ECOLOGY, BEHAVIOR AND BIONOMICS

Diversity of Bees and their Floral Resources at Altitudinal Areas in the Southern Espinhaço Range, Minas Gerais, Brazil

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Diversidade de Abelhas e suas Fontes Florais em Campos Altitudinais, na Porção Sul da Cadeia do Espinhaço, MG

RESUMO - A porção sul da Cadeia do Espinhaço apresenta amplas áreas cobertas por campos altitudinais tropicais, quartizíticos ou metalíferos. Esses ecossistemas estão extremamente ameaçados, devido ao alto impacto antrópico, como a mineração e a urbanização. Nesse estudo inventariou-se a fauna e flora apícola durante um ano em uma área de campo rupestre (Serra de Ouro Branco) e durante dois anos em uma área de canga (Ouro Preto). Foram realizadas coletadas quinzenais de 8:00h às 17:00h. Foram coletados 677 indivíduos pertencentes a 91 espécies de abelhas de cinco famílias. Apidae foi a família mais rica e abundante, seguida por Halictidae e Megachilidae. As abelhas visitaram 46 espécies de plantas e as famílias mais visitadas foram: Asteraceae (n = 220), Malpighiaceae (n = 95), Melastomataceae (n = 94), Fabaceae (n = 78), e Solanaceae (n = 63). A região de Ouro Branco apresentou maior diversidade (H = 1,47) que Ouro Preto (H = 1,17). A baixa riqueza e abundância de abelhas, quando comparada a outras regiões de cerrado, podem ser atribuídas aos fatores ambientais das áreas de estudo: alta altitude, temperatura e disponibilidade de recursos florais. Áreas de canga e campo rupestre abrigam espécies raras e ameaçadas de extinção da fauna e flora. Áreas no sul do Espinhaço podem, entretanto, serem consideradas possíveis áreas de conservação biológica permanente.

PALAVRAS-CHAVE: Apidae, cerrado, fauna de abelhas, conservação

ABSTRACT - The Southern Espinhaço Range consists of large areas covered by quartzitic or metaliferous tropical altitudinal fields. The Espinhaço Range ecosystems are endangered by anthropic high impacts, particularly due to mining and urbanization. We conducted a one-year inventory of the bee flora and fauna at the quartzitic Ouro Branco Mountains and a two-year survey of the metaliferous Ouro Preto fields. The samples were collected twice a month, from 8:00 am to 5:00 pm. The bees (677) belonged to 91 species, five families. The family Apidae was the richest and most abundant, followed by the Halictidae and Megachilidae. The bees visited 46 flowering plant species; the most visited plants were the Asteraceae (n = 220), the Malpighiaceae (n = 95), the Melastomataceae (n = 94), the Fabaceae (n = 78), and the Solanaceae (n = 63). Diversity was higher in Ouro Branco (H = 1.47) than in Ouro Preto (H = 1.17). The low richness and abundance of bees in our research site when compared to other Brazilian "Cerrado" areas can be due to the high altitude, low temperature, and low availability of flowers we found. "Canga" and rupestrian areas house fauna and flora species that are rare and threatened by extinction. The southern Espinhaço areas can, therefore, be given the status of permanent biodiversity preservation area.

KEY WORDS: Apidae, bee fauna, conservation

Approximately 30,000 bee species with several nidification habits and floral preferences are found in the world (Roubik 1989, Michener 2000); in Brazil, an estimated 3,000 species (Silveira *et al.* 2002) can be found. Most bees depend on floral resources such as pollen, nectar, and oil for food (Camargo & Roubik 1991). On the other hand, flowering plants depend on bees as pollen vectors for their sexual reproduction; this interaction is particularly important in tropical ecosystems (Buchmann & Nabhan 1996).

Although studies on bee fauna and flora have been conducted in almost every region in Brazil, studies are still scarce in some parts of the country (Sakagami *et al.* 1967, Laroca *et al.* 1982, Carmargo & Mazucato 1984, Pedro & Camargo 1991). In the State of Minas Gerais, bee fauna surveys conducted at the "Zona da Mata" (a forest area) (Cure *et al.* 1992, 1993; Silveira & Cure 1993, Antonini & Martins 2003) and the "Cerrado" (a savannah area) (Silveira & Campos 1995, Carvalho & Bego 1998) have contributed significantly for the better understanding of bees in the State.

The southern Espinhaço Range, located in Minas Gerais, contains large Cerrado areas and is one of the richest biomes in the planet (Myers *et al.* 2000). In this region, the Cerrado contains rupestrial and "Canga" areas with poor and thin soils, high insulation, and low humidity. These extreme situations make the region highly peculiar and endemic. Nonetheless, this biome has been considered one of the most critical and threatened, due to the high anthropic impact to which it is subjected (Mendonça & Lins 2000).

In spite of the high diversity found in the Cerrado, studies on bee diversity in the southern Espinhaço Range were not found. In our study, we aimed at learning about bee fauna and its flower resources and providing information to transform the region into an ecological preservation unit.

