ECOLOGY, BEHAVIOR AND BIONOMICS

Diversity in Bee (Hymenoptera: Apoidea) and Social Wasp (Hymenoptera: Vespidae, Polistinae) Community in "Campos Rupestres", Bahia, Brazil

Viviane da Silva-Pereira[1,2] and Gilberto M.M. Santos[2]

[1]Programa de Pós-Graduação em Botânica, visilvapereira@yahoo.com.br
[2]Lab. Entomologia, Depto. Ciências Biológicas, Univ. Estadual de Feira de Santana. Rodovia BR 116, km 3 Campus Universitário, 44031-460, Feira de Santana, BA

Neotropical Entomology 35(2):165-174 (2006)

Diversidade em Uma Comunidade de Abelhas (Hymenoptera: Apoidea) e Vespas Sociais (Hymenoptera: Vespidae, Polistinae) em Campos Rupestres, BA

RESUMO - Himenópteros como abelhas e vespas sociais são visitantes florais regulares em ambientes de campos rupestres. Uma comunidade de abelhas e vespas sociais foi acompanhada durante visitação floral em área de campos rupestres, na Chapada Diamantina, BA, de setembro de 2001 a abril de 2002. A comunidade foi descrita quanto à diversidade, eqüitabilidade e hierarquia de dominância, considerando a abundância de indivíduos (H' = 2.14 / J' = 0.55) e biomassa (H' = 2.34/ J' = 0.60) das espécies. Foram amostradas 39 espécies de abelhas (588 indivíduos/ 15,742 g) e 11 espécies de vespas sociais (52 indivíduos/ 2,156 g), sendo este provavelmente o primeiro registro de vespas sociais para ambientes de campos rupestres no Brasil. *Trigona spinipes* (Fabricius), *Apis mellifera* L., *Frieseomelitta francoi* (Moure) e *Bombus brevivillus* Franklin foram predominantes em abundância de indivíduos. Das espécies amostradas, 48% contribuiu com um indivíduo. Houve inversão na hierarquia de dominância quando considerada a biomassa das espécies, sendo predominantes: *B. brevivillus*, seguida de *A. mellifera*, *T. spinipes*, e outras espécies com 15 indivíduos ou menos, como as vespas sociais – *Synoeca cyanea* (Olivier), *Polistes canadensis* (L.), *Myschocyttarus drewseni* (Saussure) – e as abelhas – *Eufriesea nigrohirta* (Friese), *Xylocopa grisescens* Lepeletier e *Megachile* (*Pseudocentron*) sp.1. A utilização de biomassa nas análises de diversidade permitiu detectar diferenças na contribuição relativa de espécies na hierarquia de dominância. A comparação entre as comunidades de abelhas amostradas em diferentes áreas indica maior similaridade da fauna amostrada em Palmeiras, BA, com faunas de ecossistemas vizinhos, embora com baixos valores de similaridade.

PALAVRAS-CHAVE: Campos de altitude, Chapada Diamantina, biomassa, estrutura de comunidade, visitante floral

ABSTRACT - Hymenoptera such as bees and social wasps are regular floral visitors in "campos rupestres" vegetation. A community of bees and social wasps was studied during floral visitation in an area of "campos rupestres", at Chapada Diamantina, BA, Brazil, from September 2001 to April 2002. The community was described in relation to diversity, evenness, and dominance rank, considering the individuals abundance (H' = 2.14/ J' = 0.55) and biomass (H' = 2.34/ J' = 0.60). Thirty nine bee (588 individuals/ 15.742 g) and 11 social wasp species (52 individuals/ 2.156 g) were collected, being the first report of social wasps for the Brazilian "campos rupestres". The main species regarding number of individuals were *Trigona spinipes* (Fabricius), *Apis mellifera* L., *Frieseomelitta francoi* (Moure), and *Bombus brevivillus* Franklin. About 48% of the species were represented by a single individual. There was an inversion in the dominance rank when the species biomass was considered. *B. brevivillus*, *A. mellifera*, *T. spinipes*, and other species represented by 15 individuals or less, such as the social wasps *Synoeca cyanea* (Olivier), *Polistes canadensis* (L.) and *Myschocyttarus drewseni* (Saussure), and the bees *Eufriesea nigrohirta* (Friese), *Xylocopa grisescens* Lepeletier and *Megachile* (*Pseudocentron*) sp.1 were the predominant species. The use of biomass in diversity analysis permitted to detect differences in the relative contribution of species in hierarchy dominance. The comparison between bee faunas from different areas indicates a large similarity of the sampled fauna in Palmeiras (Bahia State) with neighboring ecosystems, although with low values of similarity.

