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Scientific Note

Bee species (Hymenoptera: Anthophila) in a Cerrado-Atlantic Forest ecotone: nesting habits related to foraging activity in a degraded forest fragment

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Abstract. The aim of this paper was to determine the species diversity and frequency of foraging performed by bees in fragment of degraded forest in a Cerrado-Atlantic Forest ecotone area, also considering the nesting habit of each species. The foraging frequency of each bee species in the main floral sources was recorded for 12 consecutive months. The nesting site was used to sort the bees into guilds: above-ground nesting bees, ground-nesting bees, and both below and above-ground nesting bees. The guild of ground-nesting bees had 24 species and accounted for 17.48 % of the foraging rate, while above-ground nesting bees were represented by 12 species which made 8.89 % of the foraging rate, and both below and above-ground nesting bees comprised five species which made 0.43 % of the foraging rate. Africanized honeybee performed 73.20 % of the foraging flight, and presented a broad food niche. Therefore, in the forest fragment studied, two types of impacts which make difficult the survival and maintenance of the native bee fauna were observed: the dominance over floral resources by the exotic species the Africanized honeybees; the small number of large trees.

Keywords: *Apis mellifera*; Environmental disturbance; Foraging; Interactions; Native bees.

The organization of bee communities is intimately related to the structure of plant communities from which they obtain resources (Steffan-Dewenter *et al.* 2002). However, the intensification of anthropic action, one of the main causes of environmental disturbance, can reduce populations of native bees, destroying food sources and nesting or egg-laying sites (Potts *et al.* 2010). In the Neotropics, the damage appears have been intensified by the introduction of African honeybees (*Apis mellifera scutellata* Lepeletier) in Brazil and the consequent formation of Africanized honeybees (Harrison *et al.* 2006), which triggered or aggravated the imbalances in the interactions between species of native bees, making relationships possibly stressful and causing competition for floral resources (Traveset & Richardson 2006). This hybrid bee has high adaptability to variable ecological conditions, produce a great number of swarms over the year, and their workers are efficient collectors of nectar and pollen (Traveset & Richardson 2006). Currently, the subspecies closest to the Africanized populations is *A. mellifera scutellata* (Francoy et al. 2009).

However, it is not enough to have floral resources available in the environment for there to be balance in the bee community. Roubik (1989) and Michener (2007) stated that the diversity of places and substrates used by each bee assemblage is immense and each bee species needs a suitable site for oviposition or nesting and uses unique materials to construct the nest or the brood cells. Cane (1991) pointed out that humidity, soil texture and compaction are important factors for ground-nesting bees. On the other hand, according to Roubik (1989), bees that live in substrates above ground, build nests at a wide range of heights, nearly everywhere, and frequently use leaf material, plant lipids or resins to construct the cell walls of the nest. Thus, the aim of this paper was to determine the diversity and frequency of foraging performed by local bees species based on the nesting sites used by them, in a Cerrado-Atlantic Forest secondary fragment in transition.

The study was performed in a secondary forest fragment covering approximately 355 ha (22°15' S; 53°48' W) in Mato Grosso do Sul State, in the midwestern region of Brazil. No apiary was found within a 1,000 m radius near the fragment, although that would not necessarily guarantee the absence of Africanized honeybees foragers arriving from apiaries located further away. Schneider & Hall (1997), for instance, reported a mean foraging distance of 1073 m for African colonies and 1387 m for hybrid colonies. Similarly, Beekman & Ratnieks (2000) noted that more than half of the flights of *A. mellifera scutellata* covered distances longer than 6 km at certain times of the year, and many worker bees would fly more than 10 km.

According to the classification of Zavattini (1992), the local climate is subtropical, ranging from sub-humid to humid. The aforementioned fragment is composed of vegetation in different stages of development, with a physiognomy of tropical savanna (Cerrado) and seasonal semi-deciduous forest (Atlantic Forest).

During 12 consecutive months (July 2010 to June 2011), 19 plant species attractive to bees and abundant inside the forest fragment were selected to record the bee community. Three plants of each species were selected to record the foraging activity of bees to flowers during the period in which the flowering synchrony among the individuals of the population was high (76%-100% of flowering plants). A 1 m^2 area with flowering branches (focal area), close to the ground, was selected in each plant. The frequency of foraging per bee species was recorded during 20-min intervals, every hour, from 6:00 a.m. to 17:20 p.m. Each foraging was defined by the presence (number) of the bee specimen (species) in the focal area sampled, regardless of the number of flowers visited before it left the area. In studies on trophic interactions, recording bee species from visual observations is considered acceptable (Memmott & Godfray 1993), although this technique can be problematical for many bee species due to the occurrence of very similar species or cryptic species, especially for small bees or bees with a dark patter of color. Methods employing active collections of bees foraging on flowers, on the other hand, make it impossible for any of the captured individuals to return for additional foraging – favoring under-sampling in any research designed to evaluate foraging frequency. Because of this, the observed frequency is referred for the species in visual observations, and not for the specimen collected for identification.