Materials and Methods

We studied two different ecosystems in the southern Espinhaço Range: the hematitic Canga and the rupestrial area in the Ouro Branco Mountains.

The hematitic Canga area is located at the Ouro Preto municipality (43º30' and 43º31' W; 20º23' and 20º24' S). The mountain peak in the area is approximately 1230 m. From 1940 to 1950, the region, which is formed by a rigid-substrate iron compound, was mined for bauxite. Grasses (20-50cm tall) completely cover the substrate and several Asteraceae, Malpighiaceae, Myrtaceae, Verbenaceae, and other species can also be found.

The Ouro Branco Mountains, located at the Ouro Branco municipality (43º46' and 43º33' W; 20º26' and 20º30' S), occupy approximately 65 km^2, maximum altitude 1573 m. The mountains' quartzitic surface rocks are mainly covered by low-mountain pluvial forests and riparia, and also by quartizitic and ferruginous fields (Alkmim 1987).

The bee samples were collected at 1250 m, every 15 days, from August 2000 to August 2002 at the Ouro Preto Canga and from October 2002 to July 2003 at the Ouro Branco Mountains. Two collectors obtained the samples from 2500 m transects. From 8:00 a.m. to 5:00 p.m., each collector remained at a flowering plant for five minutes, totalizing 256 collecting hours at the Canga and 160 hours at the Ouro Branco Mountains. The bees were trapped in entomological nets as soon as they landed on or right after leaving the flowers. The bees were placed in a lethal vial and were killed; next, they were mounted with entomological pins and identified to the taxonomic level as possible. Control species were brought to the entomological collection, Universidade Federal de Ouro Preto (UFOP), Ouro Preto, MG. Although the species *Apis mellifera* L. was abundant and its occurrence registered, we did not capture any specimen. Two samples of each flowering plant species were collected for identification and herborization. Some of the fertile material was first herborized following the techniques described by Mori & Pipoly (1984), and then deposited at the Herbário Professor José Badini, Universidade Federal de Ouro Preto.

We used the Shannon-Wienner diversity index to assess the diversity of bee species in both sampled areas. A simple linear regression analysis tested the relationship between accumulated number of bee species (*y* variable) and number of months when sampling was conducted (*x* variable); the sampling site was the co-variable (Canga area and Ouro Branco Mountains). The model was simplified to remove non-significant variables using the generalized linear model as recommended by Crawley (2002) and processed with the software R (Ihaka & Gentleman 1996).

Results

We collected 677 specimens belonging to 91 bee species. At the Canga, we found 46 species belonging to 21 genera and four families, a total of 325 individuals. At the Ouro Branco Mountans, we found 66 species belonging to 28 genera and four families, a total of 352 individuals (Table 1). Only 22 (24.2%) of the collected species were reported for both areas (Table 1). When we include the species *A. mellifera* the total increases to 3006 individuals.

At the Canga, the number of bee species collected increased until the 20th data-collecting month; after that, the number tended to stabilize. In the Ouro Branco Mountains, however, the number of captured species increased significantly until the 10th collecting month and the collecting curve did not stabilize (Fig. 1) ($\chi^2 < 0.001$, gl = 31). The Ouro Branco Mountains had a higher diversity index (H = 1.47) than the Canga (H = 1.17).

Bee abundance and richness per family had similar relationships in both areas. The Apidae was the richest and most abundant family, followed by the Halictidae and the Megachilidae. We found few specimens belonging to the families Colletidae ad Andrenidae (Table 2).

The most abundant bee species at the Canga were *Bombus* (*Fervidobombus*) *morio* (Swederus) (n = 65 specimens), *Melipona quinquefasciata* (Lepeletier) (n = 56), *Bombus* (*Fervidobombus*) *atratus* (Franklin) (n = 51) and *Pseudaugochlora graminea* (Fabricius) (n = 35). In the Ouro Branco Mountains, the most abundant species were *Trigona spinipes* (Fabricius) (n = 61), *B. atratus* (n = 40), *Trigona hyalinata* (Lepeletier) (n = 30) and *Tetrapedia* sp.1 (n = 18).

The bees visited 46 plant species belonging to 16 families

Table 1. Bee species and their abundance and seasonal distribution, and number of plants visited at the “Canga” area and the Ouro Branco Mountains. OB = Ouro Branco; OP = Ouro Preto

