Pollen load analysis of wild bees in an oil palm crop in Magdalena, Colombia

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Research group and the palynological collection

Fitotecnia del Trópico research group belongs to Agronomic Engineering Program of University of Magdalena, located in Santa Marta, Colombia. We study the agricultural production environment, the plant-insect-microorganism interactions, the biodiversity in agroecosystems, and alternatives to traditional pest management in order to improve agricultural production. Our research includes the plant-pollinator interaction by analysis of bee pollen loads, pollination biology and the improvement of the stingless bee production system. The palynological collection was processed in the Entomology Laboratory and deposited in the Biological Collections Center of the University of Magdalena (CBUMAG) (Figure 1). This collection includes approximately 2,500 slides of bee pollen loads (60 species approximately) and plant pollen (258 species).

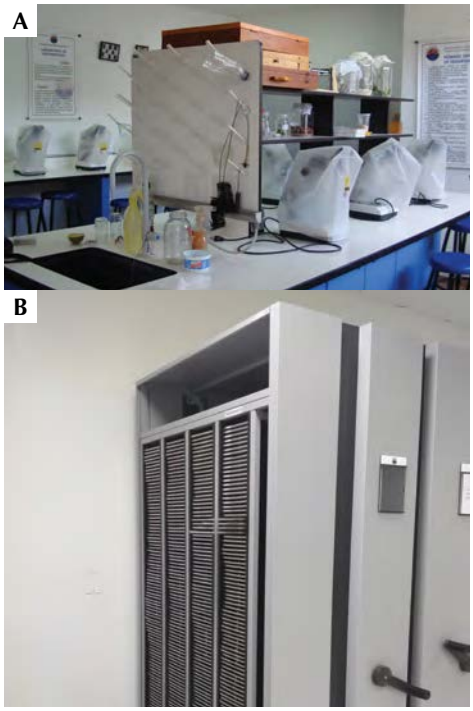

Figure 1. Biological Collections Center of the University of Magdalena (CBUMAG). **a)** Entomology Laboratory. **b)** Palynological collection of University of Magdalena.

The project

The palynological collection of University of Magdalena began with the project "Determination of the potential of palm agroecosystem for the development of conservation beekeeping proposals", whose objective was to identify the most important polyniferous and nectariferous plants used by wild and cultivated bees (stingless bees and honeybees) from pollen load analysis, associated with nine oil palm agroecosystems, in order to develop beekeeping proposals that improve the quality of life of small palm-growing families and contribute to the conservation of the socio-ecosystem components.

The northern palm area of Colombia is characterized by the presence of important dry forest ecosystems and floodplains, both in a state of threat, and these agroecosystems have been established near natural areas considered of great value due to their biodiversity, such as the Ciénaga Grande de Santa Marta, considered the largest inland aquatic ecosystem in Colombia and the Sierra Nevada de Santa Marta declared a Biosphere Reserve by UNESCO (Aguilera 2011).

Here, we show the results of one of the nine fields evaluated, located in the commercial oil palm farm Tequendama (Aracataca, Colombia), at coordinates 10°32'55,3"N and 74°10'56,8"W (Figure 2). The climate in the region is Tropical Savanna Climate (Aw), according to the Köppen climate classification, and it is a Tropical Dry Forest, according to Holdridge life zone system. The average annual rainfall is 1,348 mm with temperature of 27.8 °C.

This area has organic oil palm crops, where the growth of wild vegetation is allowed (Figure 3). The landscape is composed of native plants (50%), exotic plants (7%), naturalized plants (5%) and plants whose origin is unknown (38%).

We established two 400 m transects, one in the field edge and one in the crop interior, where all flowering plants and bees were collected manually and with nets. We conducted seven surveys between February 2016 and August 2017. The plants were stored in the Herbarium UTMC of the University of Magdalena and identified. The bees were identified, and pollen samples were taken from their bodies and stored in Eppendorf tubes with 70% alcohol.

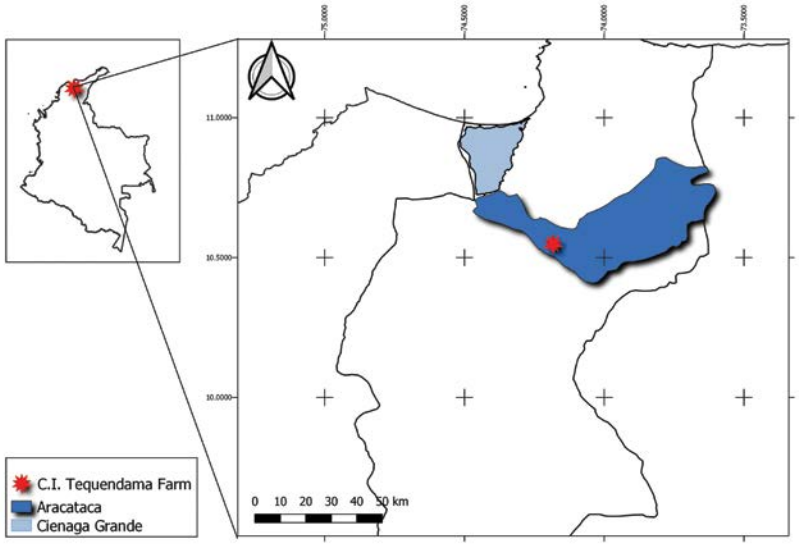

Figure 2. Location map of study area.