About one to four individuals of each bee species, visiting the plant species, were captured with an entomological net for taxonomic identification. Later, the specimens were deposited into entomological collection Prof. JMF Camargo (RPSP), from the Departamento de Biologia da Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto, Universidade de São Paulo (FFCLRP-USP), Ribeirão Preto Campus.

The nesting site used by bees was established as the primary feature for dividing the guilds. Publications on the biology of the bees present in the area were consulted and the information obtained was used to propose three guilds, as follows: **1.** Above-ground nesting bees; **2.** Ground-nesting bees; **3.** Both below and above-ground nesting bees. Besides the three guilds described, the Africanized honeybees was analyzed individually because it is an exotic species widely distributed at the study site.

The guild of ground-nesting bees had 24 species and accounted for 17.48 % of the foraging rate (Table 1). The other two guilds had fewer species which made a lower frequency of foraging recorded. Above-ground nesting bees were represented by 12 species which made 8.89 % of the foraging rate. The guild of both below and above-ground nesting bees comprised five species that undertook 0.43 % of the flower visits. Except for the species *Megachile* (*Dactylomegachile*) sp. and *Megachile* (*Pseudocentron*) sp., all of the species of that guild are parasites on the nests of other bees and, as such, they do not collect pollen for nest provisioning - and their foraging flights are exclusively to satisfy their own metabolic necessities (Roubik 1989; Michener 2007). On the other hand, the Africanized honeybees presented a broad food niche and intense foraging activity. This bee alone performed 73.20 % of the foraging rate, being the dominant species in the collection of floral resources in 11 plant species, among the 19 plant species sampled in this study (Figure 1).

The three guilds used a wide range of visited plant among those selected in this study, but showed low frequency of foraging and presented a strong trophic overlap with the Africanized honeybees. On the other hand, the Africanized honeybees did not collected floral resources in species of Malpighiaceae, but dominated the collection of resources in species of Asteraceae, Lamiaceae, Rhamnaceae, Sapindaceae and two species of Fabaceae and Bignoniaceae (Figure 1). Thereby, the oil-collecting bees [oil is a type of floral resource common in the forest fragment] were the ones that presented less trophic overlap with the Africanized honeybees. They were represented by 14 species belonging to the tribes Centridini, Tapinotaspidini, and Tetrapediini, of which 10 species nesting in the soil (Table 1). Despite being solitary (populations of small size compared to bees that have eusocial organization) (Silveira *et al.* 2002), the oil-collecting bee species showed high foraging activity (Table 1). These bees accounted for 48.62 % of the frequency of foraging performed by members of the three guilds of native bees.

Except for Halictinae and Andreninae, the other ground-nesting solitary bees possibly prefer to occupy open areas because, according to Michener (2007), underground nests are not adapted to the high relative humidity recorded within rainforests. Regarding the above-ground nesting bees, they prefer to occupy regions of preserved forests, because of the high number of vertical strata of vegetation present in the environment, which provide substrates or materials used for nest building.

But why the collection of floral resources by the exotic Africanized honeybees was favored in the forest fragment? Polatto & Chaud-Netto (2013) emphasized that the frequent occurrence of human-induced fire and deforestation within the forest fragment may have reduced the population size of bee species, including the Africanized honeybees. The swarming process is abrupt and complete in this eusocial species (Michener 2007). So, this bee has the capacity to quickly occupy the environment in relation to other species of social bees present in areas with open vegetation (Harrison *et al.* 2006), becoming dominant after successive environmental disturbances (Polatto & Chaud-Netto 2013). Furthermore, this species has a greater ability to exploit open areas, characterized by sparse vegetation (Brosi *et al.* 2008). In the case of the Africanized honeybees this behavior can be explained by the fact that this type of environment is similar to the native habitat to which the ancestral African subspecies (*A. mellifera scutellata*) is adapted (Vital *et al.* 2012).

On the other hand, why oil-collecting bees showed high foraging frequency and little trophic overlap with the Africanized honeybees? The oil-collecting bees commonly exploit oil from flowers of species that have elaiophores (Roubik 1989; Silveira *et al.* 2002; Michener 2007). Andena *et al.* (2005) showed that the Africanized bee has no preference for collecting floral resources (pollen, for example) from oil producing plants.

