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ORIGINAL ARTICLE – Conservation of Nature

Pollen Spectrum of Honey from the Bee *Melipona subnitida* Ducke (1910) in Restinga in Maranhão State

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Abstract

The study aimed to analyze the honey of *Melipona subnitida* to identify the plants visited by these bees in colonies installed in a restinga vegetation in Maranhão state. Honey was collected monthly from July/2017 to June/2018. The honey samples were submitted to the acetolysis method and the pollen grains were analyzed qualitatively and quantitatively. The pollen analysis of honey resulted in 54 pollen types and 26 families. The largest pollen variety was registered in Fabaceae. Quantitative analyzes of pollen grains in honey samples revealed that three were monofloral, in July/2017 with *Avicennia germinans* honey and December/2017 and January/2018 with *Copaifera martii* honey. In the other months, the heterofloral honeys. *Melipona subnitida* proved to be general in food gathering. Knowing the flora used by *M. subnita* contributes to the meliponiculturists to improve the handling of the colonies, the increase and quality in the production of honey.

Keywords: Delta do Parnaíba, Dunes, meliponiculture, mangrove, pollen spectrum.

1. INTRODUCTION AND OBJECTIVES

Native stingless bees comprise the species belonging to the tribe Meliponini out of the family Apidae, which include the representatives of the genus *Melipona* (Michener, 2007). This genus comprises the largest number of species in Brazil, being highlighted for its great richness in biodiversity (Camargo & Pedro, 2007).

Among the bees of the genus *Melipona*, the specie *Melipona subnitida* Ducke (1910), popularly known as jandaíra, is one of the most suitable species for breeding in semiarid environments (Cruz et al., 2004), due to its adaptations to the stressful conditions of this environment (Maia-Silva et al., 2015). Although the species occurs commonly in caatinga areas, Rêgo & Albuquerque (2006) found it in Maranhão in a restinga area, after 14 years of not appearing in works with apifaunistic surveys. More recently, it has been colonizing other environments such as mangroves, thus expanding the spectrum of plants used in its foraging (Rêgo et al., 2017).

Stingless bees are extremely connected to their environment by its floral resources (Villas-Bôas, 2012). Bees search for essential nutrients for their development and maintenance of broods and colonies. Therefore they collect nectar, pollen, and water.

During the search for these resources, when collecting nectar, forages also involuntarily collect pollen, and this pollen appears in honey. The pollen serves as an indicator

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of botanical and geographical origin of the honey (Barth, 1989). Furthermore is possible to evaluate those data of the pollen spectra in the honey samples and identify possible preferences (Luz & Barth 2012; Pinto et al. 2014; Costa et al. 2017; Caravela et al. 2019).

According to Rêgo et al. (2017), identifying plant species used by bees as food resources is extremely important to assess their potential food sources for maintaining their colonies and brood production, and to assist honey farmers to choose plant species grown in their areas. Thus, the objective of this work was to identify the plants visited by *Melipona subnitida* using/examining pollen profile present in honey samples from colonies housed in "caboclas" boxes (Venturieri et al., 2003) in the Restinga area. This study will contribute information that will increase the knowledge about the honey plants of Maranhão.

2. MATERIALS AND METHODS

2.1. Study area

Ilha Grande do Paulino is located in the municipality of Tutóia and falls within the Delta do Parnaíba Environmental Protection Area (2°43'58.2"S/42°11'23.4"W) (Figure 1 and 2). The island is one of the largest in the Parnaíba Delta with approximately 4,302 hectares. The climate is classified as Aw (tropical with dry winter season) according to the classification Köppen & Geiger (1928). The area is marked by two seasons: the dry season from July to December and the rainy season from January to June (Oliveira & Frota, 2011). During the rainy season the precipitation is intense. The natural environment is made up of different types of soil, with sandy or clayey soils, the latter almost always in areas that are seasonally flooded (Prompt, 2010).

