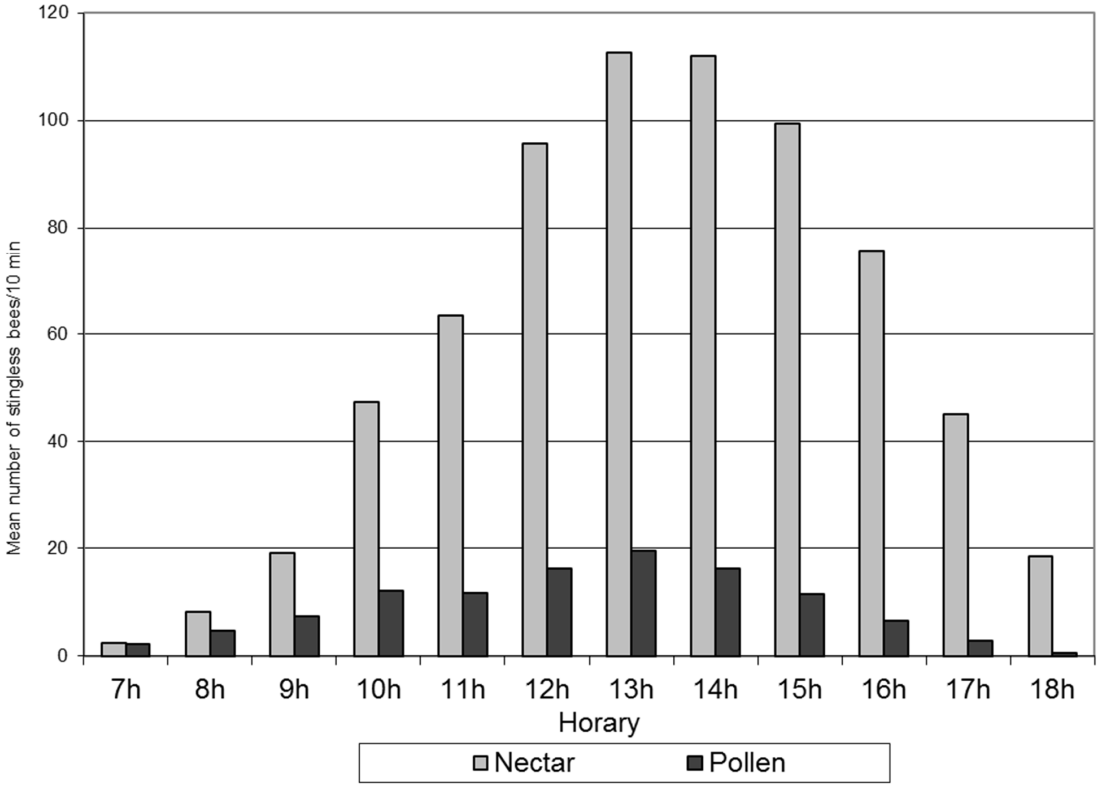


Figure 5. Mean number of stingless bees *Tetragonisca angustula* entering colonies with nectar or pollen from 07:00 a.m. to 06:00 p.m. in Ribeirão Preto, SP, Brazil, throughout the experimental period.

