FLORAL PREFERENCES OF A NEOTROPICAL STINGLESS BEE, *Melipona quadrifasciata* LEPELETIER (APIDAE: MELIPONINA) IN AN URBAN FOREST FRAGMENT

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ABSTRACT

Species of plants used by *Melipona quadrifasciata* Lepeletier for pollen and nectar gathering in an urban forest fragment were recorded in Belo Horizonte, Minas Gerais, Brazil. *Melipona quadrifasciata* visited 22 out of 103 flowering plant species. The plant species belonged mainly to Myrtaceae, Asteraceae, and Convolvulaceae (64% of the visits). *Melipona quadrifasciata* tended to collect pollen or nectar each time, except for Myrtaceae species, from which both pollen and nectar were collected. Bee abundance at flowers did not significantly correlate to food availability (expressed by flowering plant richness). We found a relatively high similarity (50%) between plant species used by *M. quadrifasciata*, which was also found in studies carried out in São Paulo State. However, low similarity (17%) was found between the results of this study and those of another done in Bahia State, Brazil.

Keywords: floral sources, stingless bee, forest fragments.

RESUMO

Preferências florais de uma espécie de abelha neotropical sem ferrão *Melipona quadrifasciata* lepeletier (apidae: meliponina) em um fragmento de floresta urbana

Inventariaram-se as espécies de plantas utilizadas por *Melipona quadrifasciata* Lepeletier, para coletar pólen e néctar. *Melipona quadrifasciata* visitou 22 das 103 espécies de plantas floridas durante o período de estudo. Sessenta e quatro por cento das visitas foram principalmente em Myrtaceae, Asteraceae e Convolvulaceae. *Melipona quadrifasciata* tende a coletar apenas pólen e néctar nas suas visitas, exceto em Myrtaceae onde ambos os recursos foram coletados. A abundância de abelhas nas flores não se correlacionou com a disponibilidade de recursos (expressa pela riqueza de plantas floridas). Houve uma similaridade relativamente alta (50%) entre as espécies de plantas visitadas por *M. quadrifasciata* nesse estudo e outro desenvolvido em São Paulo. Uma baixa similaridade (17%) na utilização dos recursos foi verificada entre este estudo e outro conduzido na Bahia.

Palavras-chave: recursos florais, abelhas sem ferrão, fragmento de floresta.

INTRODUCTION

Insect diversity, including that of bees, in urban areas has been associated with various features, *e.g.*, extent and isolation of suitable habitats, diversity of planted vegetation and amount of resources they provide, and also niche variety and disturbance degree (Mc Intyre, 2001; Zanette *et al*., 2004).

Social bees with permanent colonies need to provide food year-round for the brood as well as adults and the immature if the population is to grow. Social bees also need empty space in tree cavities to shelter colonies (Roubik, 1989). Although specialization can ensure advantages in finding and processing food, generalist species need more than one plant species whose floral resources can be exploited throughout the year.

Studies about floral resource use by bees are of great importance in bee maintenance and preservation, especially in urban habitats (Zanette *et al*., 2004) because these insects are largely responsible for a major part of the angiosperm pollination process. They are also considered a forest community's key species because they help in nutrient cycling (Buchman & Nabham, 1996). In Brazil, bees comprise about 40 to 90% of pollinators in diverse environments (Kerr *et al*., 1996). However, little attention has been given to their biology as pollinators (Roubik, 1995).

There is little information on the use of floral resources by Meliponini colonies, particularly in urban habitats. Stingless bee species present great pollination potential in relation to many native and cultivated plant species (Kevan, 1999). Data on resource diversity used, which depends on both the number of foragers in the colony and their flight range, are essential in managing greenhouse and culture field colonies and make it possible to determine the foraging area range and resource pattern (Ramalho *et al*., 1991).

We describe here the trophic niche breadth of *Melipona quadrifasciata*, as well as the kind of food resource that workers of this species gather from flowers visited in a forest fragment embedded in urban area.

MATERIAL AND METHODS

This study was done in a preservation area in which is located the Natural History Museum (NHM) and Botanical Garden, which is affiliated with the Federal University of Minas Gerais (UFMG), (Belo Horizonte, MG, Brazil). The 64 ha of semi-deciduous forest surrounding NHM is embedded in an urban area.

