Stud Neotrop Fauna & Environm (1997) Vol. 32: 212–219

0165-0521/97/3204-0212$12.00
© Swets & Zeitlinger

ABUNDANCE AND FLOWER VISITS OF BEES IN A CERRADO OF BAHIA, TROPICAL BRAZIL

Blandina Felipe Viana, Astrid de Matos Peixoto Kleinert and Vera Lúcia Imperatriz-Fonseca

Department of Ecology, University of São Paulo, Brazil

Received: 15 August 1996 *Accepted: 15 December 1997*

ABSTRACT

Abundance, seasonal phenology and flower visits of eusocial bees were studied in Diamantina, a national park with cerrado vegetation in Bahia, tropical Brazil. About 700 bees were collected, mainly native stingless bees and the introduced Africanized honey bee. Sampling along a transect was most effective March through September during the dry season. The foraging worker bees were observed on flowers of over 60 angiosperm species of which a few were visited with high frequency. Foraging activity concentrated on flowering plants of the families Leguminosae and Asteraceae. The results are discussed under aspects of nutritional resource partitioning by bee communities in neotropical habitats and the specific composition of a cerrado apifauna.

KEYWORDS: *Eusocial bee community, Apidae, resource partitioning, cerrado vegetation, flower visits, seasonal abundance, Bahia, Brazil.*

INTRODUCTION

The bee communities in neotropical ecosystems have been studied only recently under aspects of pollination (Ramalho *et al* 1990) and nutritional resource partitioning (Wilms *et al* 1996). In Brazil the so-called cerrado areas exhibit a savanna vegetation with seasonal differences in the patterns of flowering. The apifauna of such habitats is yet poorly known (Pedro & Camargo 1991; Martins 1994, 1995). In the state of Bahia, the study site at the national park of Diamantina highlands represents an undisturbed cerrado area. Like in tropical rain forests (Michener 1979), also in the cerrados the stingless bees, of which over 260 neotropical species are recognized (Camargo 1989), are the most abundant flower visitors (Campos 1989; Silveira 1989; Carvalho 1990; Pedro & Camargo 1991; Farias 1994; Martins 1994, 1995). We investigated the seasonal changes in the foraging activity and the preferences of food plants by monitoring mainly flower visits of worker bees. The results are compared with data from similar habitats and discussed under ecological and evolutionary aspects.

MATERIALS AND METHODS

In a national park at the southern part of the Diamantina highlands close to Lençóis (Bahia state, 12°34′S/41°23′W), a study site with original savanna vegetation of the Brazilian cerrado type was chosen. Within an area of 15 ha with herbaceous and

---

Correspondence to: Astrid de M.P. Kleinert, Depto. de Ecologia Geral, Instituto de Biociências, Universidade de São Paulo, 05508-900 São Paulo, S.P., Brasil. Fax: +55-11-815 4272. e-mail: astridkl@usp.br

arboreal vegetation, bees were repeatedly collected along a transect. Over a year, every two weeks two researchers sampled bees from 8:00 to 12:00 and from 14:00 to 18:00 h) per collection day according to Sakagami *et al* (1967). Here we report only on bees of eusocial species, the identification of which was kindly confirmed by J. S. Moure (Zoology Department, Federal University, Curitiba, Paraná). The sampled bees were deposited in the collection of the Bee Research Laboratory of EPABA (Empresa de Pecuária da Bahia). The plant species were determined with the help of the Radambrasil Herbarium staff at Salvador, Bahia (Instituto Brasileiro de Geographia e Estatistica, IBGE), and voucher specimens are deposited there.

In order to compare our data with published work on the apifauna of other habitats, indices of similarity (Sørensen 1948) were calculated:

$$SQ = \frac{2c}{Sa + Sb}$$

with C = number of species common in both areas; Sa, Sb = number of species at site a and site b.