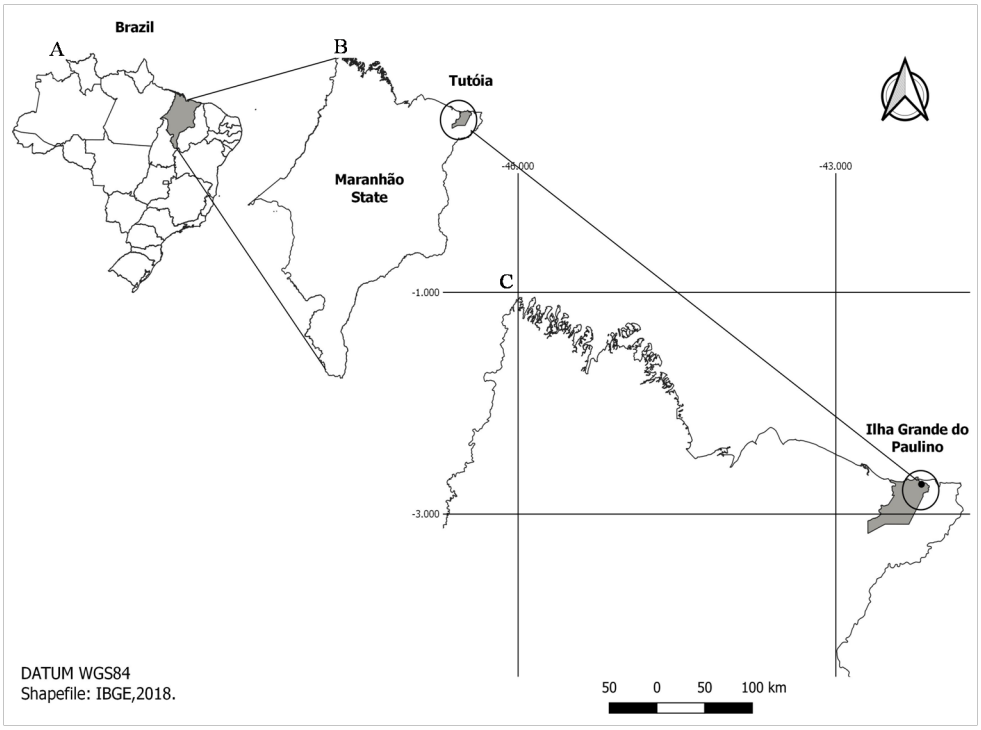

Figure 1. Location map of the study area. **A**- Map of Brazil with emphasis on the Maranhão state; **B**- Map of the state of Maranhão, showing the location of the study area in relation to the state; **C**- Magnification of the map showing Ilha Grande do Paulino, municipality of Tutóia.

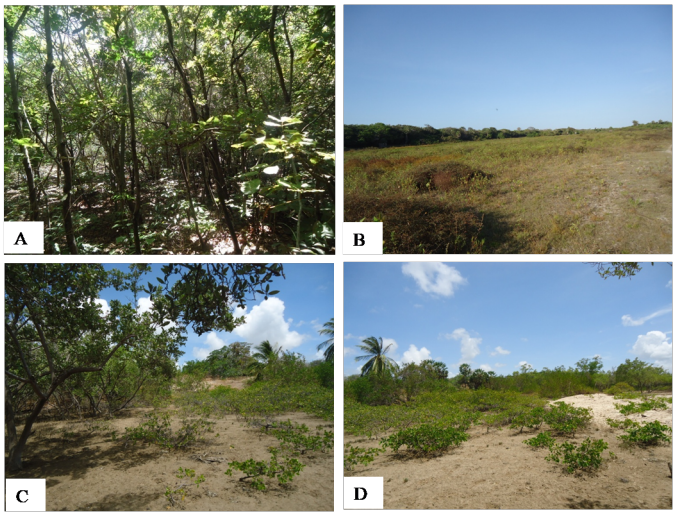

Figure 2. Partial view of restinga vegetation (A and B) and mangrove (C and D), Ilha Grande do Paulino, municipality of Tutóia, Maranhão state.

2.2. Collection of honey and pollen analysis

In total, 48 samples of honey were obtained from colonies of *Melipona subnitida* in the period from July/2017 to June/2018. The bee colonies were, housed in four "caboclas" boxes (Venturieri et al., 2003), in the same period in which the botanical material was collected. A total of 10 mL of honey was obtained from each colony with the aid of a syringe, being placed in a Falcon tube.

At the Bee Studies Laboratory (LEA), all honey samples were prepared according to the standardized method of Louveaux et al. (1970). This method consists of dissolving 10 mL of honey in 20 mL of distilled water and centrifuging at 2000 rpm for 5 minutes. The supernatant was discarded and the sediments deposited at the bottom of the test tube subjected to the acetolysis method (Erdtman, 1960). After the acetolysis process, the pollen grains at the bottom of the test tube were collected by means of a glycerin gelatin cube and then sealed with paraffin.

Pollen grains were analyzed qualitatively and quantitatively. Quantitative analysis was performed by counting pollen grains per sample, determining percentages, and defining the following frequency classes: dominant pollen (> 45%), accessory pollen (15-44%), important isolated pollen (3-14%), and isolated or occasional pollen (<3%) (Maurizio & Louveaux, 1965; Barth, 1989). To classify plants into polyniferous or nectariferous, searches were carried out in bibliographies and specialized sites.

In the qualitative analysis, the pollen types in the honeys were determined through comparison with reference slides made from flower buds of plant species collected in the study area, with the help of specialized literature and consultations with specialists. Slides of pollen were made and deposited in the reference palynotheca of the Bee Studies Laboratory, and the exsiccates filed in the MAR Herbarium of the Universidade Federal do Maranhão - UFMA. The APG IV (2016) classification system was adopted and the revision and updating of the names of the taxa were carried out using the electronic database made available by Flora do Brasil 2020 (2019).