Species	Number of bees		Months												Number of plants visited	
	OB	OP	J	F	M	A	M	J	J	A	S	O	N	D	OB	OP
Andrenidae																
01 - *Anthrenoides alfkeni* Ducke	-	2	·												-	1
02 - *Oxaea flavescens* Klug	-	1				·									-	1
Apidae																
03 - *Anthophora paranensis* Holmberg	-	1		·												1
04 - *Apis mellifera* L.	892	1437	·	·	·	·	·	·	·	·	·	·	·	·	19	21
05 - *Arhysoceble* sp.1	2	-											·		2	-
06 - *Bombus* (*Fervidobombus*) *atratus* Franklin	40	51	·	·	·	·	·	·	·	·	·		·	·	13	14
07 - *Bombus* (*Fervidobombus*) *brasiliensis* Lepeletier	-	2								·		·			-	2
08 - *Bombus* (*Fervidobombus*) *morio* Swederus	2	65	·	·	·	·	·	·	·	·		·	·	·	2	14
09 - *Centris* (*Paracentris*) *klugi* Friese	6	-		·		·									3	-
10 - *Centris* (*Ptilotopus*) *scopipes* Friese	11	-	·										·		4	-
11 - *Centris* (*Xanthemisia*) *bicolor* Lepeletier	5	3		·	·	·	·					·	·		2	2
12 - *Centris* (*Xanthemisia*) sp.1	1	-		·											1	-
13 - *Centris* (*Centris s. str.*) *aenea* Lepeletier	1	11		·	·	·				·	·	·	·		1	3
14 - *Centris* (*Centris s. str.*) *varia* Erichson	1	10		·		·	·			·	·	·		·	1	3
15 - *Centris* (*Hemisiella*) *tarsata* Smith	5	1	·									·	·	·	3	1
16 - *Centris* (*Trachina*) *fuscata* Lepeletier	1	-										·			1	-
17 - *Centris* sp.1	1	15									·	·	·	·	1	3
18 - *Centris* sp.2	-	1												·	-	1
19 - *Centris* sp.3	-	1		·											-	1
20 - *Ceratina* (*Ceratinula*) sp.1	1	-		·											1	-
21 - *Ceratina* sp.1	1	-											·		1	-
22 - *Ceratina* sp.2	3	2			·	·			·				·		3	-
23 - *Epicharis* sp.1	-	1											·		-	1
24 - *Epicharis* sp.2	-	1										·			-	1
25 - *Epicharis* (*Anepicharis*) *dejeanii* Lepeletier	6			·	·		·								4	-
26 - *Epicharis* (*Epicharana*) *flava* Friese	2	-					·		·						2	-
27 - *Epicharis* (*Epicharoides*) *grandior* Friese	4	-		·		·	·	·							4	-
28 - *Epicharis* (*Triepicharis*) *schrottkyi* Friese	3	-		·	·	·									3	-
29 - *Epicharis* (*Cyphepicharis*) sp.1	2	-	·											·	1	-
30 - *Euglossa* sp.1	6	-		·		·	·	·					·		3	-
31 - *Eulaema* (*Apeulaema*) *nigrita* Lepeletier	2	6				·	·			·	·		·		1	5
32 - *Exomalopsis* (*Exomalopsis*) *auropilosa* Spinola	1	-					·								1	-
33 - *Exomalopsis* sp.1	3	1	·				·		·				·	·	3	1
34 - *Exomalopsis* sp.2	-	2				·				·					-	2
35 - *Exomalopsis* sp.3	-	2							·	·					-	2

Continue

Table 1. Continuation

Species	Number of bees		Months												Number of plants visited	
	OB	OP	J	F	M	A	M	J	J	A	S	O	N	D	OB	OP
36 - *Exomalopsis* sp.4	-	1							·						-	1
37 - *Exomalopsis* sp.5	-	1									·				-	1
38 - *Exomalopsis* sp.6	-	1											·		-	1
39 - *Geotrigona* sp.1	2	-		·		·									2	-
40 - *Geotrigona* sp.2	5	-	·										·	·	3	-
41 - *Geotrigona* sp.3	2	-	·											·	2	-
42 - *Melipona* (*Eomelipona*) *bicolor* Lepeletier	2	-	·										·		2	-
43 - *Melipona* (*Melipona*) *quadrifasciata* Lepeletier	-	4			·			·		·	·				-	2
44 - *Melipona* (*Melikerria*) *quinquefasciata* Lepeletier	6	56	·	·	·	·	·	·	·	·	·	·	·	·	4	12
45 - *Melitoma segmentaria* Fabricius	2	-	·										·		2	-
46 - *Melissoptila cnecomola* Friese	-	2											·		-	1
47 - *Melissoptila nigroaenea* Smith	-	1									·				-	1
48 - *Monoeca* sp.1	2	-											·		2	-
49 - *Monoeca* sp.2	2	-	·										·		2	-
50 - *Monoeca* sp.3	1	-											·		1	-
51 - *Paratetrapedia* sp.1	16	5	·	·								·	·	·	8	3
52 - *Paratrigona lineata* Lepeletier	2	1					·	·		·					2	1
53 - *Paratrigona subnuda* Moure	2	1					·	·		·					2	1
54 - *Tapinotaspoides* sp.1	3	-		·	·	·									3	-
55 - *Tetragonisca angustula* Latreille	-	12		·	·	·								·	-	1
56 - *Tetrapedia* sp.1	18	-	·		·	·	·					·	·	·	7	-
57 - *Tetrapedia* sp.2	9	-	·		·	·	·	·						·	6	-
58 - *Tetrapedia* sp.3	2	-			·	·									2	-
59 - *Tetrapedia* sp.4	2	-			·	·									2	-
60 - *Thygater* sp.1	2	-						·	·						2	-
61 - *Thygater analis* Lepeletier	3	5	·									·	·	·	2	3
62 - *Trigona* sp.1	1	-					·								1	-
63 - *Trigona hyalinata* Lepeletier	30	3		·	·	·	·	·		·			·		8	2
64 - *Trigona spinipes* Fabricius	61	2	·	·	·	·	·	·				·	·	·	11	2
65 - *Trigona fulviventris* Guerin	-	1								·					-	1
66 - *Xylocopa* sp.1	1	1	·				·								1	1
67 - *Xylocopa* (*Schonnherria*) sp.1	-	1												·	-	1
68 - *Xylocopa* (*Dasyxylocopa*) sp.1	2	-		·		·									1	-
69 - *Xylocopa* (*Stenoxylocopa*) sp.1	2	-					·		·						1	-
71 - *Xylocopa* (*Neoxylocopa*) sp.1	-	2								·				·	-	1
Colletidae																
72 - *Tetraglossula* sp.1	1	-												·	1	-