RESULTS

Relative abundance and phenology

Our sample comprised bees of the subsequent 10 eusocial species of the family Apidae (with name abbreviations in parenthesis): *Apis mellifera* Linnaeus (Am), *Bombus morio* (Swederus) (Bm), *Bombus brevivillus* Franklin (Bb), *Melipona quadrifasciata anthidioides* Lepeletier (Mq), *Trigona spinipes* (Fabricius) (Ts), *Geotrigona mombuca* (Smith) (Gm), *Frieseomelitta francoi* (Moure) (Ff), *Partamona helleri* (Friese) (Ph), *Nannotrigona testaceicornis punctata* Lepeletier (Nt) and *Leurotrigona muelleri* (Cockerell) (Lm). We collected a total of 689 workers and 5 male bees, nearly all of them on flowers. Within this sample (Fig. 1), workers of *Trigona spinipes* were most abundant, representing over 40%, followed by the Africanized honey bee, *Apis mellifera*, contributing over 30%. The bulk of these foragers was sampled March through September (Fig. 2), during the relatively dry season. Bees of all the other species were collected in considerably smaller frequencies, some adding less than 3%, and without seasonal fluctuations (Figs. 1, 2). Regarding the number of nearly 700 individuals and in comparison to the other bees we collected (data not shown), the family Apidae, in particular the stingless bees, were predominantly represented in this cerrado bee community. Bumblebees were captured only in low numbers (Table 2).

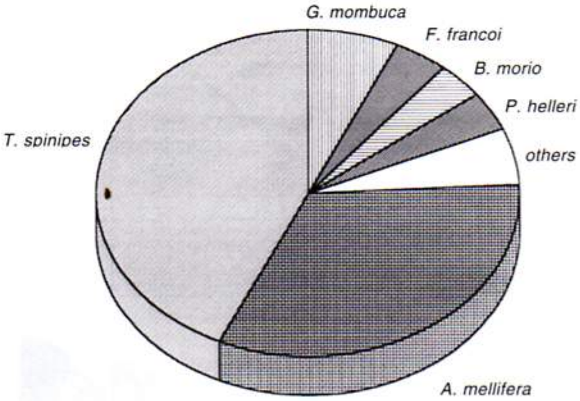

Fig. 1. Abundance of foraging eusocial bees on flowers in a cerrado vegetation. Others = workers of the stingless bee species *Melipona quadrifasciata*, *Nannotrigona testaceicornis*, *Leurotrigona muelleri* and the bumble bee *Bombus brevivillus*, all recorded only in low frequencies.

Floral resources and preferences

In the study area we found plants of about 180 species. We observed bees of the eusocial species visiting 62 flowering plants of this total, belonging to 27 families (Table 1). Foraging was particularly focusing on plants of 17 species (Fig. 3). The bees were collecting there pollen, nectar and resin, however, in varying proportions. Flowering plants of 29 species provided both pollen and nectar sources; none was visited only for resin collection (Table 1).

The colours of the most frequently visited flowers were lilac, violet and yellow (Table 1). In the course of the year, foragers of the Africanized honey bee were seen on flowers of plant species belonging to 21 families, and within this spectrum the workers were the exclusive visitors of blooming plants of 9 species. However, 34% of the bee workers were collected on flowers of plants of only 2 angiosperm species, *Tagetes minuta* and *Mimosa pudica*. We made similar observations in the stingless bee, *Trigona spinipes*. Their workers foraged on flowers of 31 plants species, belonging to 16 families, and were the only visitors of 12 species. Again, more than 50% of the individuals were collected on plants of only 2 species, *Musa sapientum* and *Cajanus cajan*.