For the elaboration of the similarity dendrogram (Bray Curtis index), data related to the months of collection were used, using the Software Past, version 2.17c (Hammer et al., 2001) was used in order to verify the similarity of the samples of honeys from the colonies in the different periods.

3. RESULTS

From pollen analyzes of *Melipona subnitida* honey, 54 pollen types were identified (Figure 3 and Table 1), distributed in 38 genera and 26 families. The largest variety of pollen was found in the families Fabaceae (15%), Myrtaceae, Amaranthaceae, Arecaceae, and Rubiaceae (5%, each), and Poaceae, Plantaginaceae, and Polygonaceae (4%, each). The other families were represented by one single type. Of the 54 pollen types found, 23 are from nectariferous plants (Table 1).

We found that only 4% of pollen types are dominant pollens, 9% accessory pollens, and 87% isolated pollens. The pollen types considered isolated were quite frequent in the samples, with 15% important isolated pollens (PIi) and 85% occasional isolated pollens (PIo). Anemophilous pollen was found in honey samples in March, April, and May 2018, which were recorded as occasional isolated pollen (PIo).

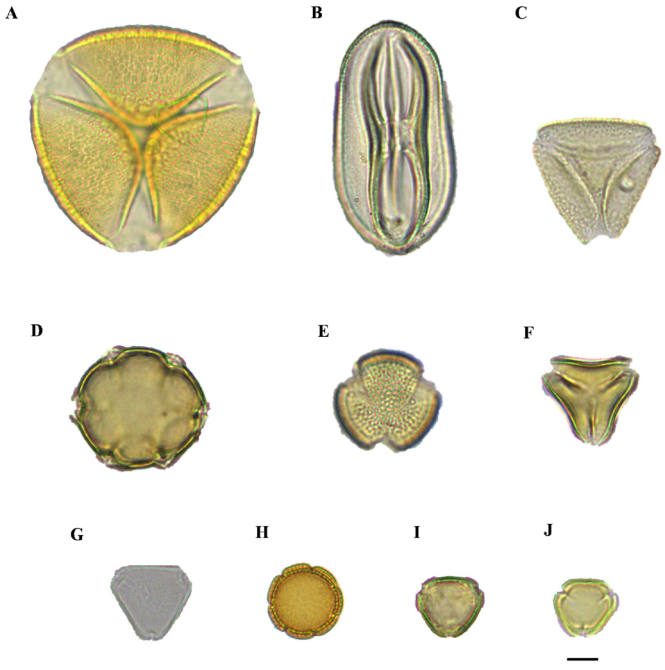

Figure 3. Photomicrographs of pollen types of the most frequent species, foundin honey samples from *Melipona subnitida* on Ilha Grande do Paulino, Tutóia-MA. **A**- *Neptunia plena* (L.) Benth., **B**- Tipo *Chamaecrista*, **C**- *Nymphoides humboldtiana* (Kunh) Kuntze, **D**- *Manilkara* sp., **E**- *Avicennia germinans* (L.) L., **F**- *Copaifera martii* Hayne var. *martii*, **G**- *Myrcia multiflora* (L.) DC., **H**- Tipo *Borreria*, **I**- *Ouratea fieldingiana* (Gardner) Engl., **J**- *Rhizophora mangle* L. Scale bar= 10µm.

Pollen from *Copaifera martii*, considered as polyniferous and nectariferous, was dominant in December 2017 and January 2018, and classified as accessory pollen in the months of February, March, and April 2018. *Myrcia multiflora*, which is only polyniferous, presented dominant pollen in the months of August and November 2017 and accessory in September and October 2017; and in the months of January, February, March, May, and June 2018. These two species were observed over the 12 months in the honey samples.

Quantitative analyzes of pollen grains in the honey samples shower that three of the samples were monofloral, that of July with *Avicennia germinans* honey and that of December and January with *Copaifera martii* honey. In the other months, the samples demonstrated heterofloral honeys.

Pollens from only two mangrove species, *Avicennia germinans* and *Rhizophora mangle*, were found in the honey samples, while all the other pollens were from plants in the restinga area.

Pollen types of species of exotic plants with available nectar located very close to the meliponary, such as *Psidium* sp. and *Syzygium* sp., were not found in honey samples, demonstrating the preference of bees for native species or the region. However, the native species *Anacardium occidentale* ("caju"), despite being quite common on the island, was not observed in honey samples. The pollens of *Nymphoides humboldtiana* and *Neptunia plenum*, common species of wetlands and observed close to the meliponary, were detected at low frequency.