Continue

Table 1. Continuation

Species	Number of bees		Months												Number of plants visited	
	OB	OP	J	F	M	A	M	J	J	A	S	O	N	D	OB	OP
Halictidae																
73 - *Augochloropsis* sp.1	3	6											·		2	3
74 - *Augochloropsis* sp.2	3	-	·											·	1	-
75 - *Augochloropsis* sp.3	1	-										·			1	-
76 - *Augochloropsis* sp.4	16	-		·	·	·									4	-
77 - *Augochloropsis* sp.5	3	-		·	·										3	-
78 - *Augochloropsis* sp.6	2	-		·		·									2	-
79 -*Dialictus* sp.1	2	-	·										·		2	-
80 - *Dialictus* sp.2	3	-	·										·	·	1	-
81 - *Dialictus* sp.3	1	-											·		1	-
82 - *Pseudagapostemon brasiliensis* Cure	1	-										.			1	-
83 - *Pseudagapostemon* sp.1	1	-		.											1	-
84 - *Pseudaugochlora* sp.1	4	-		.	.	.									3	-
85 - *Pseudaugochlora graminea* Fabricius	8	35			·	·	·	·	·		·	·	·	·	4	9
Megachilidae																
86 - *Megachile* (*Neochelynia*) sp.	12	-		·	·	·	·	·	·						4	-
87 - *Megachile* (*Leptorachis*) sp.	-	1												·	-	1
88 - *Megachile* (*Pseudocentron*) sp.	-	1												·	-	1
89 - *Megachile* sp.1	1	1		·										·	1	1
90 - *Megachile* sp.2	-	1								·					-	1
91 - *Megachile* sp.3	-	1												·	-	1
Total	1244	1762													56	46

at the Canga (Table 3) and 56 plant species (21 families) in the Ouro Branco Mountains (Table 4). The most visited plant families were: the Asteraceae, the Fabaceae, the Malpighiaceae, the Melastomataceae, the Solanaceae, and the Lythraceae (Fig. 2). At the Canga, *Solanum* sp.1 was the most visited species, with 63 bee specimens belonging to 14 species (Tables 3 and 4). In the Ouro Branco Mountains, the most visited species was *Lychnophora* sp.1 (Asteraceae), with 89 bee specimens belonging to 31 species.

Discussion

Regional fauna composition can be determined by historical and ecological factors (Strong *et al*. 1984, Cornell 1985). Among all factors related to habitat quality, food availability is the key to retain species. Several authors suggest indeed that bee diversity can be related to the availability of floral resources (Gathmann *et al.* 1994).

The number of species sampled at the Canga (46) and Ouro Branco Mountains (66) areas was lower than the number found by Silveira & Campos (1995) in Cerrado areas

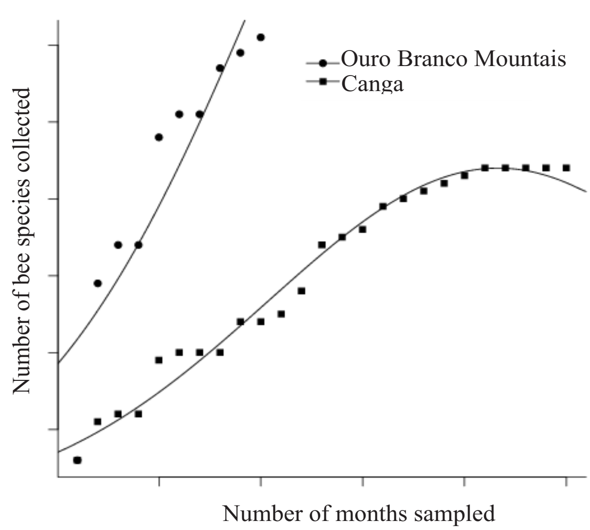

Figure 1. Cumulative distribution of bee species during the sampling months, at the “Canga” area and the Ouro Branco Mountains.

