El Colegio de la Frontera Sur

Patrones de forrajeo de *Melipona yucatanica* y su relación con la vegetación

Tesis
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Con orientación en Ecología y Sistemática

por

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Las personas abajo firmantes, miembros del jurado examinador de Gerardo Flores Taboada, hacemos constar que hemos revisado y aprobado la tesis titulada: Patrones de forrajeo de *Melipona yucatanica* y su relación con la vegetación, para obtener el grado de: Maestro en Ciencias en Recursos Naturales y Desarrollo Rural.

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A mi abuelo Gustavo,
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CONTENIDO

RESUMEN

Las abejas sin aguijón (Apidae: Meliponini) son insectos eusociales de distribución pantropical, forman colonias permanentes y requieren un suministro continuo de recursos que recolectan de las flores. El género *Melipona* contiene alrededor de 50 especies, de las cuales sólo *M. yucatanica* y *M. beecheii* se distribuyen en la península de Yucatán. Actualmente, *M. yucatanica* se considera una especie en peligro, y *M. beecheii* ha sufrido una reducción de sus poblaciones silvestres. Este estudio analizó las diferencias en sus preferencias florales por medio de la identificación palinológica y el cálculo volumétrico de los tipos de polen recolectados en muestras de las cargas corbiculares de las abejas pecoreadoras de ambas especies en dos periodos del año. Los resultados indican diferencias en las preferencias florales, así como en el modo de utilización de las especies vegetales. Algunas especies características de la selva media subcaducifolia como los árboles *Bursera simaruba, Piscidia piscipula, Brosimum alicastrum, Vachellia cornigera,* herbáceas del género *Chamaesyce* y arecáceas (palmeras) fueron recursos importantes recolectados por ambas especies. Algunas especies de la vegetación secundaria como *Leucaena leucocephala* son recursos importantes en ambientes con alteración antrópica, mientras que especies como *Cecropia peltata* y *Muntingia calabura* son fuentes de polen utilizadas con menor frecuencia a pesar su abundancia y disponibilidad. *M. yucatanica* además mostró una tendencia a la especialización temporal, con tres eventos de recolección exclusiva de un solo tipo de polen (*Vachellia cornigera, Bursera simaruba y* Arecaceae sp.), mientras que en *M. beecheii* se observó una recolección diversa de tipos de polen en todos los eventos. Durante el periodo seco se observó una mayor diferencia entre los tipos recolectados por las dos especies de abeja, relacionado con la mayor diversidad y disponibilidad de flores. En el periodo de lluvias se observó una convergencia en los tipos recolectados y la dominancia de *Leucaena leucocephala* como el recurso recolectado en mayor proporción (50%) por ambas especies.

Se concluye que, aunque las dos especies de *Melipona* estudiadas son generalistas que pueden subsistir de la vegetación secundaria, *M. yucatanica* es más selectiva y adopta especialización temporal en condiciones de adundancia y diversidad de flores.

Palabras clave: Abejas sin aguijón, melisopalinología, polen.

INTRODUCCIÓN

Las abejas sin aguijón (Apidae: Meliponini) son insectos eusociales de distribución pantropical. Forman colonias permanentes en oquedades de árboles, no presentan una fase de vida solitaria (Roubik 1992) y requieren un suministro continuo de recursos florales (i.e. néctar y polen). El género *Melipona* comprende alrededor de 50 especies (Michener 2000), de las cuáles siete habitan en México y sólo dos, *Melipona yucatanica* Camargo y *M. beecheii* Bennett, se distribuyen en la Península de Yucatán (Ayala 1999). Ambas especies fueron conocidas y documentadas por los mayas desde la antigüedad; *Melipona beecheii* fue descrita científicamente en 1831, pero *M. yucatanica* se describió formalmente hasta 1988 (Camargo et al. 1988). Aunque puede encontrarse en variedad de hábitats en la Península (May-Itzá et al. 2010; Ruiz et al. 2014), su rango de distribución comprende el sur del estado de Yucatán y las zonas con vegetación remanente de selva mediana subperennifolia primaria de Campeche y Quintana Roo (Ayala 1999). *Melipona beecheii* tiene una distribución más amplia que comprende el sur de México, Centroamérica y Cuba, y se le encuentra tanto en vegetación primaria como en zonas maduras de transición.