Due to the great difficulty in determining some pollen types, it was decided to include species with the same or similar pollen grains. This occurred with six pollen types, in the case of the *Borreria* type, there may be species of *Borreria verticilata* and *Mitracarpus strigosus*, and for the *Chamaecrista* type there may be *C. calycioides*, *C. diphylla*, *C. flexuosa,* and/or *C. ramosa*.

In the similarity dendrogram, the honey samples formed two groups (Figure 4). The December/2017-June/2018 samples were grouped with 40% similarity. The July/2017-November/2017 samples presented 35% similarity. In the first group, the months of December/2017 and January/2018 demonstrated 81.25% similarity between the species (*Copaifera martii*, and *Myrcia multiflora*). In group two, the months of August and October 2017 presented 81.41% similarity (*Avicennia germinans*, and *Myrcia multiflora*) (Table 1).

Table 1. Relative frequency of pollen types found in honey samples of *Melipona subnitida* from July 2017 to June 2018 on Ilha Grande do Paulino, Tutóia, Maranhão state. Abbreviations: PD-dominant pollen, PA-accessory pollen, PIi- important isolated pollen, PIo- occasionally isolated pollen. RF-Floral Feature, N-Nectar, P-Pollen, Re-Resin, O-Oil. *-classification based on the plant genus. #-Data not found. R- References about main resource available: 1 - Tomlinson (1994); 2 - Aleixo et al. (2014); 3 - Talebi et al. (2016); 4 - Maia-Silva et al. (2012); 5 - Oliveira et al. (2003); 6 - Kaminski and Absy (2006); 7 - Lima (2009); 8 - Dutra et al. (2009); 9 - Freitas and Oliveira (2002); 10 - Campos Filho (2012); 11 - Carvalho (2007); 12 - RCpol (2020); 13 - Albuquerque et al. (2013); 14 - Abreu (2010); 15 - Oliveira et al. (2015); 16 - Hellmuth (2020); 17 - Oliveira (2009); 18 - Vasconcelos et al. (2019); 19 - Carneiro (2013); 20 - Silva (2012); 21 - Novo (2010); 22 - Duke and Allen (2005); 23 - Lopes et al. (2016); 24 - Figueiredo (2001); 25 - Silva et al. (1986/87); 26 - Henriques (1999).

FAMÍLY	POLYNIC TYPE	RF/R	2017							2018				
			Jul (%)	Aug (%)	Sep (%)	Oct (%)	Nov (%)	Dec (%)	Jan (%)	Feb (%)	Mar (%)	Apr (%)	May (%)	Jun (%)
Acanthaceae	*Avicennia germinans* (L.) L.	N/1	55.33 (PD)	16.17 (PIi)	34.33 (PA)	11.08 (PIi)	0.50 (PIo)	2.33 (PIo)	1.00 (PIo)	-	-	-	-	-
Amaranthaceae	*Alternanthera brasiliana* (L.) Kuntze	N/2	0.17 (PIo)	-	-	-	-	-	-	-	-	-	-	3.33 (PIi)
	Amaranthus viridis L.	P/3	-	-	0.08 (PIo)	-	-	0.08 (PIo)	-	-	-	-	-	-
	Froelichia humboldtiana (Roem. & Schult.) Seub.	N/4	-	-	-	-	-	-	0.08 (PIo)	-	-	-	-	-
Arecaceae	*Astrocaryum vulgare* Mart.	P/5	0.08 (PIo)	0.08 (PIo)	-	-	-	0.08 (PIo)	0.08 (PIo)	0.25 (PIo)	-	-	0.17 (PIo)	0.33 (PIo)
	Elaeis sp.	P/25*	-	-	-	-	-	-	-	0.08 (PIo)	-	-	-	-
	Tipo Arecaceae 1	-	-	-	-	-	-	-	-	0.33 (PIo)	-	-	-	-
Asteraceae	*Mikania cordefolia* (L.f.) Willd.	NP/2	-	-	-	-	-	-	-	-	0.25 (PIo)	-	0.08 (PIo)	-
Boraginaceae	*Euploca polyphylla* (Lehm.) J.I.M. Melo & Semir	N/4	1.92 (PIo)	-	0.08 (PIo)	-	-	-	-	5.83 (PIi)	5.42 (PIi)	0.33 (PIo)	-	0.92 (PIo)
Clusiaceae	*Clusia panapanari* (Aubl.) Choisy.	ReP/6	-	-	-	-	-	-	0.17 (PIo)	-	-	-	0.17 (PIo)	-
Combretaceae	*Conocarpus erectus* L.	N/7	-	0.25 (PIo)	1.58 (PIo)	0.33 (PIo)	-	-	-	-	-	-	-	-
Fabaceae	*Andira surinamensis* (Bondt) Splitg. ex Amshoff	N/8	-	-	-	0.08 (PIo)	-	-	-	-	-	-	-	-
	Copaifera martii Hayne var. *martii*	N/9*	7.58 (PIi)	1.00 (PIo)	0.92 (PIo)	2.83 (PIo)	14.59 (PIi)	75.25 (PD)	60.33 (PD)	23.50 (PA)	22.25 (PA)	16.25 (PA)	14.75 (PIi)	10.58 (PIi)
	Enterolobium timbouva Mart.	N/10	-	-	-	-	-	0.08 (PIo)	-	-	-	-	-	-
	Mimosa caesalpiniifolia Benth.	NP/11	-	-	-	-	-	-	-	0.08 (PIo)	-	-	0.08 (PIo)	-
	M. candollei R.Grether.	NP/12	-	0.08 (PIo)	-	-	-	-	-	-	-	-	-	-

Table 1. Continued...