KEY WORDS: Altitudinal field, biomass, Chapada Diamantina, community structure, flower visitor

Hymenoptera, especially the Apoidea group, are the most important plant pollinators in natural and agricultural ecosystems (Roubik 1989, Neff & Simpson 1993), and are strongly related to the evolution and diversification of the angiosperms (Bawa 1990). Generally, the bees are totally dependent on the floral resources for the maintenance of adults and nests.

Although wasps present less effective participation as pollinators in natural ecosystems, their adults (males and females) are regular flower visitors and nectar consumers, especially social wasps, which also collect nectar for energy supply of their colonies (Gadagkar 1991). Social wasps are included in the Vespidae family, which is divided in two subfamilies: Vespinae, typical of temperate areas and Polistinae of tropical areas (Richards 1978).

Studies of insect flower visitors are especially facilitated by the possibility of observation and capture of a great number of individuals which use different and measurable resources (Sakagami *et al.* 1967, Heithaus 1979). In tropical ecosystems, most studies consist of inventories with species of insects and plants visited, where the authors include discussions about the interactions and community structure patterns of the floral visitors (Pinheiro-Machado *et al.* 2002).

Many authors have addressed more specifically the aspects of pollination (Herrera 1987, 1989), trophic resources partitioning (Aguiar 2003) and organization patterns of the populations: relative abundance and diversity (Heithaus 1979, Martins 1994, Aguiar & Martins 1997), dominance hierarchy (Carvalho & Bego 1995) and spatial and temporal distribution (Cane & Payne 1993, Silveira & Cure 1993, Alves-dos-Santos 1999). Few authors compare the results obtained from similar methodology, attempting to detect faunistic patterns among communities from the same ecosystem or between different ecosystems (Silveira & Campos 1995, Neves & Viana 2002).

Bahia State, in Brazil, presents a large area and great ecosystem diversity. The studies of floral visitor insect communities accomplished in this state involved exclusively bee guilds [exception for the social wasps in Santos (2000)], and have concentrated on semi-arid areas, within the domain of the "caatingas" (e.g. Carvalho 1999, Castro 2001, Aguiar 2003).

The "campos rupestres" vegetation in Bahia - BA is restricted to mountains higher than 900 m in Chapada Diamantina (Harley 1995). Two studies of bee communities were carried out in this area, the first one focusing on solitary and social bees (Martins 1994) and other one restricted to eusocial bees (Viana *et al.*1997). Both were conducted in "cerrado" ecosystem with elements of campos rupestres. For the campos rupestres vegetation in Minas Gerais State, the melittophilous fauna was reported in Serra do Cipó and Lavras Novas, at Serra do Espinhaço (Faria & Camargo 1996, Faria-Mucci *et al*. 2003).

In the present work, the bee and social wasp community structure was studied in a restricted area of campos rupestres in Chapada Diamantina considering two parameters for diversity analysis – the abundance of individuals and the biomass of the samples – in attempt to improve the floral visitor community description.

Material e Methods

The Serra do Espinhaço, of which Chapada Diamantina is part, is composed by a group of mountains with ca. 1000 m of altitude that extend for about 1000 km from North to South, with width varying from 50 km to 100 km. The mountain areas of Minas Gerais and Bahia present a disjunction of about 300 km, where the rivers Rio de Contas, Rio Pardo and Rio Jequitinhonha pass through (Harley 1995). Chapada Diamantina (delimited approximately by the parallel 10º43'S and 14º20'S and the meridians 40º40'W and 43º00'W) is composed by a group of local mountains in the central part of Bahia (Fig. 1).

Campos rupestres are a characteristic vegetation of areas above 800-900 m of altitude in the whole Serra do Espinhaço. This formation presents open vegetation with a stratum of monocot herbs, sub-shrubs and shrubs of dicots. Although campos rupestres dominate the landscape of higher areas in Chapada Diamantina, due to altitude, soil, and microclimatic variations, other characteristic vegetation types from different ecosystems also occur, such as "caatingas", cerrados and seasonal forests, composing a mosaic of physiognomies (Giulietti *et al.* 1996, 1997).

The climate in the region is higher elevation tropical (Cwa), according to Köppen's classification. It is defined by fresh summers and a marked dry season from May to September, and humid season from October to March.

The study was accomplished in Serra dos Brejões (12º27'30"S and 41º27'56"W), Palmeiras locality, BA. The site is located at 1000 m of altitude, over a large plateau, usually with shallow soils. Rifts on the rocks are common, on which organic material, soil and moisture are retained, allowing the development of vegetation. The lower altitudes of Serra dos Brejões are covered by cerrado vegetation, with the predominance of herbs and some scattered shrubs.

The bee and social wasp community was investigated from September 2001 to April 2002, in campos rupestres area, with approximately 1ha. The insects were collected monthly, in two consecutive days, always by two collectors, with 170h of sampling effort. Each flowering plant in the area was carefully inspected for about 5 to 10 min, in attempt to standardize the sampling effort. The methodology was adapted from Sakagami *et al.* (1967).

