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Pollen collected by *Trigona williana* (Hymenoptera: Apidae) in Central Amazonia

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Abstract: Pollen was obtained and identified from corbiculae of *Trigona williana* worker bees over a one year period at the INPA campus in the city of Manaus. Ranked by number of pollen grains, the dominant plant familes were: Arecaceae, Melastomataceae, Myrtaceae, Caricaceae, Moraceae and Malpighiaceae. Dominant plant species were *Cocos nucifera*, *Maximiliana martiana*, *Cassia* sp., *Carica papaya*, *Bellucia grossularioides*, *Artocarpus incisa* and *Stachytarpheta cayennensis*. Fewer plant species were exploited in the rainy season than in the dry season.

Key words: Pollen foraging, plant species, stingless bees, *Trigona williana*.

Pollen and nectar are essential food elements for bees, pollen being their main protein source. When bees visit flowers, pollen adhering to their bodies is also responsible for perpetuation of the plant species through the process of pollination, a natural consequence of the relationship between plants and their pollinators.

Amazonia is home to a great number of plant species. The practice of meliponine bee husbandry can benefit from a knowledge of the most important food sources. This information is also important for a better understanding of the interaction between plant and pollinator (Hubbell and Johnson 1978, Kerr 1978, Heithaus 1979, Brantjes 1981, Wilmer and Corbet 1981, Sommeijer *et al.* 1983). Other authors note the importance of the study of social bees in the context of plant communities, as subgeneralists and as efficient pollinators of particular plant species (Heinrich and Raven 1972, Bawa and Opler 1975, Hubbell and Johnson 1977, Engel and Dingemans-Bakels 1980, Rissman 1983, Roubik 1989, Ramalho *et al.* 1994).

In this study, pollen transported by workers of a meliponine bee, *T. williana*, was analyzed in order to infer possible floral preferences. Though few data (Marques-Souza 1993) are published about this species, it is well known to bee keepers of the central Amazon area, being prized for its docility and high quality honey. Data on food preferences is thus of value to anyone interested in domesticating the colonies of this bee.

MATERIAL AND METHODS

One colony of *T. williana* was introduced on the campus of the National Institute for Amazon Research (INPA) in Manaus. The site is located at 3°08'S, 60°10'W, 40 meters above sea level. The campus includes many introduced plant species not found in the native forest, many native secondary forest species and — according to Prance (1975) and Gentry (1978) — some primary forest species which sprouted from stumps, in a mixture with the secondary species, because the area was not burned when originally cut.

Pollen was collected every other day for one year between 07:00 and 09:00 hrs. This was done by briefly closing the entrance to the nest and randomly capturing five arriving workers that had pollen loads. After removal of their pollen loads with a blunt needle the workers were released. The pollen clusters from each day's collection were stored together in a sealed sterile glass vial.

Pollen was prepared for identification with a light microscope by adding one ml of glacial acetic acid, leaving for 24 hrs. The samples were then subjected to acetolysis by the method of Erdtman (1960) and mounted on microscope slides in a glycerine/gelatine mixture sealed under a cover slip with paraffin.

Identifications were made by comparison with the large reference pollen collection at INPA and by consulting appropriate literature. Identification was generally possible to the plant genus level and sometimes to the level of plant species. When more than one pollen type occurred in a plant family, but could not be identified to genus, each morpho-type received a code number, e.g. Arecaceae type 1, Arecaceae type 2, Arecaceae type 3, etc. Only one morpho-type could not be identified to the family level; this was denominated *Swartzia* type (undetermined).

About five hundred pollen grains were counted per daily sample. All grains were grouped into plant families and the percentage contributed by each family was computed for each sample in accordance with the method of Vergeron (1964).

RESULTS AND DISCUSSION

All the plant species identified are listed in Table 1. In August, at the height of the dry season, 28 different species were utilized by the bees; while in March, the rainiest month of the year, only seven species were found (Fig. 1).