Melipona beecheii es la especie del género más ampliamente manejada en meliponicultura, sin embargo, las técnicas de manejo y crianza de *M. yucatanica* no están bien establecidas (Villanueva-Gutiérrez com. pers.; May-Itzá et al. 2010), por lo que es rara en cautiverio. Se ha sugerido que la ecología de *M. yucatánica* es muy distinta de la de *M. beecheii.* Las diferencias de talla, número de abejas por colonia y volumen de ésta son aspectos que han ayudado a concluir que al menos no compiten por los sitios de anidación en las oquedades de los árboles. Estudios morfológicos y moleculares han evidenciado que no están estrechamente relacionadas y pertenecen a diferentes subgéneros (Ayala 1999; Ramírez et al. 2010), sin embargo, las preferencias florales de *M. yucatanica* no han sido estudiadas (González-Acereto y Medina 2001).

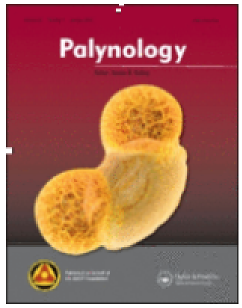
Por la naturaleza generalista de los meliponinos (Roubik y Moreno-Patiño 2013), es de suponerse que ambas especies comparten algunos recursos florales. Se ha encontrado que cuando coexisten en un mismo espacio, los meliponinos y otras abejas sociales explotan diferentes recursos (Eltz et al. 2001; Liu et al. 2013; Ferreira y Absy 2015; Tropek et al. 2018). Se ha observado *M. beecheii* y otros meliponinos han respondido a la presión competitiva de la forma africanizada de *Apis mellifera* con diferentes estrategias de forrajeo, aunque sus poblaciones se han reducido tanto en manejo como en estado silvestre (Villanueva-Gutiérrez et al. 2005). Villanueva-Gutiérrez et al. (2018) identificaron 47 tipos polínicos correspondientes a 10 géneros de plantas en colonias de *M. beecheii* estudiadas en el meliponario de El Colegio de la Frontera Sur, Chetumal; los tres más abundantes fueron *Bursera simaruba, Gliricidia sepium y Solanum sp.*

En este estudio se tomaron muestras semanales, en dos periodos de cuatro meses (febrero a mayo, y julio a octubre de 2020), del polen recolectado por las abejas, retirándolo cuidadosamente de las patas (corbículas) de abejas pecoreadoras capturadas en su regreso a la colonia. Las colonias se ubicaron en el meliponario de El Colegio de la Frontera Sur, en Chetumal. Las muestras fueron preparadas para su observación microscópica, para identificar y cuantificar volumétricamente los tipos encontrados. Estos datos se utilizaron para comparar las preferencias florales *M. yucatanica* y *M. beecheii* e identificar las especies más importantes de la vegetación para su dieta.

Existe un vacío de conocimiento acerca de la ecología de *M. yucatanica*. Se sabe que su distribución está asociada a vegetación remanente de selva alta y mediana; es muy probable que su rango actual esté muy reducido por la deforestación (Ayala 1999; De La Rúa et al. 2007; Brosi et al. 2008). A pesar de la distribución simpátrica con *M. beecheii* y la similitud aparente, estudios morfológicos y moleculares han evidenciado que no están estrechamente relacionadas y pertenecen a diferentes subgéneros (Ayala 1999; Ramírez et al. 2010). Los resultados encontrados representan una primera contribución de evidencia como base para la conservación de su medio.

CAPÍTULO 1

Pollen resources collected by the stingless bees (Apidae, Meliponini) *Melipona yucatanica* and *Melipona beecheii* in Southern Quintana Roo, Mexico.



Pollen resources collected by the stingless bees (Apidae, Meliponini) Melipona yucatanica and Melipona beecheii in southern Quintana Roo, Mexico

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Pollen resources collected by the stingless bees (Apidae, Meliponini) *Melipona yucatanica* and *Melipona beecheii* in southern Quintana Roo, Mexico

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Pollen resources collected by the stingless bees (Apidae, Meliponini) *Melipona yucatanica* and *M. beecheii* in southern Quintana Roo, Mexico

Here we show the results of analyzing the pollen resources collected by *Melipona yucatanica* and *Melipona beecheii* kept in a meliponary in southern Quintana Roo, Mexico. Corbicular pollen loads were sampled from February to May, and July to September 2020, corresponding to the dry and rainy seasons. Samples were prepared following routine palynological methods for identification under the microscope. A total of 31 pollen types belonging to 14 plant families were identified; 17 pollen types were collected by both species, five were exclusive to *Melipona yucatanica* and nine pollen types exclusive to *Melipona beecheii*. During the dry period 18 pollen types were recorded: eight collected exclusively by *Melipona beecheii*, and two only by *M. yucatanica*; eight pollen types were observed in both species. During the rainy period 22 types were recorded: 12 pollen types in both bee species, five pollen types collected exclusively by *M. beecheii* and five pollen types exclusive to *M. yucatanica*. The most represented families found in corbicular pollen loads were Fabaceae, Arecaceae and Euphorbiaceae. One leguminous species, *Leucaena leucocephala*, contributed over 50% of the volume collected by both species. Notably, three events with a single pollen type were recorded for *Melipona yucatanica.* We found that *Melipona yucatanica* showed signs of temporary specialization preferring punctual blooming plants, while *M. beecheii* exploited available pollen sources more broadly.

