Seasonal Strategies of Harvesting by *Melipona* sp in the Amazon region

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Since 1967 Jansen has pointed out that many trees of tropical areas have evolved the timing of their flowering and fruiting period with the dry season to maximize vegetative competitive ability of individuals and to maximize use of pollinating and dispersing agents.

The study of pollen and nectar gathering of a social bee colony may be observed from various standpoints, considering the collecting bee as a representative of colony necessities, its pollinating functions through the quantity and quality of pollen and nectar collected and identifying, through the pollen, the vegetal species visited.

While the production and concentration of nectar may present considerable fluctuations as a result of subtle weather changes such as wind, temperature, relative humidity, nebulosity, soil humidity, etc., the pollen is brought out only once by flowers and may have only half its protein mass.

The social bees of the *Melipona* genus, of more than 40 species, are all neotropical and are distributed throughout the Amazon. Its size is relatively large and its breeding is associated with honey extraction, a constant activity in rural populations.

These bees gather throughout the year and, regarding their polytrophic nature, seem to prefer visiting plants of the Leguminosae, Solanaceae, Myrtaceae and Melastomataceae families in southeastern Brazil, (Ramalho 1990, Wilms, 1995). In this context it has been emphasized that these bees, due to their greater size, carry out 'buzz-pollination'. It is known that they visit species of pollinia pollen grain plants, such as the Brazilian rain forest orchid *Maxillaria parviflora* aff (Cortopassi-Laurino, unpublished data), which makes them appropriate in these gatherings.

This study was done with the purpose of obtaining information about the dynamics of the seasonal gathering, considering some meteorological parameters in which the bees carry out their activities and the diversity and quantity of material gathered. Since the dry season is of vast flowering, what would be the dynamics of gathering of *Melipona* bees on both the rainy and dry seasons in the same region?

Material and Methods

Observation of the flight activities and gathering of bees were made in the Amazon region, at the city of Xapuri-Acre (10° 65'S; 68°50'W), for some days during the dry season on Oct./1999, with diurnal temperatures varying between 22-41°C, relative humidity between 47-92% and on the rainy season on Jan./2004 (23.8-33.1°C and 64-98% relative humidity). The pluvial precipitation varied from 2000-2500mm and the mean annual temperature is of about 26°C. The dry season lasts from May to October.

The external movement of *Melipona crinita*, Moure & Kerr, 1950 (uruçu amarela), *M. eburnea fuscopilosa* (ururçu roxa), *M. flavolineata* Friese, 1900 (jandaíra amarela) and *M. grandis* Guérin, 1844 was done during all day and the collected material (pollen, resin, mud) was recorded. Related to *M. fuliginosa*, Lepeletier, 1836 (uruçu boi), it was difficult to identify the collected material.

The observations were made from dawn (5:00 AM) or some minutes earlier, when bee movement was already visible, until the end of daylight (5:30 PM). The number of bees entering the colony for 10 minutes in every half hour or 15 minutes in every hour throughout the day was counted. The material that the bees were carrying and weather conditions were written down at the same time as well.

The nectar gathering of the bees was accounted for arbitrarily for all individuals that returned without any identifiable material.

Results

Results obtained in observing the flight activities are summarized in Table I and Table II, in which activity peak in both seasons occurred in the first hours of the morning for all four species of *Melipona sp*, except for *M. grandis*, which had a latter peak.

In the dynamics of bee foraging of both seasons (Table III), there was a shift of the material mostly collected (the pollen in the dry season), to a rubbery resin with seeds and mud in the rainy season. This resin or red pulp with seeds, as well as the mud, are used in the structures inside the nest, as in walls and batumen.

The gathering of mud, which was absent in the dry season, reached 48.7% in the samples of *M. crinita* and stayed above 15% for the other bee species. Immediately after the storms, these gatherings increased.

The resin gathering, little expressive in the dry season, accounted for more than 25% of all bee samples during the rainy season.

By comparing the pollen gathering of both periods (Table IV), it presented itself decreased and shifted later in the rainy season (from a few minutes to 2 hours), the same happening with the temperature at peak times but, again, in a small interval of values (between 1.4-1.5ºC) and humidity between 7-10%.

The white colored pollen collected in the corbiculae of all five bee species were from two species of Myrtaceae. The yellow colored were from four different species, being three Myrtaceae and the two orange colored pollen were from one type only, probably Umbelliferae.

Discussion

1. Flight Activities

The bees made foraging activities throughout the day. The fact that they went gathering before daybreak means that some food was already available and that they could guide themselves through the dim luminosity of daybreak.

The peak of flying activities that occurred in the two periods, in the first hours of morning for the bees analyzed, except for *M. grandis*, show synchronism between them,

regardless of the season. At the same time, the temperature parameter was very narrow: 23-26ºC in the dry season and a little higher in the rainy season, between 25.3-27.0ºC, showing that this may be a key factor for bees and their resources and leading to a synchronism in activities.

Other authors, while observing species from the same genus in Central America, have already stated similar behavior of intense morning gathering of *M. marginata*, *M. fasciata*, *M. compressipes* and *M.fuliginosa* (Roubik & Buchmann, 1984), *M. beechei*, besides *M. fasciata* (Biesmeijer 1997), and of *M. seminigra merrillae* and *M. fulva* (Oliveira, 2003) although not having evaluated meteorological conditions.

This similar behavior, shown by eleven tropical species of *Melipona*, shows a behavioral or adaptive parallelism together with morphological similarities, although having size, color and population density variations or availability of resources from the plants in the given season.