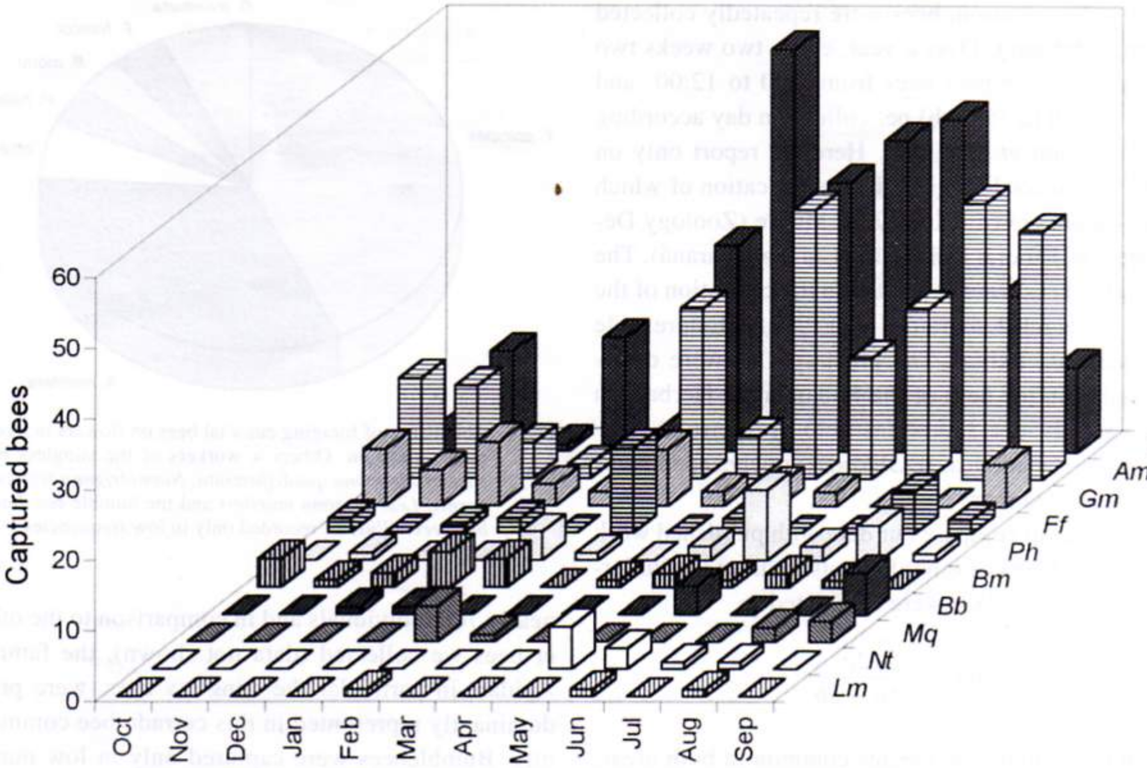

Fig. 2. Seasonal variation in capture rates of flower visiting bees. See text for abbreviations of species names.

The workers of other stingless bee species were mainly sampled on flowers of 14 plant species. From these, *Tagetes minuta* is noteworthy, as its flowers were frequently visited by foragers of *Apis mellifera* and also often by workers of the stingless bees *Partamona helleri* and *Nannotrigona testaceicornis.* Flowers of *Cajanus cajan* were visited by *Trigona spinipes* and *Geotrigona mombuca,* and those of *Microlicia* aff *torrendii* by workers of *Melipona quadrifasciata* and *Frieseomelitta francoi*. Almost 40% of the individuals of the latter species were collected on *Vellozia dasypus* flowers. Foragers of the two species of Bombinae, *Bombus morio* and *B. brevivillus*, were collected on several flowers also visited by workers of stingless bees and the Africanized honey bee, with the exception of *Microlicia* aff *torrendii* which was an important source only for the bumble bee *B. brevivillus* (Fig. 3).

The cerrado vegetation of our study area was comprising numerous species of the family Asteraceae, followed by the Leguminosae and Convolvulaceae (Fig. 4). The flowers of Leguminosae plants were particularly frequently visited by bees of the eusocial species. The next ones in bee visit frequency were plants belonging to the family Musaceae, mainly due to large numbers of *Trigona spinipes* foragers collected there, followed by several Asteraceae (Fig. 5).

DISCUSSION

Eusocial bees in cerrado habitats of Brazil

In other surveys carried out in cerrado areas with similar vegetation, bees of the family Apidae were always found to represent the most abundant group, even if the Africanized honey bee as a relatively novel intrudor was put aside (Table 2, for references see there). Evidently the native stingless bees are the most important flower visitors in many neotropical ecosystems, probably because of their populous and perennial colonies which are exclusively providing large cohorts of foraging and thereby pollinating workers all the year round (Wilms *et al* 1996).

According to the Sørensen quotient (SQ), the eusocial bee community of our study site is similar in particular to the apifauna of a 'campo rupestre' in

TABLE 1. Seasonal pattern in resource partitioning between 12 species of eusocial bees in a cerrado habitat. Flower colors are: C = cream, L = lilac, P = pink, R = red, V = violet, W = White, Y = yellow. Resources are: N = nectar, P = pollen, R = resin.