Therefore, in the forest fragment studied, two types of impacts which make difficult the survival and maintenance of the native bee fauna were observed: 1. The dominance over floral resources by the exotic species the Africanized honeybees; 2. The small number of large trees.

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Figure 1. Trophic interactions between *Apis mellifera* and bees of the three guilds foraging in flowers of the 19 plant species studied, in the municipality of Ivinhema, Mato Grosso do Sul State, Brazil. Arrows indicate the floral resources exploited by the guilds and the type of arrow represents the proportion of foraging in the flowers.

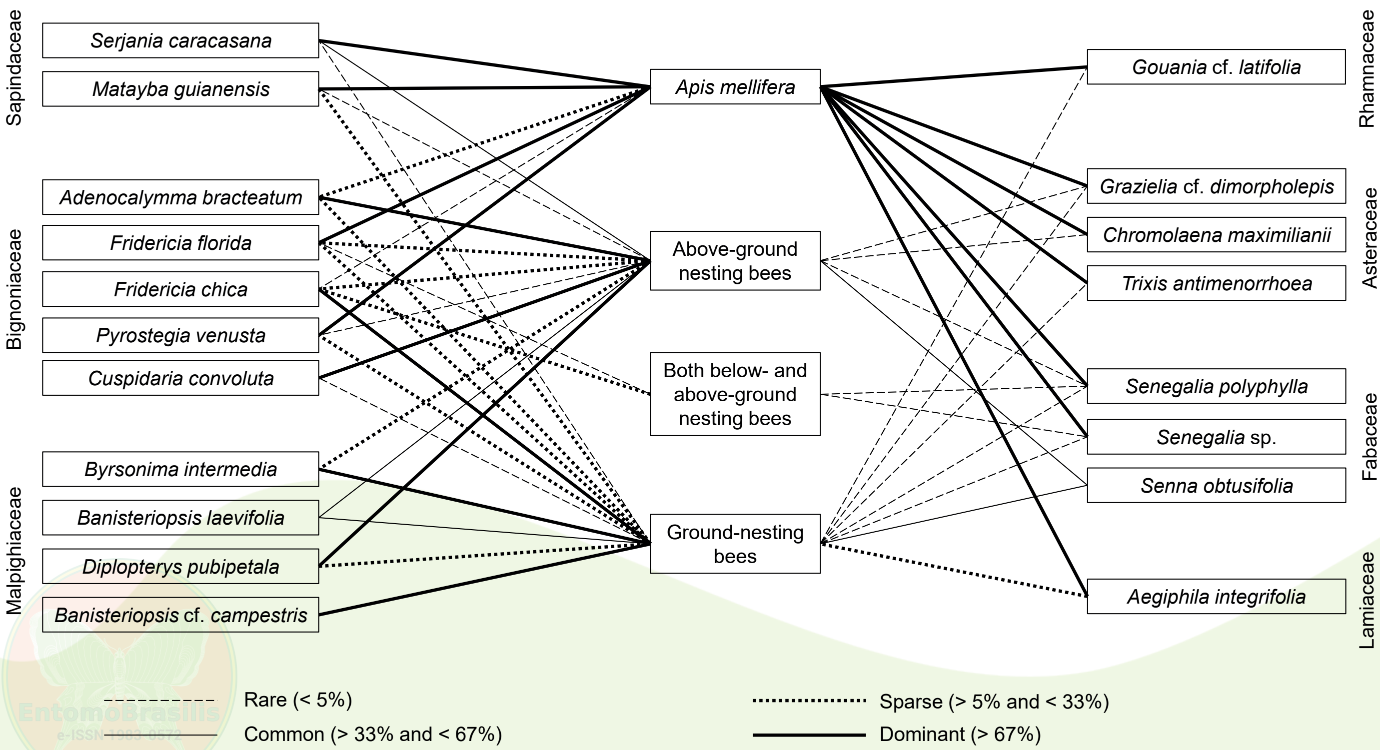

Table 1. Biological characterization of the Africanized bee *Apis mellifera* and the three guilds of bees recorded in flowers of the 19 plant species studied, in the municipality of Ivinhema, Mato Grosso do Sul State, Brazil.