Introduction

Stingless bees (Apidae: Meliponini) are eusocial bees with a strictly tropical distribution. They live in perennial colonies, which imposes the need for a continued supply of resources (Roubik and Moreno-Patiño 2013). They have a generalist diet and are important pollinators in tropical forests (Roubik 1992) and are the most abundant bees in tropical forests apifauna (Brosi et al. 2008). Brosi (2009) found that the composition of meliponine communities was strongly related to plant species richness and not to floral resource abundance. This implies a differential use of available resources by meliponine bees within a forest ecosystem, hence differential importance of plant species can be assumed for neotropical stingless bee species.

The neotropical genus *Melipona* comprises over 40 species (Michener 2000) and is the most intensively used in meliponiculture in the Americas because of their size, manageability and the amount of honey that can be harvested from their colonies (Echazarreta et al. 1997; Quezada-Euán et al. 2001). There are 7 species of *Melipona* in Mexico (Ayala 1999), of which *Melipona yucatanica* and *Melipona beecheii* are the only representatives in the Yucatan Peninsula. *Melipona yucatanica* has a more restricted distribution, associated with evergreen tropical forests from the central Yucatan Peninsula through northern Chiapas, Belize and Oaxaca, and at present it can be considered an endangered species (May-Itzá et al. 2010). *Melipona beecheii* is distributed over a wider range of forested habitats, including dry seasonal tropical forests of southeastern Mexico down to Panama (Ayala 1999; May-Itzá et al. 2010; Ruiz et al. 2014; Yurrita et al. 2017). *Melipona beecheii* has been used for meliponiculture for thousands of years (which has also likely expanded its range), while *Melipona yucatanica*, despite being documented since ancient times, was only recently formally described (Camargo et al. 1988). *Melipona yucatanica* is rarely kept for meliponiculture in the Yucatan Peninsula, probably due to insufficient knowledge on proper management and traditional preference for *Melipona beecheii*.

The floral preferences of *Melipona beecheii* have been occasionally studied by researchers throughout its distribution range. Fonte et al. (2012) found that *Citrus spp.*, *Bursera simaruba*, *Psidium guajava* and *Mimosa spp.* were the most collected pollen types in a silvopasture ecosystem in Cuba. Leal-Ramos and León-Sánchez (2013) reached similar results in a comparative study with *A. mellifera*, also in Cuba. Ramirez-Arriaga et al. (2018) in a study in the state of Campeche, found *Solanum* and *Physalis* pubescens to be the most important pollen types collected from the herb and shrub strata, and *Bursera simaruba, Mimosa bahamensis, Psidium guajava, Senna racemosa* and *Bauhinia sp*. to be the most important canopy pollen resources. Villanueva-Gutierrez et al. (2018) determined the families Burseraceae, Fabaceae, Cochlospermaceae, Arecaceae and Euphorbiaceae to be the most important pollen resources, derived from multi-year data from the eastern part of the Yucatan Peninsula. López-

Roblero et al. (2021) found the families Asteraceae, Euphorbiaceae, Fabaceae and Melastomataceae to represent the most common pollen types collected by this species in southern Chiapas, Mexico. The family Melastomataceae has been widely reported (Ferreira and Absy 2015; Ferreira and Absy 2018) to be an important group for the genus *Melipona* in tropical rainforests throughout its range, but this botanical family is absent in the Yucatan Peninsula. In Cuba, Fonte et al. (2012) found *Psidium guajava* (Myrtaceae), Burseraceae, *Mimosa* species (Fabaceae), *Cocos nucifera* (Arecaceae) and *Citrus* sp. (Rutaceae) to be the most important collected pollen types.

To our best knowledge, floral preferences of *Melipona yucatanica* have not been studied. It is expected that some resources would be collected by this species and *Melipona beecheii*, but we can assume that the use of those shared resources differs in time and space, based on abundance, competition by interference, and time of day (Johnson and Hubbell 1975; Hubbell and Johnson 1978). González-Acereto and Medina (2001) suggested that these two *Melipona* species occupy distinct ecological niches based on differences in morphology, colony population and nest volume sizes. Moreover, since floral availability varies around the year, with the most abundant and diverse blooming in the dry season (Valdez-Hernandez 2015), it is also expected that, by some interaction, each species engages in strategies to reduce competition. This study aims to compare the use of polliniferous species by both stingless bee species in the same environmental conditions in order to detect differences of plant species use during the dry and wet seasons.