The insects were collected directly from the flowers and killed with ethyl-acetate. They were dried in an oven at 40°C for 15h, and later weighted in an analytic scale with accuracy of 0.1 mg. Voucher specimens were deposited in the Entomological Collection of State University of Feira de Santana (CUFS), BA.

The flower visitor community structure was described using the abundance of individuals and biomass. The biomass of each species was obtained with the total sum of individual dry weights.

The species were classified in relation to constancy as: constant (species sampled in more than 80% of collections), accessory (species sampled between 20% and 79% of collections) and accidental (species sampled in less than 19% of collections). As heterogeneity measures of the community structure, the Shannon (H') diversity (Magurran

1988) and Pielou (J') evenness indexes (Magurran 1988) were used. The abundance distribution was described using Preston's Lognormal model (Laroca 1995).

The species dominance hierarchy was determined using the occurrence probability according to Kato's *et al*. method (Laroca 1995), with confidence limit of 0.05. With this method, dominant species are considered the ones that present lower confidence limit higher than the inverse of the total number of species, multiplied by 100 ($V_1 = S^{-1}x100$).

The faunistic similarities among bee communities studied in different ecosystems were evaluated considering faunas from: (1) campos rupestres, in Chapada Diamantina (BA, present work), (2) cerrado, within Chapada Diamantina region (Martins 1994), (3) caatinga, at approximately 300 km from Chapada Diamantina region (Aguiar 2003), (4) campos rupestres, from Serra do Cipó (Minas Gerais State, Faria & Camargo 1996), and (5) campos rupestres, at Lavras Novas (Minas Gerais State, Faria-Mucci *et al.* 2003), Fig.1.

In attempt to evaluate the similarity among the faunas we transformed the data to log (x + 1) before using the Morisita-Horn similarity coefficient (Magurran 1988) and applied the UPGMA algorithm. The similarity matrix and dendrogram were built using the software PAST (Hammer *et al.* 2001).