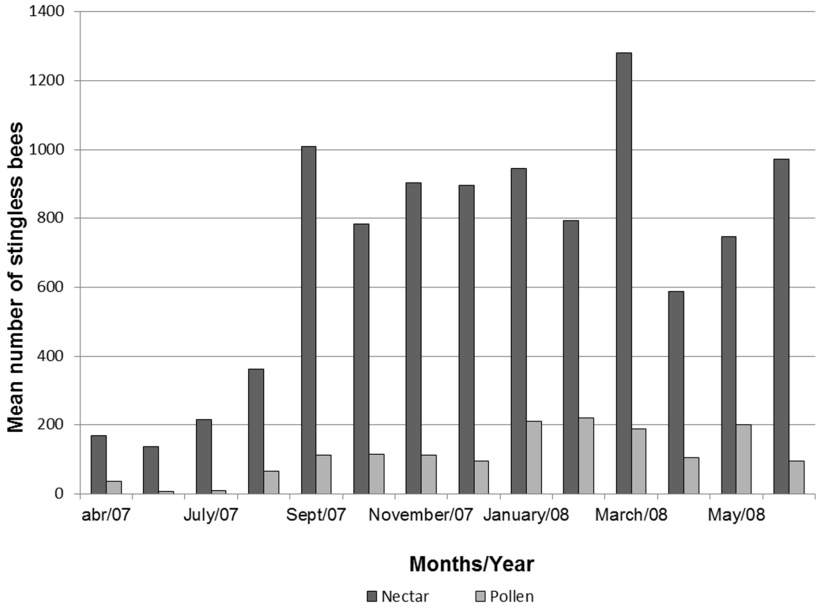


Figure 6. Mean number of stingless bees *Tetragonisca angustula* entering colonies with néctar and pollen from July 2007 to June 2008 in Ribeirão Preto, Brazil.

no pattern related to the climatic conditions, but there was a dependence on availability of floral resources.

The stingless bees begin external activity later compared to africanized honeybees, which start at dawn even in the colder months, as noted by Malerbo-Souza and Silva (2011), while the warmer periods of the year are better for the maintenance of the colonies of *T. angustula*.

Stingless bee *T. angustula* was more demanding to air temperature for starting of external activity compared to africanized honeybee *Apis mellifera* (Malerbo-Souza and Silva 2011), showing difference of 5.4 °C.

These results agree with Michener (1974) and Teixeira and Campos (2005) in that *T. angustula,* havingrelatively small body, with high surface/volume ratio, heat exchange with the environment is great and hence depending considerably on temperature. Low temperatures decrease the metabolism preventing flight and other movements, while higher temperatures cause decrease in extern al activity and induce ventilation behavior in the colony.

Borges and Blochtein (2005) studied the flight activity of stingless bee *Melipona marginata obscurior* at different seasons in San Francisco de Paula, RS, Brazil, and observed, that in spring-summer the amplitude of daily flight activity was 9 to 13 hours for colonies A and B respectively, with greatest intensity of flight between 9:00 a.m. and 11:00 a.m. The minimum temperature for flight was 14.3 °C and the highest intensity of flight occurred at about 81-90 % of relative humidity and solar radiation of 300 W/m2. In autumn-winter, the range of activities of daily flight was 10 hours, and these activities became more intense from 10:00 a.m. to 3:00 p.m.. As in spring-summer, highest flight intensity occurred at 300 W/m2 of solar radiation. Temperature and solar radiation had significant influence on the external activities of the bees in autumn-winter. The activities of pollen collection by bees in the spring-summer period occurred in the early morning while in the autumn-winter foraging was delayed, as in our experiment.

Table 3. Comparison of the means of stingless bees *Tetragonisca angustula* entering with and without pollen in the colonies between July 2007 to June 2008.

Month-Year	Without pollen	Month-Year	With pollen
Mar-08	639.5 A	Feb-08	109.0 A
Sep-07	504.5 AB	Jan-08	104.5 A
Jun-08	486.0 AB	May-08	99.5 A
Jan-08	472.5 AB	Mar-08	93.0 AB
Nov-07	451.5 AB	Oct-07	56.5 AB
Dec-07	448.0 AB	Nov-07	55.5 AB
Feb-08	396.5 AB	Sep-07	55.0 AB
Oct-07	391.5 AB	Apr-08	52.0 AB
May-08	372.5 AB	Jun-08	47.5 AB
Apr-08	293.5 AB	Dec-07	47.0 AB
Aug-07	188.0 AB	Aug-07	32.5 AB
Jul-07	107.0 B	Jul-07	4.5 B

* Means followed by different capital letters in the same column differ significantly, Tukey test at the 1% level (Dms = 453.6697, CV = 84.42).