Materials and methods

Study area

The studied colonies are located at the meliponary at ECOSUR Chetumal, southern Quintana Roo, Mexico (18.543065N, 88.262625W). Vegetation is characterized as old secondary growth, transitioning to tropical dry seasonal forest (Valdez-Hernández 2015). The vegetation of the area is representative of the degree of perturbation by human activity encountered within the potential distribution range of both *Melipona* species (Yurrita et al. 2017). The study area features characteristic secondary vegetation species of the seasonal dry tropical forests in the Yucatan Peninsula, such as *Leucaena leucocephala, Muntingia calabura* and *Cecropia peltate*; trees of the canopy stratum (height > 15 m) such as *Bursera simaruba, Piscidia piscipula, Simarouba glauca, Senna* sp., *Coccoloba* spp., *Pouteria* sp.; palm species such as *Sabal mexicana, Cocos nucifera, Thrinax radiata* and *Coccothrinax readii*. Herbaceous plants of the study area consist of different species of Euphorbiaceae, Asteraceae, Fabaceae, Poaceae, and vines of the families Bignoniaceae and Convolvulaceae.

Sampling

The colonies selected for sampling (one for each *Melipona* species) were intact in their original cut logs and housed in the meliponary at least a year prior to the study, facing in the same direction. They were selected based on their activity as a proxy for a healthy population. Weekly samples were taken during two periods (February to May, and July to September 2020), each corresponding to the dry and wet seasons. Samples were taken during the early morning hours (700-1100). The entrance holes of the colonies were blocked and returning foragers carrying pollen were captured by net or hand. Pollen loads were carefully dislodged from the corbiculae with a plastic pin and deposited into 2 ml vials. After collecting pollen loads, vials were immediately sealed and transported to the lab. A minimum of five bees of each *Melipona* species were caught per sampling event and the pollen loads were pooled in the same vial.

Processing

The weekly samples were transferred to 15 ml plastic centrifuge tubes. To remove the pollenkitt lipids and nectar residues that bees use to agglutinate corbicular loads, 4 ml of absolute ethanol were added, and the pollen mass was gently loosened with a stainless-steel spatula until no lumps were detected. The tubes were stirred in a vortex mixer in the lowest setting and centrifuged. The supernatant was removed with a pipette and the procedure was repeated two more times. On the third time, three drops of a concentrated solution of basic fuchsine were added to each tube to stain the grains. The tubes were stirred several times in the vortex to promote even staining. Then, they were centrifuged and rinsed again twice to remove the residual dye. Two slides were mounted per sample, using glycerol gelatin medium and sealed with transparent nail varnish.

Pollen grains were observed using a Zeiss Primo Star (Carl Zeiss Microscope GmbH, Germany) at 400x magnification. Photographs were taken with a digital camera with an adapter. Pollen identification was carried out using reference atlases (Palacios-Chávez et al. 1991; Roubik and Moreno 1991), and by comparison with the reference collection in the herbarium of El Colegio de la Frontera Sur (ECO-CH-H). The nearby vegetation of the study area was surveyed for flowers, and additional reference pollen slides were made from fresh material when available and processed using the same method of ethanol and basic fuchsine for consistency.

Pollen analysis

A minimum of 600 grains were counted per slide, scanning systematically, sorted by identified taxa or type (Villanueva-Gutierrez and Roubik 2004). Since pollen grains of different species vary in size from 5 to over 100 microns, the component of each pollen type was expressed as a percentage of the volume of the grains counted as a more representative figure (Buchmann and O'rourke 1991; da Silveira 1991). Ten grains of each type were randomly selected and measured using a calibrated ocular micrometer and scale was drawn by tracing over the overlaid image of a calibration micrometer slide along their polar and equatorial axes. The volume of each type or taxa was calculated using the averaged measures, following the geometrical formulas for spheres or ellipsoids (Villanueva-Gutierrez and Roubik 2004). No types with strongly prismatic shape were recorded. The volumetric proportion for each type was calculated using the frequencies of all taxa present in the sample and expressed in a percentage. Types with a frequency and volume of less than 1% were not considered in the calculations.

Data analyses

Two bipartite networks for each period were plotted in R version 4.1.0 (R Core Development Team 2021) using the *bipartite* package (Dormann et al. 2008), to illustrate the overlap and the proportional use of collected pollen types. Bipartite networks are particularly useful to visualize and analyze interactions that involve only two trophic levels, such as plants and pollinators. Topology-derived indices allow further ecological interpretation of data if appropriate, but they were not used in this study.