Table 2. Abundance of specimens and species richness per bee family, at the "Canga" area and the Ouro Branco Mountains

Family	Canga		Ouro Branco Mountains	
	Abundance	Richness	Abundance	Richness
Andrenidae	3	2	0	0
Apidae	276	37	290	50
Colletidae	0	0	1	1
Halictidae	41	2	49	13
Megachilidae	5	5	13	2
Total	325	46	353	66

(124 species in Corumbataí and 151 in Paraopeba). In Cerrado regions, fauna composition is different (Heithaus 1979, Silveira & Cure 1993) from that in our study area, mainly due to the Cerrado floristic heterogeneity (Moldenke 1975). The number of species we found (91) is similar to the number sampled by Antonini & Martins (2003) in a transition area between the Cerrado and the Atlantic Forest, at the Estação Ecológica da Universidade Federal de Minas Gerais (98).

The low number of species in our study can be related to anthropic situations, such as intense mining at the Canga. Besides, the vegetation in rupestrial areas are predominantly the same size as shrubs and herbacious plants (Sakagami & Laroca 1971). As a consequence, groupings that nidify in tree empty spaces can face limitations concerning the nidification substract, as it occurs with the Meliponini (Roubik 1989). Silveira & Campos (1995) also observed these groups' low abundance in Cerrado areas when compared to forest remanents.

The diversity of species we found was significantly different between the sampled habitats. The collector's curve did not stabilize in the Ouro Branco Mountains, which may be due to greater bee species diversity than the diversity we observed. On the other hand, the curve stabilization at the Canga can be due to species saturation and appropriate sampling that truly represents the region.

High numbers of the genus *Bombus* in both areas can be explained by the genus adaptation to the research sites altitude and low temperatures because species belonging to this genus are robust and can stand strong winds (Heinrich 1979). The exotic species *A. mellifera* was the most generalist of all and the one with the highest visit frequency. This species can affect the interaction pollinator and active plants due to its high efficiency in collecting pollen. *A. mellifera* can harm specialist bees more significantly than it can harm generalist bees (Huryn 1997, Gross 2001). In

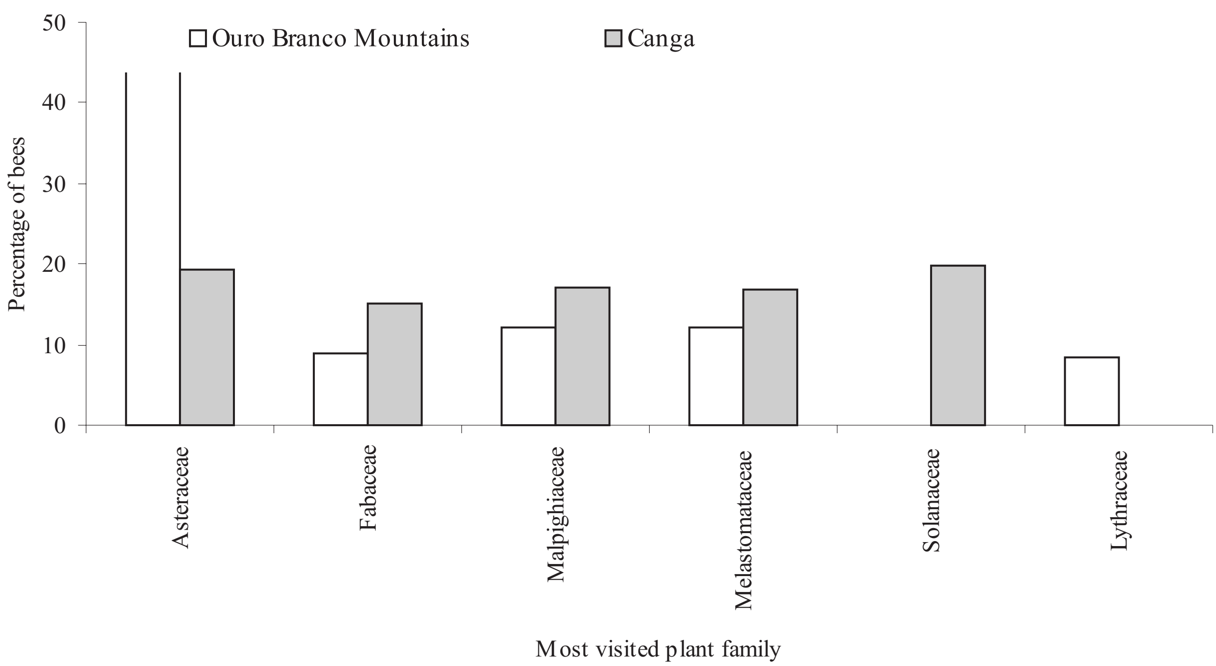

Figure 2. Percentage of bees in the most visited plant families at the "Canga" area and the Ouro Branco Mountains.

Table 3. Flowering plant species and their abundance, and visiting bees at the "Canga" (Ouro Preto, MG).