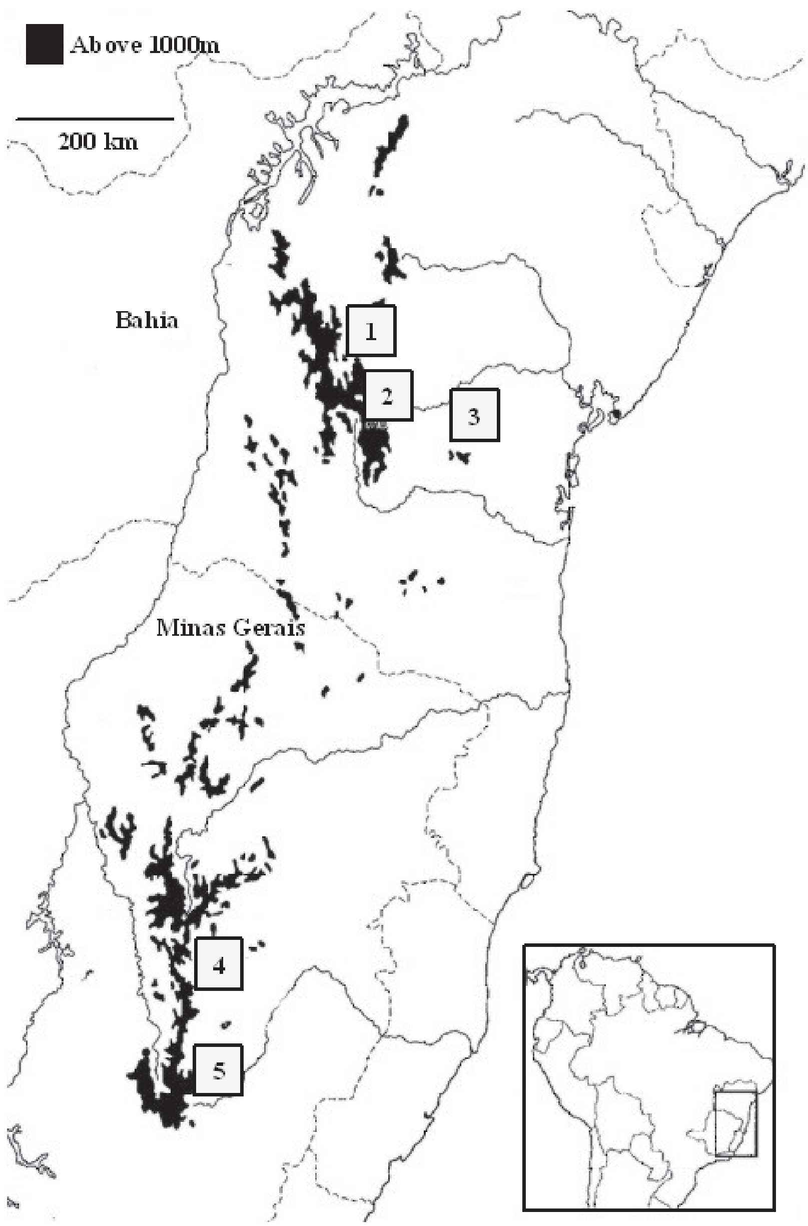

Figure 1. Map of Serra do Espinhaço and localities of the bee communities included in the similarity analysis described in the text. Localities: (1) Palmeiras, BA; (2) Lençóis, BA; (3) Itatim, BA; (4) Serra do Cipó, MG; (5) Lavras Novas, MG, Brazil. Adapted from Giulietti *et al*. 1997.

Results

We collected a total of 640 individuals (17.898 g of biomass), with representatives of 50 species, distributed in 22 genus of bees and six genus of social wasps. Thirty nine species (588 individuals/ 15.742 g) were bees from the Apoidea group and 11 species (52 individuals/ 2.156 g) were social wasps from Vespidae family.

Apidae was the richest (23 spp.) and most abundant bee family in number of individuals and biomass 551 / 15 g). Apinae subfamily was represented by seven eusocial bees species and 12 semi-social and solitary bees species, and Xylocopinae by four species. The second bee family in richness and individuals abundance was Halictidae (12 spp. / 23 individuals), followed by Megachilidae (3 spp. / 13 individuals) and Colletidae (1 sp. / 1 individual). Among the wasps, all of 11 species were representatives of Polistinae subfamily, which was the second most abundant group in number of individuals and biomass (52 / 2 g) (Table 1).

In relation to constancy, only social species were classified as constant, being collected in more than 80% of the sampled period. *Bombus brevivillus* Franklin and *Trigona spinipes* (Fabricius) (Apidae, Apinae) were the most constant bee species, being collected all months. *B. brevivillus* presented the highest abundance between September and November. *T. spinipes* was most abundant in November, and in the same period *Apis mellifera* (L.), which was the third most constant species, was absent. Among the social wasps, *Synoeca cyanea* (Fabricius) (Vespidae, Polistinae) was the most constant, being collected during the whole sampling period, except in February and April.

In terms of relative contribution of each subfamily, Apinae was the most important, representing 39% of the total species number, 85.6% of individuals and 80.3% of the biomass sampled within the community. Although Halictinae has been the second subfamily in relation to richness, Polistinae was the second most important in terms of individuals (8%) and total biomass (12.2%) contribution for community (Table 2).

As an heterogeneity measurement for the community structure, the diversity and evenness indexes calculated for individuals abundance (H' = 2.14 and J' = 0.55) and biomass (H' = 2.34 and J' = 0.60) suggest not only low richness and unbalanced distribution of the abundance among the species, but an unbalanced distribution of the biomass contribution of each species for the community too, although, a little less.

The slight difference of evenness indexes between the two parameters could be illustrated, through the Preston's Lognormal model of distribution of abundance and biomass classes (Fig. 2). The abundance distribution curve of individuals presents 84% of the total species number concentrated on the left side, indicating a much higher frequency of rare species than intermediate and common species, in terms of number of individuals. The biomass distribution curve contains 63% of the species on the left side, indicating a high frequency of species with low weight, but 37% of the species presented intermediate and large biomass, suggesting a little more even distribution of the total biomass community among the species.

The species dominance hierarchy presents differences in number of dominant species and ordination rank, between the abundance of individuals and biomass parameters (Fig. 3). Considering abundance of individuals, *T. spinipes*, *A. mellifera*, *F. francoi* (Moure) and *B. brevivillus* were the predominant species, with lower confidence limit higher than V_1 = 2.04. These species represented 81% of the total number of insects sampled. The social wasps *S. cyanea*, *Polistes canadensis* (L.), *Myschocyttarus drewseni* (Saussure) and the *Megachile* (*Pseudocentron*) sp.1 bees presented intermediate abundance in the rank. The remaining species, represented by six individuals or less, were considered rare. Among the 50 species of visitors, 48% were represented by a single individual.

Considering the biomass, there was an inversion in the dominance hierarchy of species. In this case, *B. brevivillus* contributed with a large part of biomass in the community, presenting high variation in body-size among individuals, due to the inclusion of males, queens and workers bees with different weights (average = 0.148 mg; max. = 0.511 mg and min. = 0.049 mg). The second dominant species in biomass was *A. mellifera* followed by *T. spinipes*. These three species together were responsible for 65.3% of the total sampled biomass (Fig. 3). The social wasps *S. cyanea* and *P. canadensis*, and the bees *Eufriesea nigrohirta* (Friese), *Xylocopa grisescens* Lepeletier and *M.* (*Pseudocentron*) sp.1 were also considered dominant in relation to the biomass, although few individuals had been collected.