Seventy-five pollen loads were macerated with KOH digestion procedure Slides were prepared using a little piece of glycerin jelly, in which a drop of pollen grain suspension was added. Slides were sealed with paraffin. At least 400 pollen grains of each slide were counted and compared for taxonomic identification with a reference slide from a collection compiled by González and Tejeda (2018) from flowering plants collected in different palm agroecosystems.

Bee-plant interactions were represented in a graph of binary data interactions, where one (1) indicates the presence of interaction and zero (0), absence of interaction by the bipartite package (Dormann et al. 2008) in the R software (R Core Team 2020).

Where the bees collect pollen in an oil palm crop?

Palynological analysis were performed in 150 slides of pollen loads (two for each bee) corresponding to 19 bee species of three families: Apidae, Halictidae and Megachilidae (Table 1). Thirty-eight pollen types were identified in the bee pollen loads (Table 2). The most representative families were Fabaceae (with nine species of bee-visited plants), followed by Malvaceae, Cucurbitaceae and Asteraceae. Fabaceae is a common and large family of flowering plants, considered very important for the bee diet (Alves and dos Santos 2019; Grosso et al. 2014; Angel et al. 2001), especially in the Colombian Caribbean region (León 2014).

Figure 3. Oil palm crops landscape of northern of Colombia.

Table 1. Bee species found on the C.I. Tequendama and number of pollen types per bee species.

Family	Bee species	Pollen types (#)	Abbreviation
Apidae	*Ancyloscelis* sp. (n=2)	1	Ancysp
	Apis mellifera Linnaeus, 1758 (n=29)	7	Apimel
	Centris sp. *(n=1)*	4	Centsp
	Ceratina sp1 (n=1)	3	Cersp1
	Ceratina sp2 (n=3)	2	Cersp2
	Ceratina sp3 (n=3)	11	Cersp3
	Ceratina sp4 (n=1)	3	Cersp4
	Exomalopsis sp. (n=8)	11	Exomsp
	Paratetrapedia sp. (n=1)	4	Parasp
	Thygater sp. (n=1)	4	Thygsp
	Trigona fulviventris Guérin, 1844 (n=9)	11	Triful
	Trigona (Trigona) sp. (n=2)	1	Trigsp
	Xylocopa sp. (n=1)	4	Xylosp
Halictidae	*Augochlora* sp1 (n=2)	5	Augsp1
	Augochlora sp2 (n=2)	2	Augsp2
	Augochloropsis sp. (n=1)	2	Augsis
	Halictus ligatus Say, 1837 (n=1)	2	Hallig
	Lasioglossum sp (n=3)	4	Lasssp
Megachilidae	*Megachile* sp. (n=4)	7	Megasp

Cucurbita sp., *Spilanthes urens*, *Cucurbita maxima*, *Momordica charantia* and *Talinum* sp. were the plants most used by the bees evaluated (Figure 5). Family Asteraceae was the most abundant in the total of the analyzed individuals, especially *Spilanthes urens* followed by *Mikania michranta* (Figure 6). The preference of bees for Asteraceae flowers could be explained by the fact that these plants represent a high reward of pollen and nectar, bloom for a long period of time, have a great abundance and can be found in many different habitats (Muller and Bansac 2004).

Because 81.57 % of the identified plants were herbaceous, 7.89 % arboreal and 10.52 % had other habits, it is necessary to train farmers to recognize the importance of weeds for the support of the bee community in oil palm crops and investigate the real impact they can have on oil palm production, in order to conserve them in the ruderal areas.

Table 2. Plant species corresponding to the pollen types found in the pollen loads of bees in C.I Tequendama and their frequency of occurrence.