Family	Plant species	Number of bees	Species of visiting bees
Anacardiaceae	*Spondias tuberosa* Arruda	2	10
Araliaceae	*Scheflera* sp.1	4	4,6,8,40
Asteraceae	*Aspilia laevissima* Baker	4	4,8,40,82
	Baccharis camporum DC.	6	4
	Emilia sonchifolia (L.) DC.	4	4,6,8
	Eupatorium sp.1	6	4,40
	Eupatorium sp.2	1	4,8
	Eupatorium sp.3	0	
	Eupatorium sp.4	1	28
	Piptocarpha sp.1	7	4,6,8,28,59,79
	Vanillosmopsis erythropappa (DC.) Sch. Bip.	14	40
	Vernonia laevigata Mart. ex DC.	12	4,6,8,31,40,48,79,83
	Vernonia sp.1	4	4,29
	Zynia sp.1	2	4,6
Convolvuleaceae	*Evolvulus kramerioides* Mart.	11	4,13,20,30,31,32,40,55,79
Fabaceae	*Crotalaria* sp.1	29	4,6,8,15,47,55,58,60,61,64,81,84,85
	Periandra mediterranea (Vell.) Taub.	0	
	Senna sp.1	13	4,6,8,28
	Spartium junceum L.	0	4,6,7,8,40,79
	Visna sp.1	6	1,4,6,84
Malpighiaceae	*Byrsonima coccolobifolia* Kunth	54	4,6,7,8,11,12,15,21,22,30,33,34,40,46,65,79
Malvaceae	*Hibiscus* sp.1	1	4
	Malvaviscus sp.1	0	
Melastomataceae	*Tibouchina multiflora* (Gardn.) Cogn.	43	2,4,6,8,12,17,39,40,46,58,65,79
	Tibouchina sp.1	4	4,6,8,40,79
	Tibouchina ciliaris (Vent.) Cogn., 1887	3	4,6,79
	Tibouchira sp.2	3	4,6,8,79
Meliaceae	*Cabralea* sp.1	2	4,55
	Cabralea sp.2	1	79
Myrtaceae	*Melalenca* sp.1	2	4, 40
Nytaginaceae	*Bouganville* sp.1	0	
Proteaceae	*Grevillea robusta* A. Cunn. ex R. Br.	0	
Rubiaceae	*Diodia apiculata* (Willd. ex Roem. & Schult.) K. Schum.	0	
Scrophulariaceae	*Physocalix major*	0	

Continue

Table 3. Continuation

Family	Plant species	Number of bees	Species of visiting bees
Solanaceae	*Nicotiana alata* Link & Otto., 1828	0	
	Solanum sp.1	63	4,6,8,12,15,28,29,39,40,42,46,55,65,79
Tropacolaceae	*Tropacolum majus*	1	73
Verbenaceae	*Stachytarpheta brasiliensis* Moldenke	0	
	Lantana camara L.	3	4,6,8
	Lantana lilacina Desf.	1	79
	Lantana sp.1	0	
	Lantana sp.2	1	28
	Verbena bonariensis L.	3	7,8
	Verbena sp.1	1	57
	Verbena sp.2	2	4,6
	Verbena sp.3	1	4
	Verbena sp.4	2	6
Total	48	317	44

our study, most bee species were little abundant. However, we cannot say that these populations are declining due to the presence of *A. mellifera,* or that these populations naturally have low densities; we cannot compare our data to data obtained in other studies in the region, because these are non-existent.

In the Canga, *Solanum* sp. was the most visited by bees. *Solanum* sp. and Melastomataceae flowers have poricide anthers that limit the access to the pollen. Only species of the genus *Melipona* and other large bees are able to remove the pollen and not harm the plant; their vibrating anthers work specifically for that purpose (Ramalho *et al.* 1989). Species of Melastomataceae and Solanaceae are widely found in neotropical regions (Heywood 1978), where only the genus *Melipona* occurs (Sakagami 1982). The abundance of *M. quinquefasciata* in this plant, as compared to the low numbers of *A. mellifera* points to the importance of that floral resource for fauna of native bees.

In the Ouro Branco Mountains, *Lychnophora* sp was the most visited species. For Bortoli & Laroca (1990), the abundance of bees found in this genus is due to the plant high availability and long flowering period with no bee preference or specialization.

According to our results, bee diversity can be intrinsically related to the availability of food and nidification resources. Canga and rupestrial areas contain adverse ecosystems that enhance the chances for endemism and the occurrence of rare species, which can result in a delicate interweaving of biological interactions. Several of the bees we collected could not be identified to the taxonomic level of species because they have not been described yet. Therefore, we suggest that the research sites we studied become permanent biodiversity preservation areas.

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References

Alckim, F.F. 1987. Modelo deposicional para a seqüência de metassedimentos da Serra de Ouro Branco, Quadrilátero Ferrífero, Minas Gerais. Anais do Simpósio sobre Sistemas Deposicionais no Pré-Cambriano, Ouro Preto-MG. 12p.

Antonini, Y. & R.P. Martins. 2003. The flowering-visiting bees at the Ecological Station of the Universidade Federal de Minas Gerais, Belo Horizonte, MG, Brazil. Neotrop. Entomol. 32: 565-575.