The dendrogram obtained from the similarity faunistic analysis among five floral visitor bee communities presents a higher similarity among faunas sampled in Bahia and among faunas sampled in Minas Gerais, than among the faunas sampled in campos rupestres (Fig. 4). The bee fauna from Palmeiras (Serra dos Brejões, present work) was most similar to bee faunas from Itatim with 34% of similarity, using Morisita-Horn indexes.

Discussion

The organization patterns of local flower visitor communities has been descript more frequently by the number of individuals collected during resource collection or foraging activities. In general, as well as in our study, those communities in different tropical ecosystems present high number of rare species and few common species, with low levels of evenness in the relative contribution of the component species in community, being the eusocial bees responsible for the great number of the samples (Silveira *et al.* 1993, Carvalho & Bego 1995, Aguiar & Martins 1997).

In Palmeiras (Chapada Diamantina) the common species were represented mainly by eusocial bees, with predominance of *A. mellifera* and *T. spinipes*. These species do not require specific places for colony establishment, for they build external nests. They stay active during the whole year and also store food to maintain the colony in periods of food shortage. Although their individuals are small and present low biomass, they constitute nests with great number of workers, being responsible for most of the biomass of the

Table 1. Number of individuals, biomass (mg) and constancy of the bee and social wasp collected species in Palmeiras, BA, Brazil; diversity (H') and evenness (J') indexes values.

Family/species	Individuals	Biomass (mg)	Constancy
APIDAE			
Apinae			
Apis mellifera L.	175	4,650.9	Constant
Bombus (*Fervidobombus*) *brevivillus* Franklin	43	5,187.9	Constant
Eufriesea nigrohirta (Friese)	4	614.3	Accidental
Eufriesea sp.	2	298.0	Accidental
Euglossa aff. *cordata* (Linnaeus)	1	37.0	Accidental
Eulaema (*Apeulaema*) *nigrita* Lepeletier	1	242.2	Accidental
Eulaema sp.	1	250.1	Accidental
Frieseomelitta francoi (Moure)	95	364.0	Accessory
Geotrigona subterranea (Friese)	2	12.7	Accidental
Melipona (Quadrifasciata) anthidioides Lepeletier	2	81.6	Accidental
Melipona scutellaris Latreille	1	31.6	Accidental
Plebeia sp.	6	10.2	Accidental
Trigona spinipes (Fabricius)	205	1,842.5	Constant
Centris (*Xanthemisia*) *bicolor* Lepeletier	1	131.0	Accidental
Centris aenae Lepeletier	1	52.0	Accidental
Centris (*Hemisiella*) *tarsata* Smith	3	98.0	Accidental
Centris (*Trachina*) *fuscata* Lepeletier	2	290.0	Accidental
Epicharis (*Epicharana*) *flava* (Friese)	1	160.0	Accidental
Epicharis (*Epicharis*) *bicolor* Smith	1	46.0	Accidental
Subtotal	547	14,400.0	
Xylocopinae			
Ceratina (*Ceratinula*) sp.	1	2.2	Accidental
Ceratina sp.	1	1.4	Accidental
Xylocopa (*Cyrroxylocopa*) *vestita* Hurd & Moure	1	95.0	Accidental
Xylocopa (*Neoxylocopa*) *grisescens* Lepeletier	1	592.0	Accidental
Subtotal	4	690.6	
COLLETIDAE			
Hylaeinae			
Hylaeus sp.	1	2.6	Accidental
Subtotal	1	2.6	
HALICTIDAE			
Halictinae			
Augochlora sp.1	2	16.2	Accidental
Augochlora sp.2	1	2.9	Accidental
Augochlora sp.3	1	3.8	Accidental