Results

A total of 31 pollen types, distributed in 14 families, were found to contribute each over 1% of the volume of the weekly samples. Of those, 17 types were collected by both species, 9 only by *M. beecheii* and 5 only by *Melipona yucatanica*. (Table 1) Fabaceae was the most represented family with 14 pollen types (although seven were only minor contributors, less than 5% of volume), followed by Arecaceae (four types), Euphorbiaceae (three types) and Moraceae (two types), with the rest of the detected plant families represented by a single type.

During the dry period, 18 pollen types were identified, eight pollen types were collected by both bee species, another eight were collected only by *Melipona beecheii*, and two pollen types were collected only by *Melipona yucatanica*. Volumetrically, six types contributed 99% to the diet of *Melipona yucatanica*, with the remaining four contributing less than 1% each. In contrast, for *Melipona beecheii* eight pollen types contributed 93% of the volume, and four types contributed 6% of the total. Three monolectic samples from *Melipona yucatanica* contained the pollen types *Vachellia cornigera*, *Bursera simaruba* and an unidentified palm recorded as Arecaceae Type 1 (Fig. 3).

In the rainy period 22 pollen types were recognized, 12 types used by both species, five collected only by *Melipona beecheii* and five collected only by *Melipona yucatanica*. By volume, 13 pollen types for *Melipona beecheii*, and 11 for *Melipona yucatani*ca contributed the largest part of the sample. However, a single legume species, *Leucaena leucocephala,* contributed most of the volume of the samples for both species, 62% for *M. beecheii* and 51% for *Melipona yucatanica*. Bee species and pollen type interactions were represented as separate bipartite networks for the dry period (Fig. 1) and the rainy period (Fig. 2). For the species of plants visited, Shannon diversity (H) index was 2.53 for the dry period and 2.32 for the rainy period.

Discussion

While both species used many of the same flowering species as resources, *Melipona yucatanica* engaged in temporal specialization, collecting a single resource when it became abruptly available in abundance, as in the case of *Thouinia paucidentata* during the week it was recorded. This is supported by the phenology of other taxa such as palms, which blossom profusely during short periods, in a somewhat synchronous manner (Valdez-Hernández 2015; Villanueva-Gutiérrez et al. 2015). *Melipona beecheii* collected some of the same punctual blooming species during the rainy season, but not exclusively, similar to the observed trophic interactions in other *Melipona* species from tropical South America (Ferreira and Absy 2015).

Melipona beecheii was observed to collect pollen from taxa associated with secondary vegetation and perturbation year-round, primarily *Leucaena leucocephala* and *Muntingia calabura.* This contrasts with the strategy used by *Melipona yucatanica*, which collected *Leucaena leucocephala* and *Muntingia calabura* only during the rainy season, when other available resources were probably scarce. However, both species collected *Cecropia peltata,* a secondary vegetation tree, only on two occasions during the rainy season, despite being a resource abundantly available year-round in the area. Pollen grain size seems to be negatively correlated with nutritional quality and preference (Vossler 2014). The pollen of *Cecropia peltata* and *Muntingia calabura,* which have very small grains (diameter less than 10 microns), was collected by the two species of bees only in a short period, despite those trees being abundant in the area and bearing flowers year-round. In contrast, the pollen grains of

Leucaena leucocephala, another common secondary vegetation species, are larger than average with around 50 μ in diameter (Fig. 3), were consistently preferred. Previous studies reported that honeybees can switch to suboptimal resources out of necessity (Villanueva-G. and Roubik 2004).

Both species seem to prefer arboreal species, as most of the pollen types found belong to this life form. However, the herbaceous *Chamaesyce* sp. (Euphorbiaceae) was exploited significantly by both species in the dry period. Other herbaceous plants, mainly indeterminate leguminous types, contributed only marginally. These results indicate that both species can adapt and even take advantage of secondary vegetation if the environment remains moderately dominated by tree species. This is further supported by the abrupt abundance of stingless bees in forest areas found by Brosi et al. (2008).

Melipona yucatanica probably benefits of year-round regularly occurring punctual flowering events, as supported by the sharp shifts to temporary specialization that yielded monolectic samples. Further studies should address the importance of phenology and species composition in the availability of the resources preferred by these stingless bees, and whether this defines habitat suitability of dry tropical forest areas. Colonies of *Melipona yucatanica* have smaller populations (González-Acereto and Medina 2001) than those of *Melipona beecheii* and were observed to not engage heavily or at all in pollen collection on several instances when it took a longer time to obtain a sample. Smaller colonies have lower resource demands, and bee species with larger populations are consistently observed to collect pollen from a broader diversity of plant species (Kajobe 2007; Ramalho and Carvalho 2007), which despite not yielding abundantly, serve as important complementary resources (Ramalho et al. 1989).