Plant family	Plant species	Flower color	Resource	n bees	Months												Bee species
					O	N	D	J	F	M	A	M	J	J	A	S	
Aizoaceae	*Molugo verticilata*	W	P	3												x	Gm
Apocynaceae	*Himathantus lancifolia*	W	N	1												x	Am
Asclepiadaceae	*Ditassa refusa*	W	N	4					x								Am, Ff, Ts
Asteraceae	*Aspilia foliosa*	Y	P	1	x												Bm
	Bidens pilosa	Y	P/R	3	x												Gm, Bb
	Blanchetia heterotricha	W/L	P	3		x											Ts, Mq, Lm
	Centratherum punctatum	V	P	3			x					x					Am, Ff, Gm
	Emilia sonchifolia	P	P/N	1						x							Bb
	Eremanthus bicolor	L	N/R	4								x					Ts
	Eupatorium ballotaefolium	L	P	1		x											Gm
	Tagetes minuta	Y		66					x	x	x						Ph, Nt, Bm, Am, Ts, Gm
	Vernonia brasiliensis	L/W	P/N	2									x				Am
	Vernonia chalibaea	L	P/N	1									x				Am
	Vernonia sp.	L	P	1									x				Am
	Wedelia sp.	Y		3		x			x								Am
Bignoniaceae	*Jacaranda cf. caroba*	V	P/N	12											x		Am, Ts
	Jacaranda irwini	V		3			x										Ts
Boraginaceae	*Heliotropium angiospermum*	L	P	14			x			x			x		x		Am, Gm, Lm
Convolvulaceae	*Evolvulus glomeratum*		P	7							x	x					Am, Ff
	Jacquemontia aff. ciliata	L	N	1				x									Ts
	Merremia sp.	W	P/N	12				x	x	x	x						Ts, Bb
	not identified	L	P	2						x		x					Am, Gm
Cyperaceae	*Rhynchospora barbata*	C/Y	P	4											x		Am, Ts
	Scleria bractiata		P/N/R	17								x	x				Am, Ts, Ph
Gramineae	*Panicum trinii*		P/N	9									x				Am, Ts
Humiriaceae	*Vantanea chovata*	C	P/N	15						x	x						Am, Ts
Labiatae	*Eriope hypenioides*	L	N	1									x				Am
	Marsypianthes chamaedrys	V	P/N	22										x	x	x	Am, Bm, Ff, Ts, Gm
	Ocimum aff. gratissima	W	P/N	12											x	x	Am, Ts, Gm, Mq
Leguminosae	*Cajanus cajan*	Y	P/N	57						x	x	x					Ff, Gm, Ts
	Calliandra augusta	W	P/N/R	38	x	x						x	x				Am, Bb, Mq, Ph, Ts
	Canavalia aff. dictyota		P/N	3					x								Ff, Ts
	Centrosema aff. arenarium	R	P	2											x	x	Ts
	Mimosa pudica	L	P/N	47			x	x	x	x	x	x	x				Am, Bb, Gm, Mq, Nt, Ph, Ts
	Mimosa somnians	L	P/N	10							x	x		x			Am, Bm, Gm
	Mucuna pruriens	V	P	4					x								Ts
	Periandra mediterranea	V	P	1											x		Ts
	Senna cana	Y	P/N	4				x									Ts
	Senna sylvestris	Y	P/N	4							x						Bm, Ts
	Stylosanthes guianensis	Y	P/N	13						x		x	x	x	x		Am, Bm, Gm, Ph
Lythraceae	*Cuphea impexa*	L	P/N/R	19	x		x	x						x	x	x	Am, Bm, Ts
Malpighiaceae	*Byrsonima aff. crassifolia*	Y	P	1												x	Ff
	not identified	Y	P	1	x												Ts
Malvaceae	*Sida cordifolia*	Y	P	2			x										Am
Melastomataceae	*Microlicia aff. torrendii*	L	P	9								x	x				Bb, Bm, Mq
	Pterolepsis glomerata	L	P	1										x			Bm
Musaceae	*Musa sapientum*		P/N/R	109				x	x	x	x	x	x				Ts
Ochnaceae	*Sauvagesia sprengelii*	W/L	P/N	6	x								x	x	x		Am, Bm
Onagraceae	*Ludwigia octovalis*	Y	P/R	6	x		x				x	x	x	x			Ff, Gm, Ts
Palmae	*Syagrus coronata*	Y	P/R	3										x			Ts
	Syagrus sp.		P/N/R	15			x				x						Ts
Rubiaceae	*Borreria sp.*	W	P/N	9	x				x				x		x	x	Am, Ff, Gm, Nt
	Citrus aurantifolia		P/N	3								x					Am
Scrophulariaceae	*Stemodia foliosa*		P/N/R	3								x					Am, Bb, Gm
Sterculiaceae	*Dombeya walichi*	P	P/R	2							x						Ts
	Waltheria americana	Y	N	1		x											Gm
	Waltheria cinerencens	Y	P/N	8	x	x				x		x				x	Am, Bb, Bm, Ph
Turneraceae	*Turnera cf. ulmifolia*	Y	P/N	3			x										Am
Verbenaceae	*Lippia geminata*	L	P/N	4		x								x			Am, Bm
	Lippia aff. origanoides	L	P	1								x					Ff
Velloziaceae	*Vellozia dasypus*	L	P/N	39			x	x									Am, Ff, Gm, Ph, Ts