Continue

Table 1. Continuation

Family/species	Individuals	Biomass (mg)	Constancy
Augochloropsis sp.1	1	14.2	Accidental
Augochloropsis sp.2	2	22.7	Accidental
Augochloropsis sp.3	1	16.3	Accidental
Augochloropsis sp.4	1	11.7	Accidental
Augochloropsis sp.5	2	17.1	Accidental
Caenohalictus sp.1	3	6.9	Accidental
Caenohalictus sp.2	2	10.0	Accidental
Dialictus (*Chloralictus*) sp.	5	11.2	Accessory
Neocorynura sp.	2	11.9	Accidental
Subtotal	23	144.9	
MEGACHILIDAE			
Megachilinae			
Larocanthidium bilobatum Urban	1	14.0	Accidental
Megachile (*Pseudocentron*) sp.1	11	467.6	Accessory
Megachile (*Pseudocentron*) sp.2	1	21.8	Accidental
Subtotal	13	503.4	
VESPIDAE			
Polistinae			
Brachygastra lecheguanea (Latreille)	3	43.6	Accessory
Myschocyttarus drewseni (Saussure)	10	257.0	Accessory
Polistes canadensis (Linnaeus)	10	675.0	Constant
Polistes simillimus Zikán	2	102.0	Accidental
Polybia chrysothorax (Weber)	1	36.1	Accidental
Polybia ignobilis (Haliday)	1	14.8	Accidental
Polybia occidentalis (Olivier)	2	15.9	Accidental
Polybia paulista Ihering	1	6.7	Accidental
Polybia sericea (Olivier)	6	136.3	Accessory
Protopolybia exigua (Saussure)	1	6.2	Accidental
Synoeca cyanea (Fabricius)	15	862.5	Constant
Subtotal	52	2156.0	
Total	640	17897.7	
N° of species	50	50	
Diversity H'	2.14	2.34	
Evenness J'	0.55	0.6	

whole flower visiting insect community. In addition, they are reported to occur on a broad geographical distribution in the Neotropics and are, therefore, expected in the Brazilian campos rupestres and related ecosystems (present study, Martins 1994, Faria & Camargo 1996, Viana *et al*. 1997), and also in other Brazilian ecosystems (Martins 1994, Neves & Viana 2002, Aguiar 2003). Finally, some authors consider, especially among insects, that species with numerous populations with low biomass per individual could present smaller extinction rates and could support population fluctuations (Varley & Gradwell 1970). This fact can increase competitiveness and tolerance on abrupt environmental variations and gives a larger colonizing ability in different ecosystems.

Table 2. Percentage contribution of each subfamily for the total of the number of species, number of individuals and biomass sampled in Palmeiras, BA, Brazil.

	Apinae	Xylocopinae	Hylaeinae	Halictinae	Megachilinae	Polistinae
Species (%)	39.0	8.00	2.00	24.5	6.0	20.5
Individuals (%)	85.6	0.65	0.15	3.6	2.0	8.0
Biomass (%)	80.3	3.85	0.02	0.81	2.82	12.2

In most studies, *Bombus* species do not use to be dominant because of the small number of collected animals (Martins 1994, Aguiar & Martins 1997, Aguiar 2003). In Palmeiras, *B. brevivillus* was not the most abundant species in number of individuals but it was in relation to biomass. We collected males, queens and worker bees directly on flowers during the whole sampled period, and the individuals presented a great body weight variation (0.049-0.511 mg). The high biomass of this species could be related to a great capacity of foraging for long distances and under unfavorable climatic conditions and to the capacity of energetic supply of the colonies. On the other hand, the maintenance of a large number of individuals with so high individual weight could be unviable in some ecosystems, being the balance of biomass and abundance of individuals an important point for the *Bombus* species contribution in different communities.

In our study, we present some characteristics of the floral visitor community structure that could be more evident comparing two parameters in diversity analysis – abundance of individuals and biomass – once the biomass could be used as an indirect measurement of the energetic request for each species. The slight differences in relation to: (1) diversity and evenness indexes between the parameters; (2) the frequency distribution curves of abundance and biomass; and (3) the dominance hierarchy of the number of individuals and biomass species, suggest that the effective contribution of each species on the community organization is not determinate only by the number of the consumers within the community, but also by the quantity of biomass that has to be maintained.

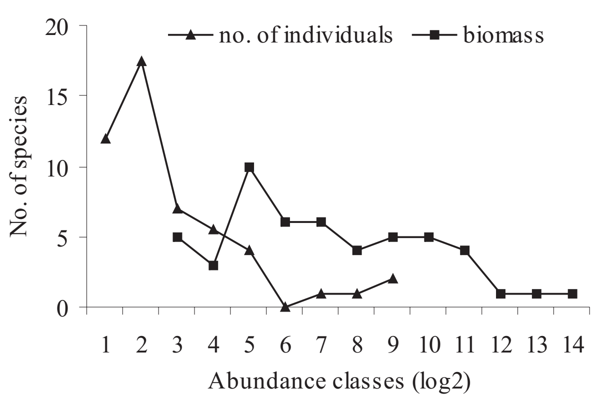

Figure 2. The abundance distribution of number of individuals and biomass classes, using the Preston's Lognormal model (*apud* Laroca 1995).

Considering that, biomass can be a good parameter to improve floral visitor community description in the attempt to detect organization patterns and relationships among the species (during resource exploitation activity), which are not evidenced in the direct quantification of individuals.