Conclusion

Both *Melipona beecheii* and *Melipona yucatanica* are generalists that respond differently to available resources, in function of the needs of the colony, which in turn seem to be imposed by their natural history. Our study revealed that, during the sampling periods, *Melipona yucatanica* applied a selective foraging strategy preferring to exploit punctual and abundant flowering. This strategy may be optimized if vegetation diversity allows for a phenological continuum consistent enough to provide an intermittent but constant supply of pollen. In disturbed environments, *Melipona yucatanica* can profit from trees and shrubs of secondary vegetation, if canopy trees cover the resource area. This first approach on *Melipona yucatanica* requires additional melissopalynological studies at more detailed spatial and temporal levels, to deepen our knowledge on the ecology of this stingless bee species and the plants it needs to thrive.

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Figure. 1 Bipartite graphs representing the pollen types found for *Melipona beecheii* (MBD) and *Melipona yucatanica* (MYD) during the dry period (February to May 2020). A: represents presence or absence of pollen types for each bee species; B: represents the volumetric proportion of pollen types measured for each bee species (only pollen types contributing more than 1% are shown for clarity.

Figure. 2 Bipartite graphs representing the pollen types found for *Melipona beecheii* (MBW) and *Melipona yucatanica* (MYW) during the rainy period (July to September 2020). A: represents presence or absence of pollen types for each bee species; B: represents the volumetric proportion of pollen types measured for each bee species (only pollen types contributing more than 1% are shown for clarity.

Figure. 3 Selected pollen grains: A, Arecaceae Type 1. B, *Bursera simaruba*. C, *Cecropia peltata*. D, *Chamaesyce* sp. E, *Leucaena leucocephala*. F, *Muntingia calabura*. G, *Senna* sp. H, *Thouinia paucidentata*. I, *Vachellia cornígera*. All scale bars are 20 microns.

Table 1. Comparative volume proportions in the corbicular samples between *Melipona yucatanica* and *M. beecheii* in the dry (n=9) and rainy (n=7) periods.

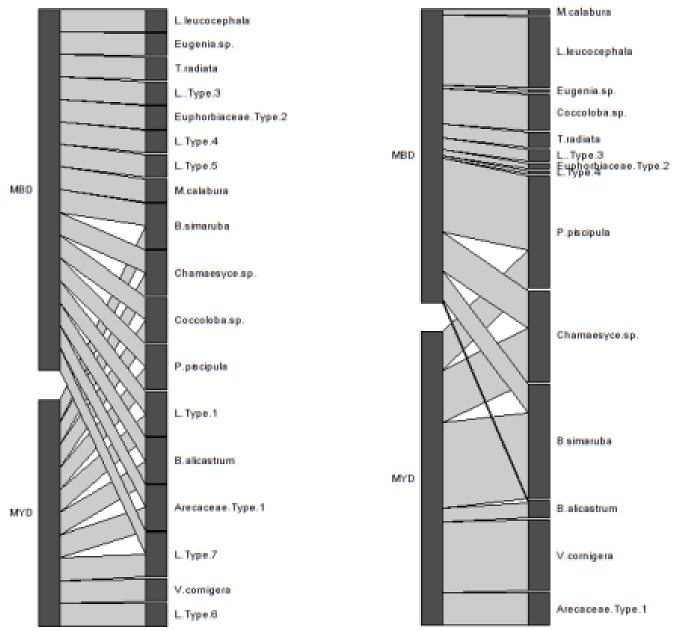

Figure. 1 Bipartite graphs representing the pollen types found for Melipona beecheii (MBD) and Melipona yucatanica (MYD) during the dry period (February to May 2020). A: represents presence or absence of pollen types for each bee species; B: represents the volumetric proportion of pollen types measured for each bee species (only pollen types contributing more than 1% are shown for clarity.

154x154mm (118 x 118 DPI)