Bortoli, C. & S. Laroca. 1990. Estudo biocenótico em Apoidea (Hymenoptera) de uma área restrita de São José dos Pinhais (PR, sul do Brasil) com notas comparativas. Dusenia. 15: 1-112.

Buchmann, S.L. & G.P. Nabhan. 1996. The Forgoten Pollinators. Washington, Island.

Camargo, J.M.F. & D.W. Roubik. 1991. Systematics and bionomies of the apoid obligate necrophages: the

Table 4. Flowering plant species and their total abundance, and visiting bees at the Ouro Branco Mountains (Ouro Branco, MG).

Family	Plant species	Number of bees	Species of visiting plants
Asclepiadaceae	*Ditassa micromeria* Decne	3	50, 69
Asteraceae	*Actinoseris polyphylla* (Baker) Cabrera	0	
	Aspilia laevissima Baker	0	
	Chaptalia sp.1	0	
	Elephanthopus sp.1	1	75
	Elephanthopus sp.2	0	
	Eupatorium sp.1	0	
	Eupatorium sp.2	21	6,27,49,57,70,77
	Lychnophora sp.1	89	6,9,11,12,23,25,27,35,38,40,43,49,50,51,52,53, 54,55,57,58,60,62,67,70,71,72,73,78,79,80,83
	Piptolepis sp.1	0	
	Trichogonia appariciol G.M. Barroso	22	6,24,35,40,48,54,57,58,80
	Trichogonia sp.1	0	
	Vernonia erythrophiloides Sch. Bip. Ex Baker, 1873	0	
	Vernonia laevigata Mart. exDC., 1836	26	6,29,51,58
	Vernonia sp.1	0	
Clusiaceae	*Clusia* sp.1	0	
Convolvulaceae	*Evolvulus kramerioides* Mart., 1841	3	23
	Ipomoea sp.1	0	
Cyperaceae	*Rhynchospora* sp.1	0	
Ericaceae	*Leucothae* cf. *pulchra*	0	
Fabaceae	*Calia* sp.1	0	
	Chamaecrista ochnacea (Vogel) H. S. Irwin & Barneby, 1982	1	11
	Chamaecrista sp.1	26	6,23,24,28,49,51,56,57,58,60,63
	Periandra mediterranea (Vell.) Taub., 1894	3	79
Iridaceae	*Irimizia* sp.1	0	
Lythraceae	*Diplusodon orbicularis* Koehne	28	57,58
Malpighiaceae	*Banisteria campestris* A.Juss., 1832	0	
	Byrsonima sp.1	21	8,10,13,14,26,35,36,38,50,51,58,66,79
	Heteropteris sp.1	0	
	Mascagnia sp.1	0	
	Peixotoa tomentosa A. Juss.	20	6,12,13,18,19,20,40,43,46,50,53,57,58,71,72,79
Malvaceae	*Malvastrum* sp.1	0	

Continue

Table 4. Continuation

Family	Plant species	Number of bees	Species of visiting plants
Melastomataceae	*Cambessedesia hilariana* (Kunth) DC.	0	
	Marcetia taxifolia (A. St.-Hil.) DC.	22	6,9,23,24,27,40,48,60,63,80
	Miconia sp.1	0	
	Miconia sp.2	0	
	Miconia sp.3	0	
	Microlicia sp.1	2	44
	Microlicia sp.2	1	6
	Microlicia sp.3	2	6,58
	Microlicia sp.4	1	6
	Tibouchina ciliaris (Vent.) Cogn., 1887	5	6,8,50
	Tibouchina multiflora (Gardn.) Cogn.	8	6,9,25,62,70,78
	Trembleya laniflora Cogn.	0	
Mimosaceae	*Mimosa* sp.1	0	
Myrtaceae	*Myrcia* sp.1.	5	5,20,50,58,74
	Myrcia sp.2	0	
Poaceae	*Poaceae* sp.1	0	
Rubiaceae	*Borreria* sp.1	0	
	Palicourea rigida Kunth	0	
Scrophulariaceae	*Buchnera lavandulacea* Cham. & Schltdl., 1827	9	5,15,29,41,46,67
Solanaceae	*Solanum* sp.1	0	
Velloziaceae	*Vellozia compacta* Mart. Ex Schult. F.	8	10,29,70
	Vellozia graminea Pohl	0	
Verbenaceae	*Lippia florida* Cham.	1	58
Vochysiaceae	*Vochysia emarginata* Vahl	9	6,35,45,51,57
Total	56	337	61

Trigona hypogea group. Biol. J. Linn. Soc. 44: 13-39.

Camargo, J.M.F. & M. Mazucato. 1984. Inventário da apifauna e flora apícola de Ribeirão Preto, SP, Brasil. Dusenia. 14: 55-87.

Carvalho, A.M.C. & L.R. Bego. 1998. Studies on Apoidea fauna if cerrado vegetation at the Panga Ecological Reserve, Uberlândia, MG, Brazil. Rev. Bras. Entomol. 40: 147-156.