From April 1998 to November 1999, sampling was carried out twice a month, from 6 h to 17 h (440 h), along six permanent transects in the forest. Herbaceous shrub vegetation and trees whose canopies were below 10 m high were sampled.

The bees were sought in all flowering plants. When one was spotted, it was caught with an entomological net. The floral resource (pollen or nectar) collected by the bee was identified by observing pollen in the corbicula or provoking regurgitation through a slight pressure on the bee's abdomen.

Visit frequency was recorded by counting the number of times that workers of *Melipona quadrifasciata* were seen at plants of each species visited. Samples of all flowering plants in the study area (visited or not by *M. quadrifasciata*) were collected and identified.

Richness of the actual plant-species trophic niches and of those not used ones was determined by recording both the number of visited and non-visited flowering species. Trophic niche breadth was calculated by using the Shannon-Wiener Diversity Index (Pielou, 1969).

To determine whether the trophic niche of *M. quadrifasciata* changes from one region to another, the results obtained here were compared to those presented in studies carried out in São Paulo and Bahia states. Thus, Sorensen's similarity index was used to compare similarities among plant families visited. Using the dissimilarity measures we performed a cluster analysis to evaluate each site's degree of tropic niche similarity.

Differences in food availability, which in these analyses refers to richness of flowering plants along the study period, and frequency of visits were evaluated by the chi-square test. Spearman's correlation was used to determine if number of visits and richness of flowering plants correlated.

RESULTS

One hundred and three flowering plant species belonging to 33 families were collected at NHM (Table 1). *Melipona quadrifasciata*

TABLE 1
Flowering plants used by *M. quadrifasciata* at the Natural History Museum (NHM) of UFMG from April 1998 to December 1999; "a" indicates months that each plant species was flowering but not visited; "•" indicates flowering but unvisited species.

Plant Family	Species	Months																		
		A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N
Amaranthaceae	*Alternanthera brasiliana*		a				a				a										
-	*Amaranthus* sp.																				a
Annonaceae	Asteraceae sp1									a		a	a								
	Asteraceae sp2									a			a								
Asteraceae	Asteraceae sp3														•						
	Centratherum sp.												a								
	Cosmos sulphureus												a								
	Eupatorium sp.														a						
	Helianthus annus												a								
	Mikania micrantha																	•			
	Mutisia sp.									a											
	Tanaecium sp.													a	•						
	Tithonia diversifolia	a					a		a	a											
	Trixis sp.															•			•	•	
	Vernonia platensis												a								
	V. polyantes				•	•											•	•			
Balsaminaceae	*Impatiens balsamina*																				
Bignoniaceae	*Arrabidaea* sp.											a									
	Spathodea campanulata							a													
	Tecoma stans						a														
Brassicaceae	*Brassica oleraceae*													a							
Cactaceae	*Rhipsalis salicornioides*																	a			
	Peireskia aculeata												•								
Caprifoliaceae	*Sambucus nigra*															a					
Commelinaceae	*Commelina* sp.							a													
	Tradescantia sp.											a									
	Tripogandra sp.												a								
Convolvulaceae	Convolvulaceae sp1	a																			
	Ipomoea cayrica	•							•				a	•							
-	*Merremia* sp1																				
-	*Merremia macrocalyx*																				
Cucurbitaceae	*Luffa cylindra*																	a			
	Momordica charantia										a										
0	*Sechium edule*																				a
Ericaceae	*Rhododendron* sp																				a
Euphorbiaceae	*Croton lundianus*								•	•	•										
-	*Euphorbia milli*																		a		
-	*Ricinus* sp.											a									
Fabaceae	*Acacia paniculata*											a	a								
-	*Acacia plumosa*								•				•								
-	*Bowdichia* sp.						a														
-	*Brownea* sp.						a														
	Caesalpinia pelthophoroides											a									
-	*Chamaecrista* sp.										a										
-	*Fabaceae* sp.												a								
-	*Indigofera* sp.											a									
-	*Mimosa* sp.											a									
-	*Prosops* sp.											a									

TABLE 1
Continued...