Family	Plant species	Spanish common name	FO%	Abbreviation
Aizoaceae	*Trianthema portulcastrum* L.	Araña de perro	R	Tripor
Amaranthaceae	*Alternanthera albotomentosa* Suess	Abrojo blanco	PF	Altalb
Arecaceae	*Elaeis guineensis* Jacq.	Palma africana	*F*	Elagui
Asteraceae	*Asteraceae* sp1		*R*	Aster1
	Asteraceae sp2		*R*	Aster2
	Mikania micrantha Kunth	Guaco blanco	*R*	Mikmic
	Spilanthes urens Jacq.	Botón de plata, dormidera	*F*	Spiure
Caryophyllaceae	*Caryophyllaceae* sp1		R	Caryo1
Cleomaceae	*Cleome spinosa* Jacq.	Jardín del río	R	Clespi
Commelinaceae	*Commelina diffusa* Burm.f.	Canutillo	R	Comdif
	Murdannia nudiflora (L.) Brenan		R	Murnud
Convolvulaceae	*Ipomoea* sp1	Campanita	F	Ipomsp
Cucurbitaceae	*Cucurbita maxima* Duchesne	Ahuyama	F	Cucmax
	Cucurbita sp.		F	Cucusp
	Melothria pendula L.	Pepinillo de monte	R	Melpen
	Momordica charantia L.	Balsamina	F	Momcha
Fabaceae	*Caesalpinoidae*		R	Caesal
	Calopogonium caeruleum (Benth.) Sauvalle		R	Calcae
	Centrosema sp.		R	Centsp
	Chamaecrista sp.		R	Chamsp
	Mimosa pudica L.	Dormidera	R	Mimpud
	Mimosoidae		PF	Mimoso
	Pueraria phaseloides (Roxb.) Benth.	Kudzu	R	Puepha
	Senna obtusifolia (L.) H.S.Irwin & Barneby	Bicho macho	F	Senobt
	Vigna sp.	Platanillo	PF	Vignsp
Undeterminated taxa	Type 1.		R	Tipop1
	Type 2		R	Tipop2
	Type 3		R	Tipop3
Lythraceae	*Cuphea carthagenensis* (Jacq.) J.F.Macbr.		R	Cupcar
Malvaceae	*Corchorus aestuans* L.		R	Coraes
	Melochia parvifolia Kunth	Escoba blanca	R	Melpar
	Melochia pyramidata L.	Escoba	PF	Melpyr
	Sida jamaicensis L.	Escoba dura	PF	Sidjam
	Sida rhombifolia L.	Escoba amarilla	R	Sidrho
Nyctaginaceae	*Boerhavia erecta* L.		R	Boeere
Phytolaccaceae	*Microtea debilis* Sw.		PF	Micdeb
Rubiaceae	*Mitracarpus hirtus* (L.) DC.		PF	Mithir
Talinaceae	*Talinum* sp.	Verdolaga montaña	F	Talisp

Frequency of occurrence: very frequent (MF) (> 50%), frequent (F) (20-50%), infrequent (PF) (3-15%) and rare (R) (<10%)

Conclusion

Apparently, the community of bees present in the oil palm crop evaluated, is composed of bees with generalist behavior. Pollen of oil palm during its flowering stage is used by the bee community, however, many of the plants considered as weeds in oil palm crops and which are normally eradicated by farmers (such as *Momordica charantia*, *Spilanthes urens, Melochia parvifolia, Mimosa pudica, Commelina diffusa* or *Trianthema portulcastrum*) are important sources of pollen for the bees in the agroecosystem, causing bee populations to become at risk, especially those with a narrow diet.

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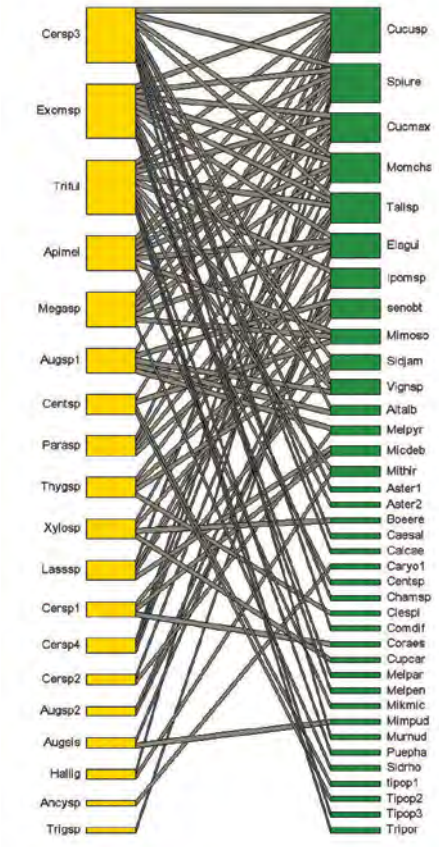

Figure 5. Diagram of bee-plant interaction networks based on the frequency of pollen types (Abbreviations: see table 1 and 2).

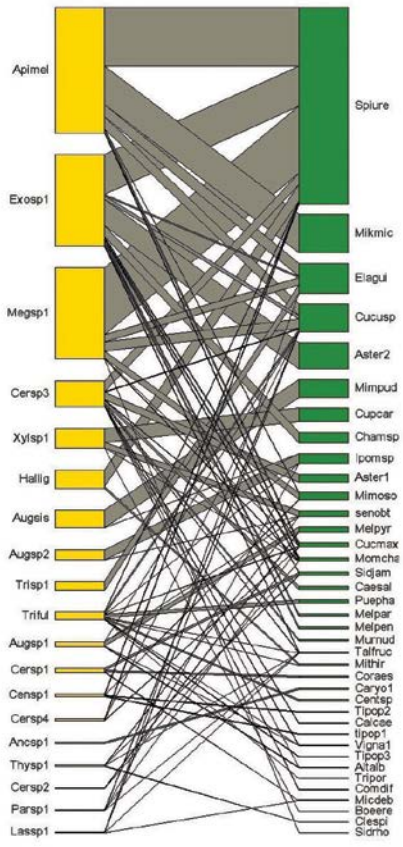

Figure 6. Diagram of plant-bee interaction networks from accumulated abundance (Abbreviations: see table 1 and 2)

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***Augochloropsis* sp.**