TABLE 2. Comparative analysis of environmental conditions and the bee communities in a number of semiarid habitats of tropical Brazil. The SQ was calculated for the different habitats in relation to the data of this study.

Author	Habitat	Latitude/ Longitude	Altitude (m)	Rainfall (mm/a)	Area (ha)	Study period (months)	Frequency (collect./ month)	Sampling (total hours)	Sample (n bees)	Stingless bee (N species)	Stingless bees (n captured)	Stingless bees (SQ)	Bumblebee (N species)	Bumblebees (n captured)
This study	Cerrado with rocky fields	12°S/41°W	700	1445	15	12	2	90	1761	7	412		2	35
Carvalho unpublished	Cerrado	19°S/48°W	800	not determ.	1	12	2	200	971	11	516	0.33	1	2
Faria & Camargo 1996	Rocky fields	19°S/43°W	1050	1500	1	12	1	288	518	7	25	0.46	2	75
Silveira & Campos 1996	Cerrado with secondary vegetation	19°S/44°W	740	1302	0.6	12	1	380	1228	15	518	0.27	2	48
Pedro & Camargo 1991	Cerrado	21°S/47°W	800	not determ.	1	12	2	312	3848	19	1855	0.31	2	145
Silveira & Campos 1996	Cerrado within agricultural land	22°S/47°W	815	1500	38	36	4	480	605	10	136	0.24	2	25