Plant Family	Species	Months																			
		A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N
-	*Schizolobium parahyba*						a														
	Swartzia sp.																				
-	*Vigna* sp.													a							
Iridaceae	Iridaceae sp.										a										
Labiatae	*Hyptis* sp.													a							
-	*Ocimum kylimandscharicum*						a														
-	*Salvia* sp.												a								
	Sconurus sibiricus					a															
Lauraceae	*Persea americana*				a																
Loranthaceae	*Struthanthus* sp.																		a		
Malphighiaceae	*Abutilon* sp.												a								
	Herissanthia sp.												a								
	Malphighiaceae sp.												a								
Malvaceae	*Sida rhombifolia*											a	a								
Melastomataceae	*Tibouchina mutabilis*						a														
Myrtaceae	*Campomanesia* sp.	a										a									
-	*Eucalyptus* sp.	a												a							
-	*Eugenia* sp.						•												•	•	•
-	*Myrcia* sp.								a												
-	*Myrciaria* sp.			•																	
	Myrciaria trunciflora	a												a							
-	Myrtaceae sp5						a														
-	*Psidium guayava*						•														
-	*Psidium* sp.						•														
-	*Syzygium malaccensis*																	a			
Oleaceae	*Ligustrum* sp.						a														
Onagraceae	*Ludwigia* sp1					a															
Plantaginaceae	*Plantago minor*					a															
Poaceae	*Paspalum* sp.												a								
Polygonaceae	*Polygonum* sp.																		a		
Rosaceae	*Rosa sinensis*																		a		
Rubiaceae-	*Borreria* sp.											a									
-	*Coffea arábica*																		a		
-	*Diodia* sp.												a								
-	*Palicourea* sp.											a	a								
Rutaceae	*Ruta graneolens*				a																
	Murraya paniculata											a									
-	*Citrus* sp.															a					
	Rutaceae sp.								a												
	Rutaceae sp1								a												
Sapindaceae	*Paullinia* sp.												•								
-	*Serjania lethalis*					•									•						
-	*Serjania* sp.			•										•							
	Serjania sp1							•						•							
Solanaceae	*Solanum americanum*								a												
-	*S. cernuum*					a															
-	*S.granulosoleprosum*	•	•	•	•									•		•	•				
	S.tabacifolium				•				•												
Sterculiaceae	*Waltheria americana*										a										
Tiliaceae	*Triumphaetta semitrilola*					a															
Verbenaceae	*Congea scanalens*						a														
-	*Lantana* sp.						a														
Violaceae	*Viola* sp.											a									

visited 19 species (18%) from 8 families (24.4%). Forty-six % of 86 visits were to six species of Asteraceae and six of Myrtaceae (Table 2).

Despite Asteraceae and Fabaceae being the richest, only 4 (33%) of 12 species of Asteraceae and of 13 (8%) species of Fabaceae were visited at NHM (Table 2). Myrtaceae (40%) and Asteraceae (33%) were the most visited families. 78% of *M. quadrifasciata v*isits were to four species of Convolvulaceae. *Vernonia polyanthes* and *Psidium guayava* were the most visited species of Asteraceae and Myrtaceae, respectively (Table 3).

TABLE 2
Family, number of species, and number and percentages of species visited by *M. quadrifasciata* from April 1998 to December 1999 at the NHN of UFMG.

Family	Flowering species (N)	Visited species (N)	Visited species (%)
Asteraceae	12	4	33
Convolvulaceae	4	3	75
Cactaceae	2	1	50
Euphorbiaceae	3	1	33
Fabaceae	13	1	8
Myrtaceae	10	4	40
Sapindaceae	4	3	75
Solanaceae	4	2	50
Total			

TABLE 3
Resource (Pollen: P - Nectar: N) collected and number of visits by *M. quadrifasciata* at the NHM.

Family	Specie	Resource	Visits (N)
Asteraceae	Asteraceae sp3	N	1
	Cosmos sulphureus	P	3
	Mikania micrantha	N/P	1
	Tanaecium sp.	N	1
	Trixis sp.	N	2
	Vernonia polyanthes	N	9
Cactaceae	*Peireskia aculeata*	N	1
Convolvulaceae	*Ipomoea cayrica*	N	5
	Merremya macrocalyx	N	4
	Merremya sp1	N	6
Euphorbiaceae	*Croton lundianus*	N	7
Fabaceae	*Acacia* sp.	P	5
Myrtaceae	*Eugenia* sp.	N	4
	Myrciaria sp.	N	1
	Myrtaceae sp5	N/P	4
	Myrcia sp.	N/P	2
	Psidium sp1	N/P	3
	Psidium guayava	N/P	8
Sapindaceae	*Serjania* sp.	N	3
	Serjania lethalis	N	2
	Serjania sp1	N	1
Solanaceae	*Solanum granulosoleprosum*	P	5
	Solanum tabacifolium	P	8