Guilds	Taxon	Behavior	Species	Floral resource (%)		
				N	P	O
	APIDAE					
	Apini	Eussocial	*Apis mellifera* Linnaeus (exotic)	61.35	11.85	-
Ground-nesting bees	ANDRENIDAE					
	Oxaeini	Not Eussocial	*Oxaea flavescens* Klug	3.98	-	-
	APIDAE					
	Bombini	Eussocial	*Bombus* (*Thoracobombus*) *morio* Swederus	0.34	0.07	-
	Centridini	Not Eussocial	*Centris* (*Centris*) *aenea* Lepeletier	0.09	-	0.31
			Centris (*Centris*) *nitens* Lepeletier	-	-	1.18
			Centris (*Centris*) *varia* (Erichson)	0.02	-	1.13
			Centris (*Centris*) sp. 1	-	-	0.07
			Centris (*Centris*) sp. 2	-	-	0.02
			Centris (*Melacentris*) *obsoleta* Lepeletier	-	-	0.19
			Epicharis (*Epicharana*) *flava* Friese	-	0.02	0.72
			Epicharis (*Epicharoides*) *maculata* Smith	0.19	-	1.80
	Exomalopsini	Not Eussocial	*Exomalopsis* (*Exomalopsis*) *analis* Spinola	0.09	0.10	-
			Exomalopsis (*Exomalopsis*) *auropilosa* Spinola	0.29	0.16	-
			Exomalopsis (*Exomalopsis*) *fulvofasciata* Smith	0.17	-	-
			Exomalopsis (*Exomalopsis*) *tomentosa* Friese	0.02	0.07	-
	Meliponini	Eussocial	*Geotrigona Mombuca* (Smith)	-	0.14	-
	Tapinotaspidini	Not Eussocial	*Monoeca* sp.	-	-	0.31
			Lophopedia pygmaea (Schrottky)	-	1.94	2.23
	HALICTIDAE					
	Augochlorini	Not Eussocial	*Augochlora* (*Oxystoglossella*) *thalia* Smith	0.02	0.05	-
			Augochloropsis smithiana (Cockerell)	0.02	0.10	-
			Augochloropsis cupreola (Cockerell)	0.47	0.05	-
			Augochloropsis aurifluens (Vachal)	0.24	-	-
			Thectochlora alaris (Vachal)	0.07	0.40	-
			Pseudaugochlora graminea (Fabricius)	-	0.34	-
	Halictini	Not Eussocial	*Dialictus opacus* (Moure)	-	0.07	-
	Total			**6.01**	**3.51**	**7.96**
Above-ground nesting bees	APIDAE					
	Meliponini	Eussocial	*Tetragonisca fiebrigi* (Schwarz)	0.10	0.17	-
			Trigona spinipes (Fabricius)	0.17	3.36	-
	Centridini	Not Eussocial	*Centris* (*Heterocentris*) *analis* (Fabricius)	-	-	0.24
			Centris (*Hemisiella*) *tarsata* Smith	0.46	0.02	1.22
			Centris (*Ptilotopus*) *scopipes* Friese	-	-	0.47
	Xylocopini	Not Eussocial	*Ceratina (Crewella)* sp.	0.66	0.31	-
			Xylocopa (*Neoxylocopa*) *hirsutissima* Maidl	0.07	0.43	-
	Tetrapediini	Not Eussocial	*Tetrapedia diversipes* Klug	0.14	-	0.26
	HALICTIDAE					
	Augochlorini	Not Eussocial	*Augochlora* (*Augochlora*) *esox* (Vachal)	0.07	0.21	-
			Augochlora (*Augochlora*) *caerulior* Cockerell	0.04	-	-
			Augochlora (Augochlora) sp. 1	0.29	0.10	-
			Augochlora (Augochlora) sp. 2	0.10	-	-
	Total			**2.10**	**4.60**	**2.19**
Both below- and above-ground nesting bees	APIDAE					
	Epeolini	Parasite	*Thalestria spinosa* (Fabricius)	0.26	-	-
	MEGACHILIDAE					
	Anthidiini	Parasite	*Anthodioctes megachiloides* Holmberg	0.04	-	-
	Megachilini	Parasite	*Coelioxys* (*Neocoelioxys*) *simillima* Smith	0.02	-	-
	Megachilini	Not Eussocial	*Megachile* (*Dactylomegachile*) sp.	0.09	-	-
			Megachile (*Pseudocentron*) sp.	0.02	-	-
	Total			**0.43**	**-**	**-**
Grand total				**69.89**	**19.96**	**10.15**
					100	

N = nectar; P = pollen; O = oil.
References consulted – Main nesting site of the bees: Michener (2007); Silveira *et al.* (2002); Coville *et al.* (1983); Roubik (1989).

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