FAMÍLY	POLYNIC TYPE	RF/R	2017								2018			
			Jul (%)	Aug (%)	Sep (%)	Oct (%)	Nov (%)	Dec (%)	Jan (%)	Feb (%)	Mar (%)	Apr (%)	May (%)	Jun (%)
	Neptunia plena (L.) Benth.	N/13	2.08 (PIo)	-	0.17 (PIo)	-	0.17 (PIo)	0.08 (PIo)	-	-	0.75 (PIo)	0.75 (PIo)	2.00 (PIo)	3.58 (PIi)
	Tipo *Chamaecrista*	-	15.25 (PA)	1.58 (PIo)	2.50 (PIo)	1.92 (PIo)	0.17 (PIo)	1.42 (PIo)	0.67 (PIo)	1.92 (PIo)	1.67 (PIo)	0.58 (PIo)	25.67 (PA)	18.58 (PA)
	Tipo Fabaceae	-	-	-	-	-	2.32 (PIo)	-	-	-	-	-	-	-
Lamiaceae	*Mesosphaerum suaveolens* (L.) Kuntze	N/12	-	0.67 (PIo)	-	-	-	-	-	-	-	-	-	-
Loranthaceae	*Psittacanthus robustus* (Mart.) Mart.	N/14	-	-	-	-	-	0.08 (PIo)	-	-	-	-	-	-
Malpighiaceae	*Byrsonima* sp.	PO/10	-	1.83 (PIo)	2.75 (PIo)	1.17 (PIo)	-	-	-	0.25 (PIo)	0.08 (PIo)	-	0.33 (PIo)	-
Melastomataceae	*Mouriri cearensis* Huber	PO/15	-	-	0.08 (PIo)	-	-	-	-	-	-	-	-	-
Menyanthaceae	*Nymphoides humboldtiana* (Kunh) Kuntze	NP/16	0.58 (PIo)	-	-	0.08 (PIo)	-	0.08 (PIo)	-	-	-	0.17 (PIo)	0.08 (PIo)	0.42 (PIo)
Myrtaceae	*Campomanesia aromatica* (Aubl.) Griseb.	P/17	-	-	-	-	-	-	-	0,08 (PIo)	-	-	0.25 (PIo)	0.08 (PIo)
	Eugenia biflora (L.) DC.	P/18	-	-	-	-	0.83 (PIo)	-	7.17 (PIi)	0.25 (PIo)	0.67 (PIo)	5.33 (PIi)	0.17 (PIo)	1.67 (PIo)
	Myrcia multiflora (L.) DC.	P/18	12,17 (PIi)	68.33 (PD)	48.25 (PD)	63.67 (PD)	76.12 (PD)	15.25 (PA)	24.17 (PA)	27.33 (PA)	18.33 (PA)	17.75 (PA)	20.50 (PA)	18.58 (PA)
Nyctaginaceae	*Guapira* aff. *noxia* (Netto) Lundell	N/19*	-	-	-	-	-	-	0.33 (PIo)	1.75 (PIo)	0.08 (PIo)	0.08 (PIo)	0.08 (PIo)	0.08 (PIo)
Piperaceae	*Peperomia* sp.	#	-	0.17 (PIo)	0.50 (PIo)	-	-	-	-	-	-	-	-	-
Plantaginaceae	*Scoparia dulcis* L.	P/12	-	-	-	0.08 (PIo)	-	-	-	3.17 (PIi)	3.42 (PIi)	0.92 (PIo)	0.42 (PIo)	1.00 (PIo)
	Bacopa angulata (Benth.) Edwall	#	-	-	-	-	-	-	-	0.08 (PIo)	-	-	-	-
Poaceae	*Cenchrus echinatus* L.	#	-	-	-	-	-	-	-	-	-	-	0.17 (PIo)	-
	Tipo Poaceae	-	-	-	-	-	-	-	-	-	0.50 (PIo)	0.75 (PIo)	2.17 (PIo)	-
Polygonaceae	*Coccoloba ramosissima* Wedd.	N/20	-	-	-	-	-	-	-	0.42 (PIo)	-	-	-	-
	Coccoloba sp.	N/20*	-	-	-	-	-	-	-	13.92 (PIi)	3.42 (PIi)	36.33 (PA)	3.17 (PIi)	0.50 (PIo)

Table 1. Continued...