The estimated number of workers that leave the nest throughout the day was considerable for all stingless bees in the dry season. This relation may have been casual, but if in each trip the bee visits a hypothetical number of 5-6 flowers, we may suggest the number of flowers visited or its "pollinating efficiency". Many of these bees may have left the nest to collect water, get rid of wastes, make guiding flights, etc., but it is also known that bees visit more than 5-6 flowers to gather pollen or nectar. *M. flavolineata* and *M. grandis* don't follow this gathering proportion. The first probably due to not having a very strong nest at that time, the latter for having been observed until only 1:00 PM.

2. Pollen Foraging

The peak of pollen gathering, observed on both seasons, happened between limited values for the four species, being the temperature values the lowest (24-26ºC) and the air humidity values the highest (84-95%). These results, as well as the activity peaks, suggest total independence of this behavior with the colony condition, besides the workers' color and size. The pollen gathering, even if in small quantities, shows that some botanic species offer resources even with the eventual dilution of its nectar, because of the rain, and the less exposure time for the polinators, etc.

The *M. grandis* colony, with peak activity at 11:15 AM (35ºC and 57%), also showed the greatest early pollen gathering, at 5:50 AM (24ºC and 91%), following the same behavior as other bee species observed.

According to Cooper et al (1985), the *Apis* bees gather pollen in hot regions, though they always do so in lower temperatures than those that gather nectar or water, since the latter are able to reduce their body temperature through cooling by evaporating the liquids they carry. This theory is consistent with our results, considering the great convergence in values. However, high levels of humidity may also take part in the facilitation of this job, whether by the agglutinating pollen process or by the viability of grains or even by the availability of grains by the plants. In guava flowers, bees only collected pollen in the first hours of the morning.

Regarding the botanical origin of honey, all the *Melipona* (with the exception of *grandis*), plus *Tetragonisca weyrauchi*, *Scaptotrigona* sp and *Plebeia alvarengae,* nesting in Xapuri, all presented Myrtaceae pollen as the predominant component (>75.8%).

A similar result was observed in pollen of larvae food, with a presence greater than 94.8% of Myrtaceae. The limited size of these grains (15-24ì) may be related to its digestibility, since the egg size is very similar in *Melipona* species. In this case, the quantity of larval food varies, being greater for bigger species (Velthuis et al 2003). The remaining pollen aren't bigger that 56.5 ì.

3. Resin Foraging

The gathering of the rubbery resin, which was present in minute quantities only on the dry season, has an orange-red coloring. The aggregation of oval seeds suggests that this gathering was made out of some fruit. These resins with seeds were only observed on door ornaments, batumen and walls of the hives. These were neither observed in combs nor in pots. *M. crinita* bees brought, sometimes, bubbles of this resin on the jaw and on the corbiculae.

According to Garcia et al (1992), these resins or rubbery pulp with seed are provenient from two already observed plants: *Vismia sp* (Guttiferae) and *Coussapoa asperifolia* (Cecropiaceae), but only the latter has oval shaped seeds and is frequently targeted by stingless bees. *Vismia* sp is locally known as "lacre". The fact that some of these seeds germinate through hive holes where bee nests and presented follicles in hives batumen shifting from their original position, suggests that stingless bees, like other animals, may be contributing for the dispersal of seeds in the Amazon region.

Table I: Flight Activities in the dry season by five *Melipona* bees

Bees	Peak of Activities			Number of Total Flights	Estimated Nest Population
	Time	Temperature (°C)	Humidity (%)		
M. crinita	05:40	23.0	92	10,851	1,000-1,500
M.e.fuscopilosa	05:20	24.0	91	12,044	1,500-2,000
M. grandis	11:15	35.0	57	2,325	500-700
M. flavolineata	05:55	26.0	84	2,757	500-1,000
*M. fuliginosa**	12:00	23.5	91	21,894	1,500-2,000
M. fuliginosa	6:00	22.0	93	-	1,500-2,000

* rainy day

Table II: Flight Activities in the rainy season by five *Melipona* bees

Bees	Peak of the Activities			Number of observations	Estimated Nest population
	Time	Temperature (°C)	Humidity (%)		
M. crinita	6:25	25.3	91	2086	1,000-1,500
M.e.fuscopilosa	7:50	27.0	83	405	1,500-2,000
M. grandis	10:45	33.0	64	442	700-1000
M. flavolineata	6:45	26.3	94	824	500-1,000
M. fuliginosa	5:25	25.4	92	329	1,500-2,000

Table III: Harvested Materials by *Melipona* bees during two seasons

Dry season

Bees	Mud (%)	Resin (%)	Pollen (%)	"Nectar" (%)
M. flavolineata	0.0	0.4	56.6	51.3
M. grandis	0.0	4.2	11.7	85.2
M. crinita	0.0	3.5	38.0	58.5
M.fuscopilosa	0.0	0.2	50.5	49.3

Rainy season

Bees	Mud (%)	Resin (%)	Pollen (%)	"Nectar" (%)
M. flavolineata	18.1	26.7	2.9	52.3
M. grandis	15.6	25.3	9.0	50.0
M. crinita	48.7	26.1	3.9	21.3
M.e.fuscopilosa	15.1	25.7	9.6	49.6

Table IV: Pollen Gathering by *Melipona* bees in two seasons

Dry season

Bees	Peak of Activities			Last collection	
	Time	Temperature (°C)	Humidity (%)	Temperature (°C)	Humidity (%)
M. crinita	05:40 - 06:20	26.0	84-91	35.0	57
M.fuscopilosa	06:55	26.0	84	36.0	53
M. grandis	5:50	24.5	91	35.0	57
M.flavolineata	05:45	24.0	84		

Rainy season

Bees	Peak of Activities		
	Time	Temperature (°C)	Humidity (%)
M. crinita	7:00	27.3	84
M.fuscopilosa	7:15	27.0	83
M. grandis	7:50	27.7	82
M.flavolineata	6:45	26.3	94

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