M. quadrifasciata was collected during almost the entire study period at NHM, except for October 1998 (Fig. 1). However, we found a high variation in the number of flowering plants during the study period ($\chi^2 = 77$; $df = 19$; $P < 0.001$). The highest numbers of flowering species were collected during the spring (September-November) and summer (December-March) (Fig. 1). The number of visited species significantly changed during the study period ($\chi^2 = 85$; $df = 19$; $P < 0.001$). However, no correlation was found between monthly richness of flowering and visited plants.

Melipona quadrifasciata gathered pollen and/or nectar from different species: pollen from only 4 species, and nectar from 14 others. Both pollen and nectar were collected from 4 Myrtaceae and one Asteraceae species (Table 3). The Solanaceae species were the main pollen sources, accounting for 62% of 21 visits. But the main floral resource collected was nectar, accounting for 56% of 86 visits, while pollen collection accounted for only 24%. Bees collected both pollen and nectar from Myrtaceae species (Table 3).

Melipona quadrifasciata collected only nectar on species of Sapindaceae, Convolvulaceae, Euphorbiaceae, and Cactaceae. Asteraceae and Myrtaceae were visited both for pollen and nectar, while only pollen was collected from Fabaceae (Fig. 2). A significant difference was registered between Asteraceae and Myrtaceae in the type of floral resource collected. *Cosmos sulphureus* was visited only for pollen, but *Mikania micrantha* was visited for both pollen and nectar. The other species in the family were visited only for nectar. Only nectar was collected from *Eugenia* sp. and *Myrciaria* sp. (Myrtaceae). Both floral resources were collected from the other species in this family.

A high similarity was found in composition of visited species between that reported in this study and those of four other studies, carried out at forest sites in São Paulo State and in which the similarity rate was higher than 50%. Two clusters, the first of which (site 3) was studied in this work and the second, at another (site 4) in Belo Horizonte (Antonini *et al*., unpublished data) presented a low Euclidean distance; a second group comprising two sites (5 and 6) in São Paulo State was separated by a low Euclidean distance (Fig. 3). When compared, these two groups presented a Euclidean distance higher than 60% (Fig. 3). Because *M. quadrifasciata* collected pollen and nectar from different plant families originating in the cerrado, we found a high Euclidean distance between the sites reported on in this study and the cerrado site (site 1) (Fig. 3).

DISCUSSION

Melipona quadrifasciata collected pollen in 19 plant species at NHM and can be considered a

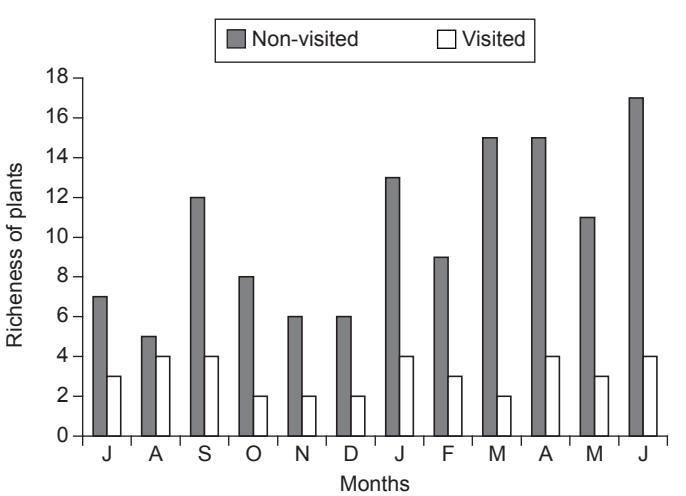

Fig. 1 — Monthly richness of visited and non-visited flowering plants at the Natural History Museum of UFMG from April 1998 to November 1999.