For August the most important pollen type by family was *Swartzia* type (37.0% of all

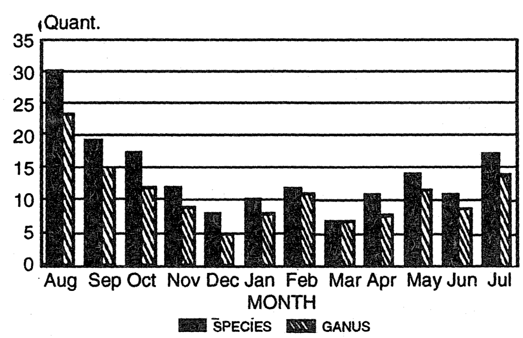

Fig. 1. Number of plant species visited by *Trigona williana.*

pollen grains) followed by Myrtaceae (27.7%), Arecaceae (12.5%), Bignoniaceae (11.4%) and Melastomataceae (6.3%) (Fig. 2). In September the Arecaceae became dominant (31.5%) while a different mixture of plant families grew in importance. Arecaceae continued to increase until November, when it accounted for 76.7% of all pollen grains, stabilizing near this level for the following months (Figs. 2 and 3). Eleven species of Arecaceae were identified. Presence/absence scoring over 12 months for

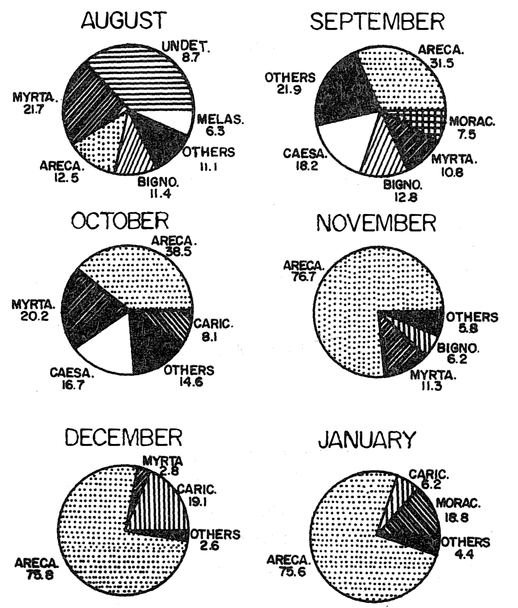

Fig. 2. Relative abundance of pollen types, grouped by familly, collected by *Trigona williana* from August 1988 to January 1989.

some of the palms were: *Maximiliana martiana* (11 months), *Cocos nucifera* (10 months), *Astrocaryum* sp. and *Elaeis oleifera* (4 months), and *Bactris gasipaes* (3 months). Five other palm species were collected during just two months while *Oenocarpus bacaba* was found in one month only (Table 1).

The palms, with their large inflorescences present almost year-round, are a major source of pollen for their visitors, as noted by Marques-Souza *et al.* (1993a). Bees which visit palms, including *T. williana*, are opportunistic pollen thieves, effecting pollination only occasionally and accidentally (Absy *et al.* 1984, Marques-Souza *et al.* 1993a). The main pollinators of the palms mentioned above are small

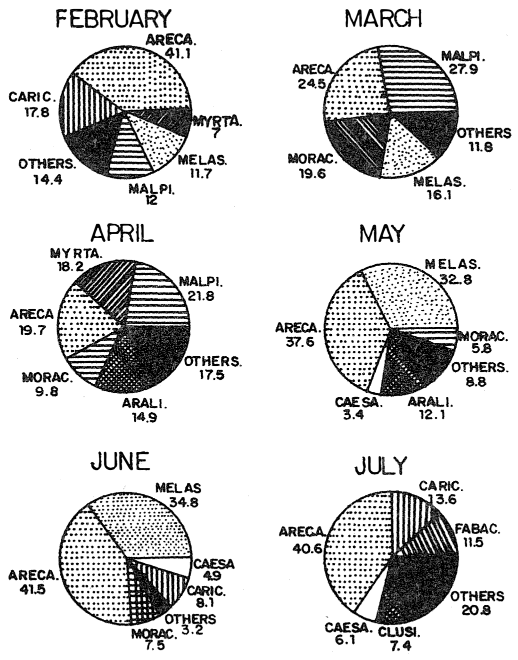

Fig. 3. Relative abundance of pollen types, grouped by family, collected by *Trigona williana* from February to July, 1989.

curculionid beetles (Silva *et al.* 1987, Miranda and Clement 1990). These sedentary insects do not inhibit pollen collection by bees.