FAMÍLY	POLYNIC TYPE	RF/R	2017							2018				
			Jul (%)	Aug (%)	Sep (%)	Oct (%)	Nov (%)	Dec (%)	Jan (%)	Feb (%)	Mar (%)	Apr (%)	May (%)	Jun (%)
Rubiaceae	*Guettarda angelica* Mart. ex Müll.Arg.	N/21*	-	-	-	-	-	-	1.08 (PIo)	2.17 (PIo)	0.08 (PIo)	-	-	-
	Tipo *Borreria*	-	0.50 (PIo)	0.25 (PIo)	0.33 (PIo)	0.08 (PIo)	-	-	-	13.75 (PIi)	34.58 (PA)	16.33 (PA)	5.75 (PIi)	6.92 (PIi)
	Tipo *Palicourea*	-	-	-	-	-	-	-	-	0.08 (PIo)	-	0.08 (PIo)	-	-
Rhizophoraceae	*Rhizophora mangle* L.	P/22	1.17 (PIo)	-	0.08 (PIo)	-	-	0,42 (PIo)	0.83 (PIo)	1.17 (PIo)	2.33 (PIo)	3.08 (PIi)	21.17 (PA)	0.83 (PIo)
Rutaceae	*Zanthoxylum* sp.	N/19*	-	-	-	-	-	-	-	0.42 (PIo)	0.67 (PIo)	0.50 (PIo)	0.42 (PIo)	0.67 (PIo)
Sapotaceae	*Manilkara* sp.	N/20*	2.58 (PIo)	0.25 (PIo)	-	0.33 (PIo)	-	-	0.08 (PIo)	-	-	-	-	28.81 (PA)
Ochnaceae	*Ouratea fieldingiana* (Gardner) Engl.	P/26	-	-	-	15.92 (PA)	1.99 (PIo)	4.58 (PIi)	3.50 (PIi)	2.33 (PIo)	4.50 (PIi)	0.08 (PIo)	0.75 (PIo)	2.33 (PIo)
Turneraceae	*Turnera melochioides* Cambess.	NP/23	0.33 (PIo)	9.17 (PIi)	8.33 (PIi)	2.33 (PIo)	2.32 (PIo)	0.17 (PIo)	-	0,17 (PIo)	0.92 (PIo)	0.17 (PIo)	1.42 (PIo)	0.58 (PIo)
Verbenaceae	*Petrea volubilis* L.	N/24	-	-	-	-	-	-	-	0.33 (PIo)	-	0.17 (PIo)	-	-
Não identificados	Tipo Indeterminado 1	-	0.25 (PIo)	-	-	-	-	-	-	-	-	-	-	-
	Tipo Indeterminado 2	-	-	0.17 (PIo)	-	-	-	0.08 (PIo)	-	-	-	-	-	-
	Tipo Indeterminado 3	-	-	-	-	0.08 (PIo)	-	-	-	-	-	-	-	-
	Tipo Indeterminado 4	-	-	-	-	-	-	-	0.50 (PIo)	0.25 (PIo)	0.08 (PIo)	0.08 (PIo)	-	-
	Tipo Indeterminado 5	-	-	-	-	-	-	-	-	0.08 (PIo)	-	-	-	-
	Tipo Indeterminado 6	-	-	-	-	-	-	-	-	-	-	0.25 (PIo)	-	0.08 (PIo)
	Tipo Indeterminado 7	-	-	-	-	-	-	-	-	-	-	-	0.25 (PIo)	-
	Tipo Indeterminado 8	-	-	-	-	-	-	-	-	-	-	-	-	0.08 (PIo)
	Tipo Indeterminado 9	-	-	-	-	-	0.33 (PIo)	-	-	-	-	-	-	-
	Tipo Indeterminado 10	-	-	-	-	-	0.66 (PIo)	-	-	-	-	-	-	-