The 11 social wasp species from the subfamily Polistinae collected in this study are the first report of this group in Brazilian campos rupestres. Santos (2000), focusing on the Polistinae wasps in a caatinga area (locality of Itatim, BA), registered 13 species, which six of them were also sampled in the present work in Chapada Diamantina. Sporadic collections carried out elsewhere in Chapada Diamantina (localities of Jacobina, Morro do Chapéu, Lençóis, Mucugê and Rio de Contas) indicate the occurrence of at least seven other social wasp species in the region.

In Palmeiras, most of the social wasps species are rare and collected sporadically, but two specifically species, *S. cyanea* and *P. Canadensis*, were present in more than 50% of the samples. *S. cyanea* (Epiponini tribe) was the most abundant and constant species among the wasps, presenting activity during the whole sampling period. This occurrence pattern of Epiponini wasps was also observed by Santos (2000) in caatinga ecossistem and by Heithaus (1979) in tropical forest. Rossi & Hunt (1988) suggested that the constancy of the Epiponini tribe can be associated to greater capacity to produce honey and to maintain the colony activities during eventual shortage periods than the other tropical social wasp tribes (Polistini and Myschocitarini).

Although wasps constantly visit flowers of several plant species in different tropical ecosystems (Gadagkar 1991), and therefore are effective components of insect floral resource consumers community, few works include bees and wasps in their diversity analysis (Heithaus 1979, Gess & Gess 1993). In the present study, the wasps represented 20% of number of species and 12.2% of the total biomass sampled, being the second most important group in the community.

Comparative analyses among faunas from different places are usually hindered because of the differences in the sampling intensity, sampling period, area size and the type of habitat studied (Heithaus 1979, Cure *et al*. 1990). However, qualitative and quantitative comparisons of studied faunas that used similar methodologies can supply information about possible richness and abundance patterns for communities from the same ecosystem type, ecotone zones or different ecosystems (Silveira & Campos 1995, Viana *et al*. 1997, Neves & Viana 2002).

The comparative analysis among different bee surveys presented in the work, suggested greater similarity among the bees faunas in Bahia, including different ecosystems as campos rupestres, cerrados and caatinga (present study, Martins 1994, Aguiar 2003) than to faunas from campos rupestres in Minas Gerais (Faria & Camargo 1996, Faria-Mucci *et al.* 2003).

Comparing the bee community in Palmeiras to the two nearest community (Lençóis, Martins 1994 and Itatim, Aguiar 2003), we found a low Morisit-Horns index values. This low similarity could be explained mainly by the great differences among the habitats in the three localities, influencing the composition of floral visitor community. In