Cornell, H.V. 1985. Local and regional richness of cynipine gall wasps on California oaks. Ecology. 66: 1247-1260.

Crawley, M. 2002. Glim for Ecologists. Blackwell Scientific Publications, London.

Cure, J.R., G.S. Bastos-Filho, M.J.F. Oliveira & F.A. Silveira. 1993. Levantamento das abelhas silvestres na Zona da Mata de Minas Gerais na região de Viçosa (Hymenoptera: Apoidea). Ceres. 40: 131-161.

Cure, J.R., M. Thiengo, F.A. Silveira & L.B. Rocha. 1992. Levantamento da fauna de abelhas silvestres na Zona da Mata de Minas Gerais. III: Mata secundária na região de Viçosa (Hymenoptera: Apoidea). Rev. Bras. Entomol. 9: 223-239.

Gathmann, A., H.J. Greiler & T.T. Scharntke. 1994. Trap-nesting bees and wasp colonizing set-aside fields: sucession and body size, management by cutting and sowing. Oecologia. 98: 8-14.

Gross, C.L. 2001. The effect of introduced honeybees on native bee visitation and fruit-set in *Dillwynia juniperina*

(Fabaceae) in a fragmented ecosystem. Biol. Conserv. 102: 89–95.

Heinrich, B. 1979. Bumblebee economics. Harvard University Press, Cambridge, 245p.

Heithaus, E.R. 1979. Community structure of neotropical flower visiting bees and wasps: diversity and phenology. Ecology. 60: 190-202.

Heywood, V.H. 1978. Flowering plants of the world. Oxford University Press.

Huryn, V.M.B. 1997. Ecological impacts of introduced honeybees. Q. Rev. Biol. 72: 275–297.

Ihaka, R. & R. Gentleman. 1996. R: A language for data analysis and graphics. J. Comp. Graph. Stat. 5: 299-314.

Laroca, S., J.R. Cure & C. Bortoli. 1982. A associação de abelhas silvestres (Hymenoptera: Apoidea) de uma área restrita no interior da cidade de Curitiba (Brasil) uma abordagem biocenótica. Dusenia. 13: 93-117.

Mendonça, M.P. & D.A. Lins. 2000. Lista vermelha de espécies ameaçadas de extinção da flora de Minas Gerais. Fundação Biodiversistas, Belo Horizonte.

Michener, C.D. 2000. The bees of the world. The Johns Hopkins Univ. Press, Baltimore. Maryland, 913p.

Moldenke, A.R. 1975. Niche specialization and species diversity along a California transect. Oecologia. 21: 219-242.

Mori, S.A. & J.L. Pipoly. 1984. Observations on the big bang flowering of Miconia munitiflora (Melastomatacea). Brittonia. 36: 330-341.

Myers, N., R.A. Mittermeier, C.G. Mittermeier, G.A.B. Fonseca & J. Kent. 2000. Biodiversity hotsposts for preservationpriorities. Nature. 403: 853-858.

Pedro, M.S.R. & J.M.F. Camargo. 1991. Interactions on floral resources between the Africanized honey bee *Apis mellifera* L. and native bee community (Hymenoptera: Apoidea) in a natural cerrado ecosystem in southeast Brazil. Apidologie. 22: 397-415.

Ramalho, M., A. Kleinert-Giovannini & V.L. Imperatriz-Fonseca. 1989. Utilization of floral resources by species of *Melipona* (Apidae, Meliponinae): flora preferences. Apidologie. 20:185-195.

Roubik, D.W. 1989. Ecology and natural history of tropical bees. New York, Cambridge University Press, 514 p.

Sakagami, S.F. 1982. Stingless bees. In: social Insectes. Vo. 3 (Herman H.R., ed.). London, Academic Press, 361-423.

Sakagami, S.F. & S. Laroca. 1971. Relative abundance phenology and flower visits of apid bees in eastern Parana southern Brazil (Hymenoptera: Apidae). Kontyu Sapporo. 39: 217-230.

Sakagami, S.F., S. Laroca & J.S. Moure. 1967. Wild bee biocenotics in São José dos Pinhais (PR), south Brazil. Preliminary report. J. Fac. Sci. Hokkaido Univ. Serie VI, Zoology. 16: 253-291.

Silveira, F.A., G.A.R. Melo & E.A.B. Almeida. 2002. Abelhas Brasileiras: Sistemática e Identificação. Belo Horizonte, 253p.

Silveira, F.A. & J.R. Cure. 1993. High altitude bee fauna of Southeastern Brazil: Implications for biogeographic patterns. (Hymenoptera: Apoidea). Stud. Neotrop. Fauna Environ. 28: 47-55.

Silveira, F.A. & M.J.O. Campos. 1995. A melissofauna de Corumbataí (SP) e Paraopeba (MG) e uma análise da biogeografia das abelhas do cerrado brasileiro (Hymenoptera: Apoidea). Rev. Bras. Entomol. 39: 371-401.

Strong, D.R., J.H. Lawton & R. Southwood. 1984. Insects on Plants: Community. Patterns and Mechanisms. Oxford, Blackwel.

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