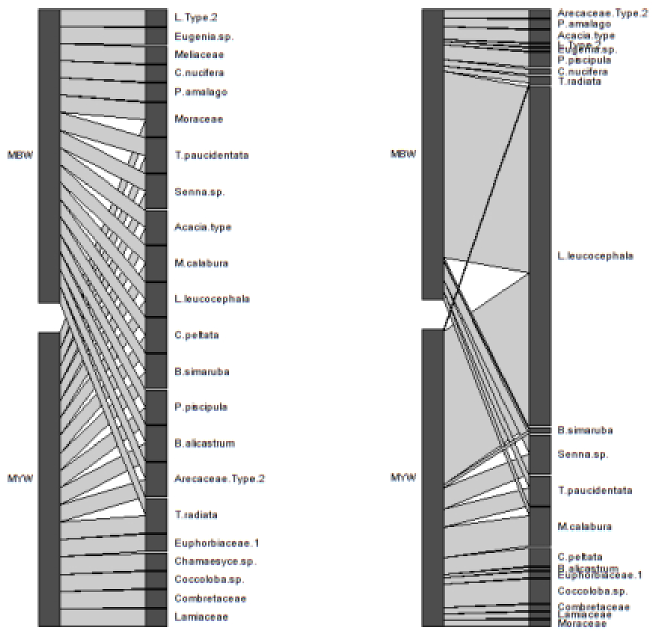

Figure. 2 Bipartite graphs representing the pollen types found for Melipona beecheii (MBW) and Melipona yucatanica (MYW) during the rainy period (July to September 2020). A: represents presence or absence of pollen types for each bee species; B: represents the volumetric proportion of pollen types measured for each bee species (only pollen types contributing more than 1% are shown for clarity.

154x154mm (118 x 118 DPI)

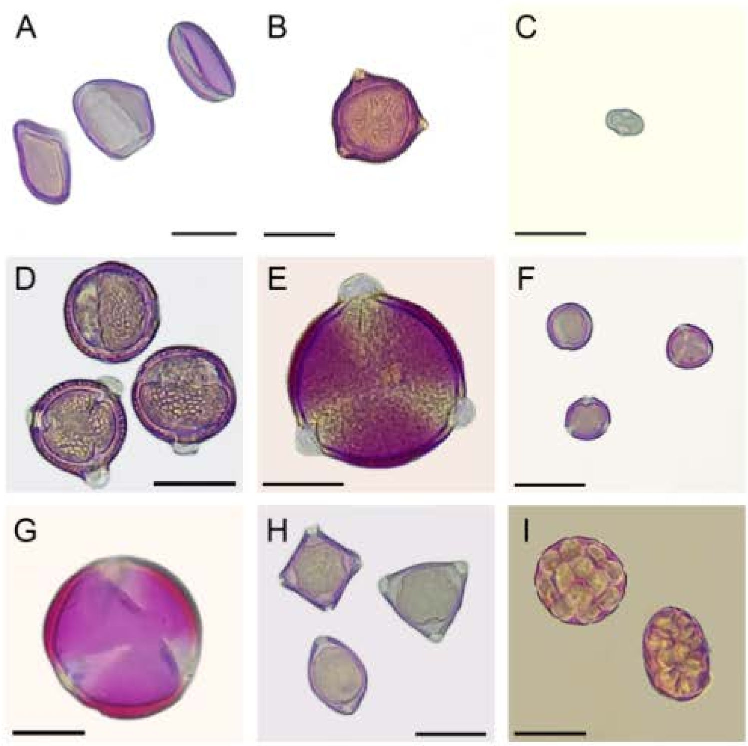

Figure. 3 Selected pollen grains: A, Arecaceae Type 1. B, Bursera simaruba. C, Cecropia peltata. D, Chamaesyce sp. E, Leucaena leucocephala. F, Muntingia calabura. G, Senna sp. H, Thouinia paucidentata. I, Vachellia cornígera. All scale bars are 20 microns.

304x299mm (300 x 300 DPI)

Table 1

	M. yuca							
	Dry period							
	02/24/20	03/18/20	03/28/20	04/13/20	04/20/20	04/27/20	05/04/20	05/11/20
Arecaceae								
Cocos nucifera								
Thrinax radiata								
Arecaceae Type 1								
Arecaceae Type 2								
Burseraceae								
Bursera simaruba					9.14%	60.32%	87.14%	100.00%
Cecropiaceae								
Cecropia peltata								
Combretaceae								
Combretaceae Type								
Euphorbiaceae								
Chamaesyce sp.				73.02%	76.19%	9.41%		
Euphorbiaceae Type 1								
Euphorbiaceae Type 2								
Lamiaceae								
Lamiaceae Type								
Leguminosae								
Acacia Type								
Leucaena leucocephala								
Piscidia piscipula	92.48%		19.11%				4.87%	
Senna sp.								
Vachellia cornigera		100.00%	77.88%	15.43%	6.67%	6.13%	7.99%	
Leguminosae Type 1								
Leguminosae Type 2								
Leguminosae Type 3								
Leguminosae Type 4								
Leguminosae Type 5								
Leguminosae Type 6	3.07%							
Leguminosae Type 7	4.46%							
Meliaceae								
Meliaceae Type								
Moraceae								
Brosimum alicastrum				11.55%	8.01%	24.14%		
Moraceae Type								
Muntingiaceae								
Muntingia calabura								
Myrtaceae								
Eugenia sp.								
Piperaceae								
Piper amalago								
Polygonaceae								
Coccoloba sp.			1.34%					
Sapindaceae								
Thouinia paucidentata								