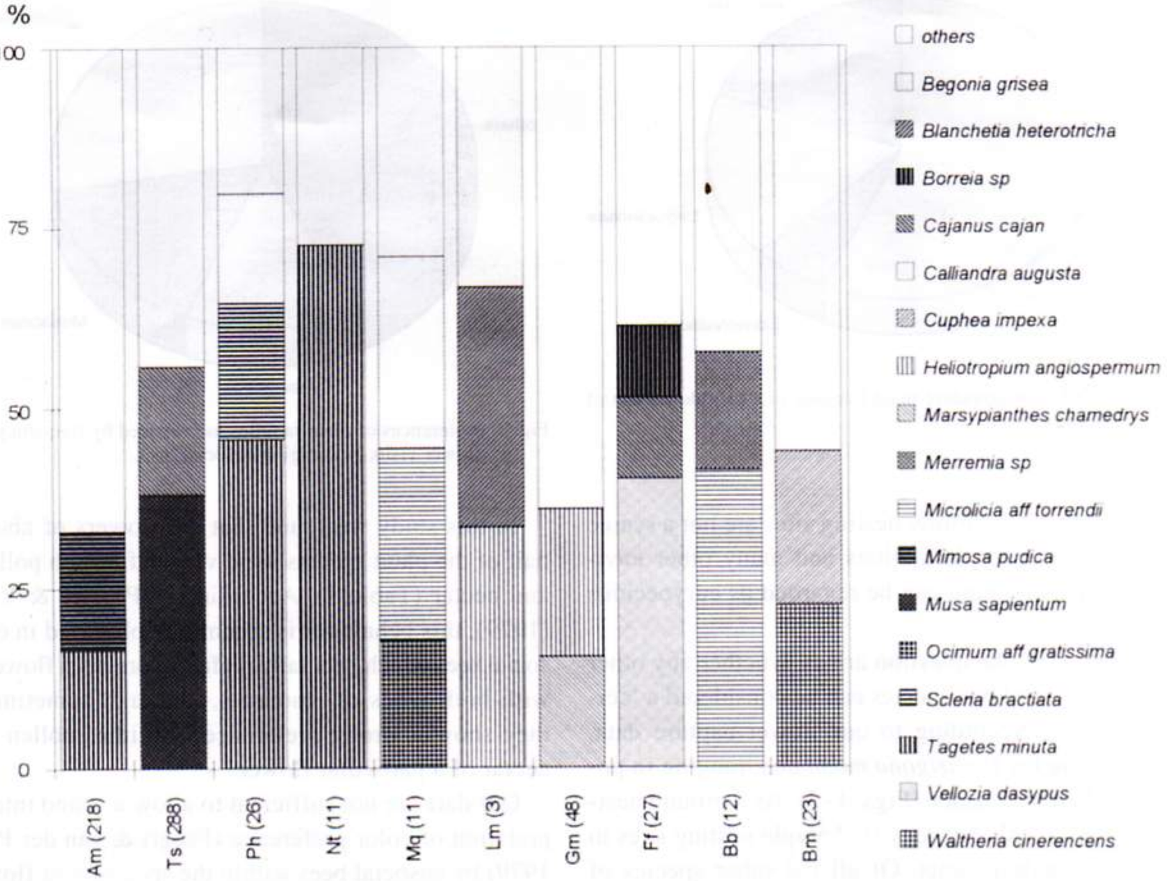

Fig. 3. Main floral resources of foraging eusocial bees in a cerrado habitat. See text for abbreviations of species names. In parenthesis = numbers of captured bees.

the Serra do Cipó, State of Minas Gerais (Faria & Camargo 1996), a site located at a little higher altitude and 7 degrees more south than our study area in the Diamantina highlands of Bahia (Table 2). In fact both areas share a rather similar vegetation, especially on their rocky fields, and presumably also have a carrying capacity for eusocial bees ranging in the same magnitude. For all the other cerrado areas in Brazil, of which the fauna of eusocial bees has been surveyed so far, a much lesser similarity with our study site was calculated.

Since the cerrado is quite a common type of habitat in many regions of central Brazil (Joly 1970), bee communities adapted to the resources available in these environments must have evolved. To answer this question more data are required which should be obtained by field studies to be carried out according to an appropriate protocol. The currently available information is yet insufficient, however, the dominance of stingless bees is evident in spite of site differences in the spectrum of species as indicated by the SQ (Table 2).

The extraordinary abundance of the stingless bee *Trigona spinipes* recorded for all the cerrado habitats may in part be due to the large worker population of their nests, ranging from 20,000 to 30,000 individuals (Lindauer & Kerr 1960). Furthermore, the nests are free-hanging constructions not depending on cavities of appropriate size. This trigonine species is widely distributed over a geographical range not surpassed by any other neotropical stingless bee (Almeida & Laroca 1988). In terms of abundance, today this native eusocial bee is competing in many habitats with the introduced Africanized honey bee (Carvalho 1990; Pedro & Camargo 1991), the species ranging in the second position of collection frequency also in our study area. This honey bee is accepting any type of cavity as a nesting site, including burrows in the ground, and often builds free hanging combs under rocks. For both of these eudomi-

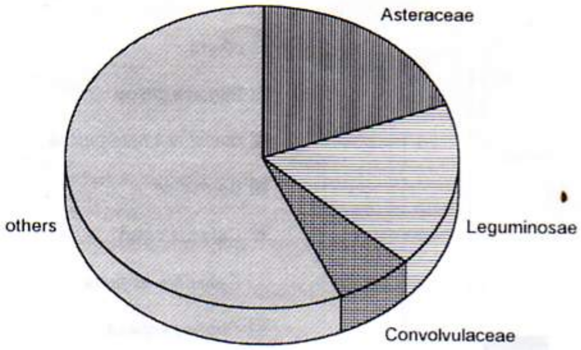

Fig. 4. The most abundant plant families in a cerrado habitat of Bahia.

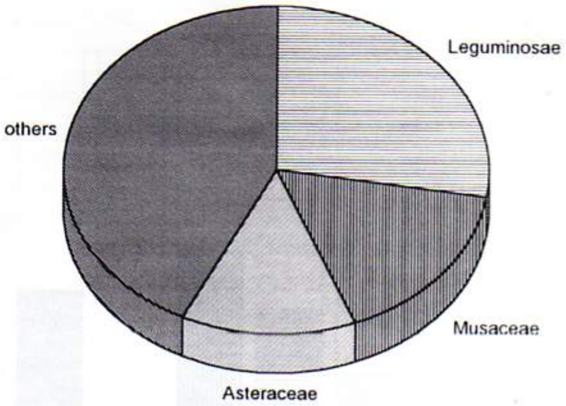

Fig. 5. Preferences of plant families as indicated by frequency of flower visits by foraging eusocial bees.

nant species, therefore, nesting sites are not a scarce resource in cerrado habitats and many other environments, and both can be regarded as euryoecious syntopics.