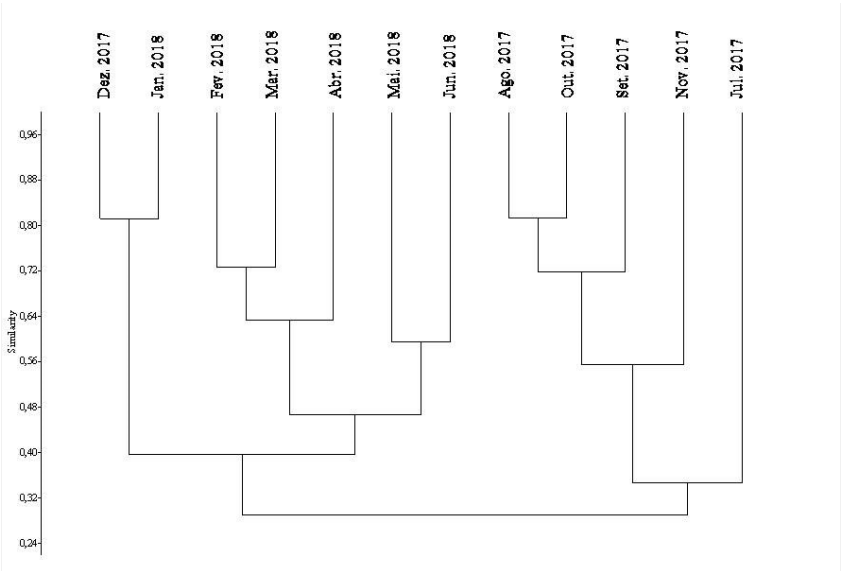

Figure 4. Similarity dendrogram of honey samples from the *Melipona subnitida* colonies from July 2017 to June 2018 in Ilha Grande do Paulino, Tutóia, Maranhão state.

4. DISCUSSION

Analyzes showed that *Melipona subnitida* uses a wide variety of plants to obtain its food (nectar and pollen), being considered a polyletic bee (Roubik, 1989), in different studies carried out in Brazil (Absy et al., 1980-Manaus; Kerr et al., 1986; Martins et al., 2011-Maranhão; Carvalho et al., 2001; Alves et al., 2006-Bahia; Radaeski et al., 2019-Rio Grande do Sul).

Pinto et al. (2014) and Costa et al. (2017) observed that *Melipona subnitida* uses a great diversity of flowers to acquire its food, although with differences in the species found. This variation in plants between regions can often be explained by the diversity and characteristics of the local flora, edaphoclimatic conditions, distance from colonies to available resources, and level of degradation of local vegetation (Carvalho et al., 2001).

The greatest pollen richness was found among Fabaceae, Myrtaceae, Amaranthaceae, Arecaceae, Rubiaceae, Poaceae, Plantaginaceae, and Polygonaceae. The Fabaceae, and Myrtaceae families are important in the diet of stingless bees (Ramalho et al., 1990). According to Souza et al. (2015), species of Fabaceae, mainly from the subfamily Mimosoideae, offer an abundance of nectar and pollen resources for bees. Some species of the Myrtaceae family, on the other hand, attract bees through the sweet scent exhaled by flowers, offering pollen to their visitors (Oliveira et al., 2009).

Pollens classified as isolated presented a high percentage (87%), and similar indices were found in other studies (Alves et al., 2006; Martins et al., 2011; Sousa et al., 2015). Pollen grains classified as Isolated Pollens are of little importance in terms of the amount of nectar supplied, however, they can provide data on the geographical origin of the sample (Barth, 1989). Pollen grains classified as occasional isolated pollen, which obtained 85%, are characteristic of Brazilian honeys according to Barth (1970).

The species *Mimosa caesalpiniifolia* and *Mimosa candolei* were recorded as Occasional Isolated Pollens (PIo). Species of this genus are suppliers of little nectar, but a lot of pollen (Barth, 1989). However, Carvalho (2007) considers that *M. caesalpiniifolia* is a plant that produces a large amount of pollen, and also an abundance of nectar, being classified for a long time as a polyniferous plant, not being included how nectariferous plants.

In several melissopalynology studies, species of the genus *Mimosa* appear in the pollen spectrum in almost every month of the year, and in some of them as dominant pollen (Alves et al., 2006; Oliveira et al., 2010; Martins et al., 2011; Costa et al., 2017). Perhaps some of the reasons for the low representativeness of *Mimosa* in honey samples on Ilha Grande do Paulino are related to the fact that one species (*Mimosa caesalpiniifolia*) does not occur close to the meliponary and these species have a short flowering period, only recorded in March. In general, the flowering of this species extends from April to June (Ribaski, 2003), while in Bahia the flowering peak occurs from April to May (Dohler & Pina, 2017).

Pinto et al. (2014) in a restinga area and with the bee *M. subnitida*, also found a low percentage of pollen (<3%) for *Mimosa caesalpiniifolia*, over four months (April, June, August, and October).

Another pollen considered Occasional Isolated Pollen was from anemophilous plants, such as species of Poaceae. These plants do not produce nectar, only large amounts of pollen that serve as proteins for bees (Barth, 2004; 2005).

Plants of the genus *Copaifera* produce nectar and pollen, with pollen being present in greater quantities than nectar (Rigamonte-Azevedo et al., 2004). A study carried out with *Copaifera langsdorffii* showed that the species only produces about 0.2 µl of nectar (Freitas & Oliveira, 2002). Although plants of this genus do not provide a large amount of nectar and, therefore, do not contribute to the production of honey, being considered important sources of proteins for maintaining colonies (Almeida-Anacleto et al., 2012; Pinto et al., 2014).