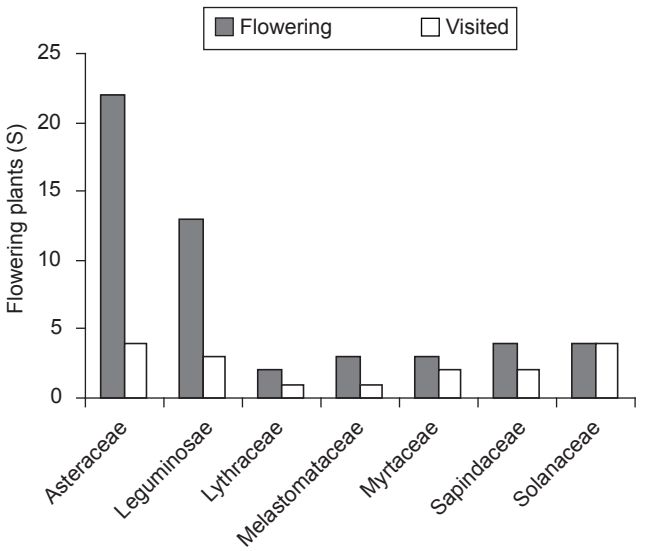

Fig. 2 — Monthly richness of visited and non-visited families of flowering plants at the Natural History Museum of UFMG from April-1998 to November-1999.

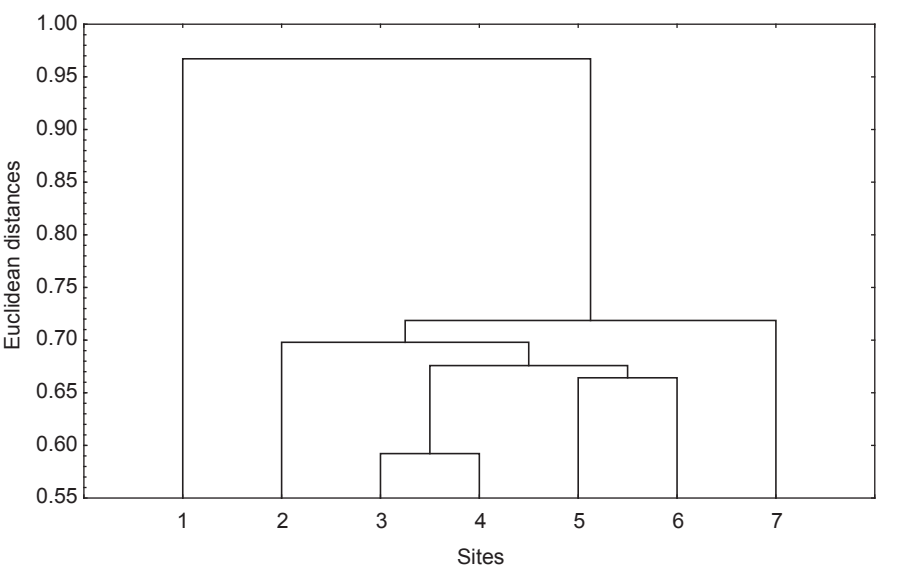

Fig. 3 — Cluster analysis by families of plant species used by *M. quadrifasciata* at different sites in Brazil. 1- Bahian cerrado (Viana *et al*., 1997); 2- São Paulo forest fragment (Wilms *et al*., 1997); 3- Belo Horizonte forest fragment (the present study); 4- Belo Horizonte forest fragment (Antonini *et al*., unpublished); 5- São Paulo forest (Ramalho *et al*., 1989); 6- São Paulo forest fragment (Imperatriz-Fonseca *et al*., 1989); and 7- São Paulo forest fragment (Wilms *et al*., 1996).

pollen generalist according to criteria proposed by Absy *et al*., (1984) who analyzed pollen samples taken from nests of 5 *Melipona* species. In species whose colonies used more than 10 plant species, the bees were considered or generalists. *Melipona interrupta*, for which 24 types of pollen were registered, was the leading generalist among *Melipona* species. In contrast, *M. quadrifasciata*

tended to specialize in certain families, as shown by the high number of visits to relatively few floral resources, including some well-represented families at MHN. For example, the great number of visits to two Solanaceae and all four Myrtaceae species indicated that their flowers these were important pollen sources for *M. quadrifasciata* (Table 2). In addition, Guibu *et al*. (1988) sampled pollen from laboratory colonies and found, as did this study, Myrtaceae and Solanaceae to be the most visited families.

We found a slight difference in the number of plant species visited by *M. quadrifasciata* at NHM (19) and those visited at the University of São Paulo (USP) campus (14) (Pirani & Cortopassi-Laurino, 1994) where *M. quadrifasciata* used species of 10 families, as opposed to the 8 used at NHM. Although Asteraceae and Fabaceae presented the greatest abundance of flowering species at MHM, *M. quadrifasciata* visited only 4 of the former and one of the latter.