Table 1

atanica									
	Rainy period								
05/31/20	07/25/20	08/24/20	08/31/20	09/07/20	09/14/20	09/21/20	09/28/20	02/24/20	03/18/20
							6.34%		
100.00%									
	0.59%			0.32%					
	5.16%		0.32%	0.24%					
		28.92%		0.40%			13.57%		
						12.26%			
				0.12%					
			0.11%	1.58%		12.47%			
						6.33%	9.56%		
	2.65%								
	87.27%		82.91%	79.65%	51.13%	54.20%		72.52%	84.67%
	0.25%		0.21%					17.29%	4.76%
	2.85%		14.28%	17.47%	6.97%		5.64%		
								0.41%	4.71%
								0.53%	
							5.58%	9.25%	
			1.84%			14.74%			
	1.22%	71.08%	0.33%	0.21%					5.87%
							59.30%		
					41.90%				

Table 1

M. beecheii									
Dry period									
03/28/20	04/13/20	04/20/20	04/27/20	05/04/20	05/11/20	05/31/20	07/25/20	08/24/20	08/31/20
									12.68%
						42.80%			
		2.13%							
							2.43%	2.64%	
		2.55%	10.06%	32.95%	41.21%				8.15%
	8.77%	36.80%	63.95%	9.39%					
						18.38%			
	17.71%	15.72%		1.38%	20.60%		72.21%	79.73%	72.21%
95.98%	26.65%	2.06%	20.63%	33.32%	23.77%		12.68%		
								6.78%	4.53%
0.68%									
							8.15%		
						38.82%			
3.34%									
								2.74%	
					0.99%				2.43%
	8.85%							8.11%	
				10.51%			4.53%		
	38.01%	40.74%	5.36%	12.45%	13.43%				

Table 1

Rainy period			
09/07/20	09/14/20	09/21/20	09/28/20
			15.22%
	17.97%		
			3.17%
			28.51%
75.46%	34.59%	60.03%	41.59%
		24.70%	
16.92%	3.56%	5.73%	3.84%
			2.96%
7.62%			4.71%
	13.12%	9.55%	
	30.77%		

CONCLUSIONES

Por medio del análisis del polen recolectado de las corbículas de *Melipona yucatanica* y *M. beecheii* se pudo corroborar los hábitos generalistas de ambas especies, y se obtuvo evidencia de diferencias marcadas en sus preferencias florales, especialmente durante el periodo de secas en el que la diversidad y abundancia de flores es mayor. *Melipona yucatanica* mostró una mayor selectividad y preferencia por eventos de floración profusa puntual, evidenciado por los eventos de recolección monofloral: *Vachellia cornigera* en su periodo de floración anual, *Bursera simaruba* en un pico de floración en el periodo seco, y Arecaceae sp., un evento puntual de abundancia de un recurso por el tipo de inflorescencia característico de la familia y la posible sincronicidad fenológica de varios individuos. En contraste, *Melipona beecheii* recolectó polen de manera más intensiva y se benefició de los eventos de floración puntual. Este resultado sugiere la dependencia de un continuo fenológico propio de la composición de especies de vegetación en buen estado de conservación para la viabilidad de las poblaciones silvestres de *M. yucatanica*.

Durante el periodo de lluvias, en el que la floración es menos abundante, ambas especies recolectaron principalmente el polen de *Leucaena leucocephala*, una especie de vegetación secundaria de floración continua. En contraste, se encontró que otras dos especies abundantes y de floración continua de la vegetación secundaria, *Muntingia calabura* y *Cecropia peltata* aparecieron sólo intermitentemente en las muestras recolectadas. La preferencia por el polen de *L. leucocephala* puede deberse a que los granos de polen son de mucho mayor tamaño (diámetro de 50 µ contra menos de 10 µ en *M. calabura* y *C. peltata*), y que posiblemente influye en su calidad nutritiva para las abejas. Es también importante señalar que, de estas tres especies de vegetación secundaria, sólo *M. calabura* produce néctar y los árboles con flores son visitados por abejas, por lo que debe considerarse su estudio como recurso nectarífero.

La determinación más avanzada de las preferencias florales de estas abejas a lo largo de periodos multianuales permitirá comprender mejor su ecología, e identificar las especies más importantes en la vegetación para su permanencia en el medio silvestre. Debido a la destrucción de su hábitat por deforestación y la reducción de sus poblaciones, es posible que la conservación de *M. yucatanica* dependa de mantenerla y propagarla en meliponicultura. Por tanto, es importante determinar con evidencia las especies de plantas que componen su dieta para procurar su cultivo y preservación.

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