Therefore, the question arises, whether any other of the eusocial bee species can be considered a 'cerrado bee'? According to our flower capture data, this is true for *Geotrigona mombuca,* ranging in position 3 of abundance (Figs. 1–3). As a ground nesting species, this bee may find ample nesting sites in cerrado environments. Of all the other species of eusocial bees, we were able to collect only small numbers of foragers. Most of them require hollow trunks as nesting sites, which are difficult to find in a cerrado type of vegetation, at least with a sufficient diameter of over 10 cm. This may be a limiting factor and may result in low population densities of many eusocial bee species.

Floral resources and preferences

All eusocial bees exhibit generalistic foraging strategies, however, temporal flower constancy may result in concentration of foraging activities on a few plants actually providing rich pollen and nectar sources. Sometimes only a limited number of floral resources contributed to most of the annual pollen harvest of stingless bee colonies (Table 1). Similar tendencies of floral preference were recorded for eusocial bees in a number of neotropical habitats by Imperatriz-Fonseca *et al* (1989); Ramalho (1990); Ramalho *et al* (1990) and Wilms *et al* (1996). Recently Wilms & Wiechers (1997) stated such relations also in analyses of pollen stored inside the nests of two stingless bee species and the Africanized honey bee.

In this study we found that the flowers of about half of the plant species were visited for both pollen and nectar (Table 1). According to Proctor & Yeo (1979), this behaviour is commonly observed in eusocial bees which generally prefer to forage on flowers with both types of resources, although sometimes they show a strong preference for either pollen or nectar of a particular flower.

Our data are not sufficient to allow a sound interpretation of color preference (Faegri & van der Pijl 1979) by eusocial bees within the spectrum of flower colors occurring at the study site in the cerrado of Diamantina. Bee/flower relationships are the result of quite a number of evolutionary trends of which color recognition (Menzel & Backhaus 1989) has to be considered as only one of several traits ensuring the attraction of pollinators (Meeuse 1961) in a specific environment. Flowers usually try to contrast the background colors (Wittmann *et al* 1990), but the flower colors of zoogamic Angiosperms are quite often also directed towards visitors of specific groups of pollinators such as bees, butterflies or birds (Gottsberger 1986). To answer the question if among neotropical ecosystems the vegetation of cerrado habitats evolved such specific flower/pollinator relations, which may even provide niche preemption (Roubik 1990), requires much more field studies.

Though at our study site plants of the family Asteraceae represented the highest biodiversity (Fig. 4), like in many other Brazilian habitats (Sakagami & Laroca 1971; Carvalho 1990; Campos 1998), their flowers were not as intensively visited by eusocial bees as those of Leguminosae (Fig. 5), a family likewise well represented in different South American plant associations (Joly 1977; Heywood 1978). Since similar data were obtained at other semiarid Brazilian sites (references in Table 2), this may be typical for many neotropical habitats, despite of regional differences (Ramalho *et al* 1990).

ACKNOWLEDGMENTS

We wish to thank Geraldo C. P. Pinto, Joana D'Arc A. Ferreira and Maria Clara Ferreira, RADAMBRASIL-IBGE, for identifying the plants, and FINEP and CNPq for support.

REFERENCES

ALMEIDA M C, LAROCA S (1988) *Trigona spinipes* (Apidae, Meliponinae): taxonomia, bionomia e relações tróficas em áreas restritas. Acta Biol Par 17: 67–108

CAMARGO J M F (1989) Comentários sobre a sistemática de Meliponinae (Hym., Apidae). An XIV Simpósio Anual da ACIESP: 41-61

FAEGRI K, VAN DER PIJL L (1979) The principles of pollination ecology. New York Pergamon Press, New York

FARIA G M, CAMARGO J M F (1996) A flora melitófila e a fauna de Apoidea de um ecossistema de campos rupestres, Serra do Cipó-MG, Brasil. Anais do Encontro sobre abelhas 2: 217–228

GOTTSBERGER G (1986) Beziehungen tropischer Pflanzen und Tiere bei der Blütenbestäubung. *In* ENGELS W (ed), Die Tropen als Lebensraum, Attempto Verlag Tübingen. pp. 125–150