Inflorescences of the peach palm, *B. gasipaes*, were visited by three species of meliponine bees — *T. williana, T. branneri* and *T. fulviventris guianae* —, which collected pollen from a dense white carpet of male flowers fallen on the ground at the base of the plant (Marques-Souza pers. obs.). Ramirez W. (pers. comm.) has also observed this behavior in honeybees (*Apis mellifera*) visiting flowers on the ground under the Cuban royal palm. This behavior may be due to the difficulty large bees have in prying open the small, tightly closed floral parts when the flowers are still on the tree, or the difficulty of reaching tall plants (Ramirez W., pers. obs.). Furthermore, the pollen of *B. gasipaes* is dry, and non-sticky at anthesis to facilitate wind dispersal. This probably makes it difficult for bees to accumulate a pollen load. After the flowers fall to the humid ground the grains become stickier (Miranda, pers. comm.) so they can be gathered into pollen loads and carried off by *T.*

TABLE 1

Monthly variation in pollen types collected by Trigona williana *from August 1988 to July 1989*

	MONTHS											
FAMILY/SPECIES	8	9	10	11	12	1	2	3	4	5	6	7
AMARANTHACEAE												
Celosia sp.			+									
ANACARDIACEAE												
Spondias mombim			+									
ARALIACEAE												
Schefflera morototoni									+	+		
ARECACEAE												
Astrocaryum sp.	+		+	+		+						
Bactris gasipaes	+		+	+								
Cocos nucifera		+	+	+	+	+	+	+		+	+	+
Elaeis oleifera	+	+					+					+
Euterpe oleracea									+	+		
Mauritia flexuosa	+	+										
Maximiliana martiana	+	+	+	+	+	+	+	+	+	+	+	
Oenocarpus bacaba	+											
Type 1	+			+								
Type 2					+	+						
Type 3							+		+			
BIGNONIACEAE												
Arrabidaea sp.	+	+										+
Type	+	+	+	+	+	+					+	+
BOMBACACEAE												
Matisia cordata												+
Type 1	+	+		+	+					+	+	+
Type 2			+									

CAESALPINIACEAE												
Bauhinia purpurea	+											
Cassia latifolia			+									
Cassia quangulata											+	
Cassia siamea					+							
Cassia sp.		+	+			+	+	+	+	+		
CAESALPINIACEAE												
Cynometra sp.	+											
Swartzia sp.												+
CARICACEAE												
Carica papaya	+	+	+	+	+	+	+		+	+	+	+
CLUSIACEAE												
Clusia sp.												+
CONVOLVULACEAE												
Merremia sp.		+	+									
CUCURBITACEAE												
Cucurbita sp.				+	+							+
EUPHORBIACEAE												
Mabea caudata	+	+										
Mabea occidentalis	+											
FABACEAE												
Dalbergia sp.	+	+										
Derris sp.	+											
Desmodium sp.												+
Macrolobium sp.					+	+				+	+	+
FLACOURTIACEAE												
Lindackeria sp.							+					
MALPIGHIACEAE												
Byrsonima sp.							+	+	+	+		
MELASTOMATACEAE												
Bellucia grossularioides	+	+					+	+	+	+	+	+
Miconia sp.										+		
MIMOSACEAE												
Mimosa pudica						+					+	
MORACEAE												
Artocarpus incisa	+	+				+	+	+	+	+	+	
MYRTACEAE												
Eugenia stipitata	+						+					
Myrcia amazonica	+	+										
MYRTACEAE												
Myrcia sp.	+	+	+	+								+
Psidium acutangulum	+	+	+		+							
Psidium sp.			+									
Syzygium jambolanum	+								+			
NYCTAGINACEAE												
Neea sp.		+	+									
OCHNACEAE												
Ouratea sp.	+											
POACEAE												
Type		+										
PORTULACACEAE												
Talinum sp.		+										
SOLANACEAE												
Solanum caavurana												+
VERBENACEAE												
Stachytarpheta cayennensis	+						+	+	+		+	+
Vitex sp.	+											
UNDETERMINED												
Type *Swartzia*	+	+								+		

williana, T. branneri and T. fulviventris guianae.

Though *T. williana* workers did collect from plant species with small pollen grains, such as *Byrsonima* sp., *Miconia* sp., *Bellucia grossularioides* and *Myrcia* sp., they showed a preference for the medium to large size grains of Arecaceae, Bignoniaceae and Caricaceae. Cortopassi-Laurino and Ramalho (1988) determined that *Apis mellifera* workers do not collect pollen grains larger than 71 mm in diameter, while *T. spinipes* workers, which prefer grains in the range of 20-30 mm (medium size), will nonetheless collect grains up to 100 mm in diameter (large size).