In several studies on honey analysis, large amounts of pollen from polliniferous plants are found, mainly from Myrtaceae (Martins et al., 2011; Pinto et al., 2014; Luz et al., 2019). The high representation of pollinating plants may be related to contamination (Barth 1989), between the bees forage with the nectar-receiving worker bees during the exchange of food, or it is due to the fact that the bees deposit the pollen grains collected in the honey pots (Costa *et al*. 2017).

The pollinating species *Myrcia multiflora* and the *Chamaecrista* type are important sources of food for bees, because the pollen types of these species appeared in the 12 months evaluated. *Avicennia germinans* despite occurring only in seven months, it also has great importance for bees in view of the large amount of nectar (Raju et al. 2012). Thus, the present study shows the need to conserve the species found in the pollen spectrum as they are important sources of resources for bees.

Analyzing the results of studies carried out with bees of the genus *Melipona*, it was observed that honeys are also heterofloral (Carvalho et al., 2001; Alves et al., 2006; Martins et al., 2011; Silva, 2016; Costa et al., 2017); being common in stingless bees (Souza et al., 2006).

Balata (2008), analyzing the honey of the stinging bee (*Apis mellifera*) in a mangrove area, observed that some plant species in this ecosystem contribute to the production of honey, with a high percentage of pollen from *Laguncularia racemosa* (47%). During the dry period, some apiarists in the state of Maranhão migrate their hives to the mangrove area, where they remain until the beginning of the rainy season, in order to increase honey production (Balata, 2008). This is because the mangrove species show annual variation in flowering and flower peaks from August to January (Fernandes, 1999).

Other plants that provide nectar for honey production are exotic plants. In Bahia, Carvalho et al. (2001) found dominant pollen from species of *Eucalyptus* spp. and *Psidium* sp. in honey of *Melipona scutellaris* Latreille. In Ceará, Aires & Freitas (2001) with the bee *Apis mellifera* L. found pollen of *Aloysia virgate* (Ruiz & Pav.) Juss., *Cocos nucifera* L., and *Eucalyptus* sp. that showed great potential for honey production.

The native species *Anacardium occidentale* is one of the main plants pollinated by stingless bees in search of nectar, mainly by *Melipona subnitida* (Maia-Silva et al., 2012), however, from the analyzes, the presence of pollen of this species was not observed in honey. Although the species is considered by the authors mentioned above as a plant pollinated by *Melipona subnitida*, Silva et al. (2014) pointed out that the cashew tree is not a good source of pollen or nectar, as bees visit it only because it blooms in the dry period.

In the analysis of tiúba honey (*Melipona fasciculata* Smith) performed by Martins et al. (2011), the species *Pontederia parviflora*, found in flooded areas of the Baixada Maranhense, was important for the production of honey. This plant offers nectar as the main resource and occurred as a dominant pollen in five months and an accessory in three months. *Neptunia plena* and *Nymphoides humboldtiana*, which demonstrate nectar availability and occur in flooded areas close to the study meliponary, presented isolated pollens.

In the analysis of similarity between the honey samples, two large groups were formed: Group 1 (December 2017 to June 2018) and Group 2 (July 2017 to November 2017). This may be related to rainfall in the region, with the dry period between July and December being recorded, and the rainy period from January to June (Oliveira & Frota, 2011). In Group 1 (rainy season) the largest number of pollen types was found, due to the greater number of species in flowering, providing a greater supply of food resources for bees (Moraes et al., 2020). The similarity between the December/2017 and January/2018 samples; August/2017 and October/2017 have in common the abundance of pollen grains from *Copaifera martii* and *Myrcia multiflora*; *Avicennia germinans* and *Myrcia multiflora*, respectively.

5. CONCLUSIONS

Based on the study carried out, 54 pollen types were identified confirming that *Melipona subnitida* is quite generalist in food collection, visiting several species in the restinga. The pollen profile of honey from the island of "Ilha do Paulino" is mainly made up of representatives of the family Fabaceae, Myrtaceae, Amaranthaceae, Arecaceae, Rubiaceae, Poaceae, Plantaginaceae, and Polygonaceae. In the analyzed samples, a large amount of isolated pollens was registered, demonstrating that the bees had no preference for any flowering. In the months of December 2017 and January and July 2018, honey was registered as monofloral. This can be explained by the preference of bees for flowering *Avicennia germinans* and *Copaifera martii*.

In all honey samples collected throughout the year, pollens of Fabaceae (*Copaifera martii*, *Chamaecrista* type) and Myrtaceae (*Myrcia multiflora*) were observed in their composition, showing the great meliponic potential of these plants in the region. Finally, knowing the plants visited by bees are important for meliponicultores to understand the relationship between meliponicola flora and their colonies, being able to invest in the colonies and consequently add more commercial value to the type of honey produced.

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