Pirani & Cortopassi-Laurino (1994) recorded *M. quadrifasciata* visiting *Eucalyptus* sp. in the gardens of USP campus. But despite high abundance of *Eucalyptus* sp. in the two sites studied in Belo Horizonte, no visits to this species were observed. The difference, however, could be explained by methodologically: Sampling done in food pots is apparently more efficient than that done using entomological nets. Furthermore, plants higher than 10 m, which was the case with *Eucalyptus* individuals in NHM, could not be sampled. In addition, the greater plant richness found at NHM as compared to that at USP may indicate preference by *M. quadrifasciata* for greater plant diversity. Plants not visited at NHM usually have low densities. Efforts to locate them was probably avoided to conserve energy (see Roubik, 1989).

Some species, *e.g.*, *Vernonia polyanthes*, *Cosmos sulphureus*, and *Helianthus annus*, although present at both USP and NHM, were visited only at the latter, possibly due to distances from nest to resource and food quantity provided by other flowering plants. *M. quadrifasciata* appears to have a tendency to collect the same resource, whether pollen, nectar, or both, in flowers belonging to the same family, which - for example - in the case of Sapindaceae and Convolvulaceae was nectar. In Myrtaceae and Asteraceae, *M. quadrifasciata* collected pollen and nectar. There was a difference in the type of resource gathered only in Asteraceae (Table 2).

According to Johnson & Hubbell (1974), food collection sites selected depend on flower quantity or productivity, making Meliponini, which gather resources from plants of both high and low floral density, classifiable as a generalist. As for *Melipona quadrifasciata*, our results suggest that this species favors predictable resources, since most of the visited species belong to families having flowering individuals year-round. Grant (1950) also reported such fidelity of bees to certain plant species.

Only in five of more than fifty fragments in Belo Horizonte does *M. quadrifasciata* naturally occur (Antonini; *pers. com.*). Although we did not estimate the population size of *Melipona quadrifasciata* in 20 months of study, many collections were made, indicating high abundance of individuals (n = 86). In contrast, two other studies in which *M. quadrifasciata* was collected showed very low abundance for this species, which supports Wilms *et al*. (1997) who affirmed that this bee species is rare compared to others of stingless bees. These researchers collected 666 individuals belonging to highly social bee species, less than 1% of which were individuals of *M. quadrifasciata*. Similar results were found by Wilms *et al.* (1996) who in 36 months collected 2.5 individuals per plant species (n = 28). In any case, food resources available at MHN is obviously sufficient to satisfy the needs of the colony.

Flowers of Solanaceae present a great amount of pollen, while Asteraceae provides nectar in abundance. But while practically all Solanaceae present in the area were visited, only three species of Asteraceae - although it is well represented in the area - were. This is probably because *Apis mellifera* visits with great frequency the Asteraceae species, which normally provide great amounts of nectar. Thus, presumably to avoid competition at the same food source, *M. quadrifasciata* could tend to seek alternatives. Some indirect evidence indicates that competition modifies floral source use among the Apidae. For example, in the presence of competitors some *Bombus* species concentrate nectar collecting in flowers to whose tubular corollas their lengthy proboscides better adapted (Inouye, 1978; Heinrich, 1978; Pyke, 1984).

Urbanization is generally regarded as causing disturbance, fragmentation, and decrease

in available habitats for plant populations and wildlife (Mc Intyre, 2001). But even though NHM is embedded in an urban fragment, the evidence indicates that it has been able to maintain, at least for the past six years (Antonini; *pers. obs.*), a population of *M. quadrifasciata*. The first author of this work observed that richness of tree species and tree density inside the fragment has been determinant in the continuing presence of *M. quadrifasciata*, in spite of disturbance intensity inside and degree of urbanization immediately outside. At NHM, several large diameter trees exist that could supply future needs of the colonies for cavities (see also Antonini & Martins, 2003).

Similar to all studied social bees, *Melipona quadrifasciata* is a generalist in floral resource use, which makes it adaptable in using those of several species throughout the year. Despite these bees visiting many plant species, only a few were significant parts of their diet. In conclusion, fragment quality, as well as its floral composition, is crucial in maintaining the *M. quadrifasciata* population, specially in urban environments.

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