Though not yet supported by enough data, one can infer that *T. williana* prefers pollen of Arecaceae, Bignoniaceae and Caricaceae because of the large grain size, which permits a more rapid accumulation of a large pollen load and fewer visits. Silveira (1991), working with pollen loads of several bees, determined that *Croton* sp. and Gramineae were more important by volume than families with a larger number of pollen grains, such as Myrtaceae. It is possible that the time spent to accumulate a full load of medium to large size grains is less than the time required for smaller grains.

Preference for pollen of different species also depends on other parameters, among which the nutrient content in the form of proteins, sugars, vitamins, enzymes, etc. Few studies have shown large pollen grains to supply all the nutrients required by a bee. If this were the case they would not collect small grains. For the Agavaceae, protein content has been reported as being 20-30%, occasionally 40% (Stanley and Linskens 1974). Miranda (1993) found that a gram of fresh pollen from the palm *B. gasipaes* contained 223 micrograms of protein, in addition to 2,860 micrograms of total soluble sugars and 132 micrograms of reductive sugars. She also determined that eight macronutrient elements were present as well as twelve micronutrient elements. This type of analysis should be applied to plant species with small pollen grains to determine whether bees make their choice based on the nutrient content of the pollen (Louveaux 1968).

Another important determinant of a potential pollinator's choice of plants lies in the ability of a flower to attract bees using color, size, odor, time of opening, etc. The height and position of a flower on a plant are of some importance to visitors (Ramirez W. pers. com.). Flower morphology may also aid or inhibit pollen collection by certain insects species. For example, poricidal anthers make it difficult for *Trigona* workers to obtain pollen since they lack the ability to buzz pollinate. Nonetheless, *T. williana* did manage to obtain pollen from the poricidal anthers of *B. grossularioides*, *Miconia* sp. (Melastomataceae) and *Solanum caavurana* (Solanaceae), as well as four species of *Cassia* (Table 1). These are exploited by destroying the anther (Michener 1962; Renner 1983). Kerr (pers. comm.) notes that these species have pollen with a high protein content, which justifies the extra effort expended.

To obtain nectar from flowers with tubiform corollas, *T. williana* bees perforate the corolla at the base, damaging the flower (Roubik 1982; Marques-Souza *et al.* 1993b). Oil produced by glandular hairs in the tubular corolla of *Drymonia serrulata* (Gesneriaceae) is obtained by workers of *T. pallens*, also using destructive methods (Steiner 1985).

T. williana workers may monopolize the flowers of a host plant, not allowing other meliponine bees to approach (Marques-Souza 1993). Such behavior is not observed, however, on plants with very abundant pollen, including *Spondias mombim* (Anacardiaceae), *Lindackeria* sp. (Flacourtiaceae), *Byrsonima* sp. (Malpighiaceae), *Mimosa pudica* (Mimosaceae), *Miconia* sp. (Melastomataceae) and *Myrcia* sp. (Myrtaceae). These species have their flowering peaks in August, which is the early dry season. During the rainy season alternative plant species must be found and competition is more intense. Both inter and intra-specific agressive interactions are observed (Roubik 1980, Le Thomas *et al.* 1988, Marques-Souza 1993b).

Another pattern observed for the colony of *T. williana* was fidelity to a single plant species during any one day or during a particular morning. Workers whose pollen loads were first collected at 07:00 hrs and hourly thereafter on a single morning showed little variation in pollen type. Generally, on the next day the pollen type would be different, but again they remained fairly constant during the morning. This may be due to the colony monopolizing a single highly attractive source plant each day coupled with a strategy of diversifying sources over a period of days.

Regarding foraging strategy of individuals, during the entire month of August each worker carried only one type of pollen. Only on two occasions was a slight amount of a second pollen type found mixed on the corbiculae of an individual. This may have been a remnant from a previous collection or cross-species contamination within the flower visited by the bee.

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RESUMEN

Se analizó el polen recolectado por obreras de *Trigona williana* durante el período de un año. Las familias de plantas más visitadas fueron Arecaceae, Melastomataceae y un poco atrás Myrtaceae, Caricaceae, Moraceae y Malpighiaceae. De las clases de pollen colectados en el período de estudio se destacan entre otros: *Cocos nucifera, Maximiliana martiana, Cassia* sp., *Carica papaya, Bellucia grossularioides, Artocarpus incisa* y *Stachytarpheta cayennensis*. Se observó que las colectas de polen por las abejas trigonas puede estar relacionada con posibles cambios climáticos o el patrón de floración de las diferentes especies de plantas, pues en el período lluvioso hubo disminución del número de especies vegetales colectadas por esa abeja.

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