However, our data differ from Ramos et al. (2008), who observed a different species of stingless bees at the Indigenous School Tuyuka Utapinpona in Alto Rio Negro, Brazil, and concluded that January-March and June-July showed high external activity. Between these periods there was a short interval of low activity, viz. in the months of April and May. August to December was the period with lower activity of bees. The peak of external activity was in March , while October was the month with lowest external activity. These differences are due to the bee species studied and to different geography and environment.

In Ribeirão Preto, from August to September 2007 there was flowering jackfruit (*Artocarpus heterophyllus*) and grevillea (*Grevillea robusta*), which were much visited by stingless bees. At the end of October and in November 2007, in close neighborhood of a flowering corn plantation (*Zea mays*) an increase in the collection of pollen by stingless bees was observed. The male flower of corn was visited by various bee species, including *T. angustula*. for pollen collecting. Stingless bees collecting nectar and pollen on sunflower (*Helianthus annuus*), which flourished at the same period at the experimental site, were also observed.

In Table 3, the Tukey test shows that January, February, March and May 2008 (late summer) were the best months for external activity of *T. angustula* and differ significantly from July 2007 (winter), which was the month with worst sampling. Normally, in summer the floral resource is larger than in winter . These data are important for meliponicultors being a tool for assisting management such as organizing supplementation with syrup or feed in periods with minor external activity. In our experiment we noted that July was a month that needed a proper management for the maintenance of colonies.

In Table 4 can be observed that *T. angustula* entering in colony preferably with nectar (86.26 %) compared with loads of pollen (13.74 %). These data disagree with Heard (1994) that related 90 % of the stingless bees foraging for pollen and only 10% for nectar. These results showed that bees collect nectar and pollen according to floral resources available in different months of the year. July 2007 showed

Table 4. Proportion of stingless bees *Tetragonisca angustula* entering in colonies with nectar or pollen in percentage.

Tetragonisca angustula			
Month	Year	Pollen (%)	Nectar (%)
July	2007	4.04	95.96
August	2007	14.74	85.26
September	2007	9.83	90.17
October	2007	12.61	87.39
November	2007	10.95	89.05
December	2007	9.5	90.5
January	2008	18.11	81.89
February	2008	21.56	78.44
March	2008	12.69	87.3
April	2008	15.05	84.95
May	2008	21.08	78.92
June	2008	8.9	91.1
Mean		13.74	86.26

lower pollen input in colonies (4.04 %) and February 2008 the largest input (21.56 %).

As this experiment several studies reported the temperature as a determining factor in flight activity of different species of stingless bees. Kleinert-Giovannini (1982) noted that *Plebeia emerina* does not leave the colony when the ambient temperature is low, even the lighting and humidity conditions are adequate. Heard and Hendrikz (1993) reported stingless bees *Trigona carbonaria* beginning of flight activity in winter regulated by temperature and in the warmer months by solar radiation.

Hilario et al. (2007) studying the flight activity of stingless bees *Plebeia remote* from December 1998 to December 1999 correlated with rainfall. Observed decreases in external activity both before and during precipitation. After stopped raining there was a predominance of increases which indicated a compensation flight activity in relation to the rainy season. In general, the largest decrease of flight activity before rain occurred in the autumn and the greatest increase in flight activity after rain occurred in the spring.

Our results demonstrate that the assessment carried out by stingless bees *T. angustula* are closely related to air temperature and food resources available in different seasons.

Conclusions

There are significant differences in external activity of stingless bees *Tetragonisca. angustula* between the seasons. Stingless bees entering in colonies with nectar most is March 2008 and what stands out is least July 2007. For bees entering with loads of pollen in February 2008 occured more activity and minor acitivity in July 2007. July 2007 was the month with temperatures and minor external activity of these bees.

T. angustula is very sensitive to air temperature. The beggining of external activity with nectar occurs with temperature of 17.8 °C and entering with loads of pollen needed higher temperature (19.6 °C) for begining external.

The relative humidity is not a limiting factor for the foraging behavior of *T. angustula* and these stingless bees entering in colonies preferably

carring nectar (86.3 %) than with loads of pollen (13.7 %).

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