HEYWOOD V H (1978) The flowering plants of the world. Oxford University Press, Oxford

IMPERATRIZ-FONSECA V L, KLEINERT-GIOVANNINI A, RAMALHO M (1989) Pollen harvest by eusocial bees in a non-natural community in Brazil. J Trop Ecol 5: 239–242

JOLY A B (1970) Conheça a vegetação Brasiliera. Editora da Universidade de São Paulo e Polígono, São Paulo

JOLY A B (1977) Botânica - introdução à taxonomia vegetal. Cia. Editora Nacional, São Paulo, Brazil

LINDAUER M, KERR W E (1960) Communication between workers of stingless bees. Bee World 41: 29–41

MARTINS C F (1994) Comunidade de abelhas (Hym., Apoidea) da caatinga e do cerrado com elementos de campo rupestre do Estado da Bahia, Brasil. Rev Nordestina Biol 9: 225–257

MARTINS C F (1995) Flora apícola e nichos tróficos de abelhas (Hym., Apoidea) na Chapada Diamantina (Lençóis-BA, Brasil). Rev Nordestina Biol 10: 119–140

MEEUSE B J D (1961) The story of pollination. The Roland Press Co., New York.

MENZEL R, BACKHAUS W (1989) Color vision in insects. *In* GICHERAS P (ed), Vision and visual dysfunction Vol VII: Perception of color, Houndsville: MacMillan Pess

MICHENER C D (1979) Biogeography of the bees. Ann Missouri Bot Gard 66: 277–347

PEDRO S R M, CAMARGO J M F (1991) Interactions on floral resources between the Africanized honey bee *Apis mellifera* L. and the native bee community (Hymenoptera: Apoidea) in a natural "cerrado" ecosystem in Southeast Brazil. Apidol 22: 397–415

PROCTOR M, YEO P (1979) The pollination of flowers. William Collins Sons & Co. Ltd., Glasgow

RAMALHO M (1990) Foraging by stingless bees of the genus *Scaptotrigona* (Apidae, Meliponinae). J Apicult Res 29: 61–67

RAMALHO M, KLEINERT-GIOVANNINI A, IMPERATRIZ-FONSECA V L (1990) Important bee plants for stingless bees (*Melipona* and Trigonini) and Africanized honeybees (*Apis mellifera*) in neotropical habitats: a review. Apidol 21: 469-488

ROUBIK D W (1990) Niche preemption in tropical bee communities: a comparison of neotropical and malesian faunas. *In:* SAKAGAMI S F, OHGUSHI R, ROUBIK DW (eds), Natural history of social bees and wasps in equatorial Sumatra, pp. 245–257. Hokkaido University Press, Sapporo, Japan

SAKAGAMI S F, LAROCA S, MOURE J S (1967) Wild biocenotics in São José dos Pinhais (PR), South Brazil. Preliminary report. J Fac Sci Hokkaido Univ Ser. VI, Zoology 19: 253–291

SAKAGAMI S F, LAROCA S (1971) Relative abundance, phenology and flower visits of Apid bees in eastern Paraná, South Brazil (Hym: Apidae). Kontyü 39: 213–230

SILVEIRA F A, CAMPOS M J O (1996) A melissofauna de Corumbataí (SP) e Paraopeba (MG) e uma análise da biogeografia das abelhas do cerrado (Hymenoptera, Apoidea). Rev bras Ent

SØRENSEN T (1948) A method for establishing groups of equal amplitude in plant sociology based on similarity of species content. Kong Dan Vidensk Selsk Biol Skr 5: 1–34

WILMS W, IMPERATRIZ-FONSECA V L, ENGELS W (1996) Resource partitioning between highly eusocial bees and possible impact of the introduced Africanized honey bee on native Stingless bees in the Brazilian Altlantic Rainforest. Stud Neotrop Fauna & Environm 31: 137–151

WILMS W, WIECHERS B (1997) Floral resource partitioning between native Melipona bees and the introduced Africanized honey bee in the Brazilian Atlantic rainforest Apidol 28 (in press)

WITTMANN D, RADTKE R, CURE J R, SCHIFINO-WITTMANN M T (1990) Coevolved reproductive strategies in the oligolectic bee *Callonychium petuniae* (Apoidea, Andrenidae) and three purple flowered Petunia species (Solanaceae) in southern Brazil. Z Zool Syst Evolutionsforsch 28: 157–165