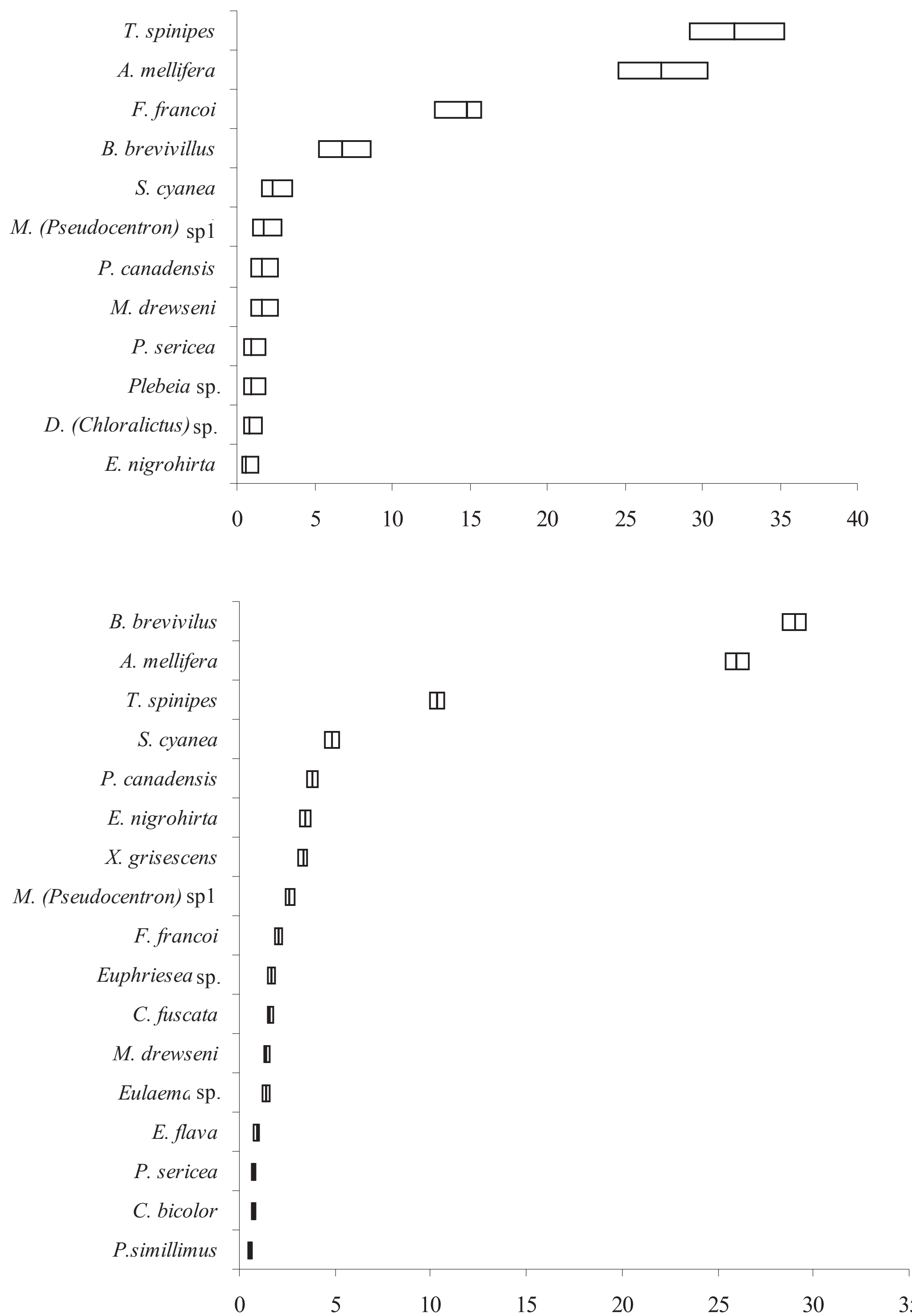

Figure 3. The dominance hierarchy of bee and social wasp species for number of individuals and biomass parameters, using the Kato's model (Laroca 1995). $V_1 = 2.04$.

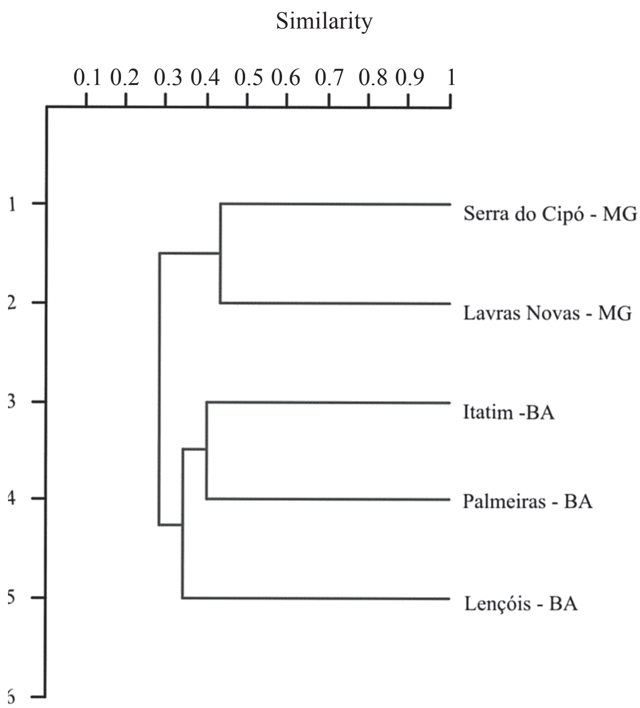

Figure 4. The faunistic similarities among bee communities studied in five different localities: Palmeiras, BA (present work); Lençóis, BA (Martins 1994); Itatim, BA (Aguiar 2003); Serra do Cipó, MG (Faria & Camargo 1996); Lavras Novas, MG (Faria-Mucci 2003), Brazil.

Lençóis is not only observed the cerrado ecosystem, but also areas of campos rupestres on rocky outcrops, humid and seasonal forests. This way, this area could constitute a legitimate ecological tension zone associated to immigrant populations from other ecosystems (Martins 1994). In the same way, the bee fauna in Itatim presents a composition typical of caatinga areas, with high number of Centridini species (Aguiar 2003).

Considering that, the results presented in this work and the comparison with other areas indicate a large similarity of the sampled fauna in Palmeiras with neighboring ecosystems, even though with low values of similarity , in spite of occurrence of a campos rupestres richness pattern.

Acknowledgments

Eric C. Smidt for helping with fieldwork; Isabel Alves-dos-Santos, Pe. Jesus S. Moure, Danúncia Urban, Favízia F. de Oliveira, and Gabriel A.R. Melo for the bees identification; Cândida M.L. Aguiar, Cássio van den Berg and anonymous reviewers for valuable comments. Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq 131703/2001-3) for the fellowship.

References

Aguiar, C.M.L. 2003. Utilização de recursos florais por abelhas (Hymenoptera, Apoidea) em uma área de caatinga (Itatim, Bahia, Brasil). Rev. Bras. Zool. 20: 457-467.

Aguiar, C.M.L. & C.F. Martins. 1997. Abundância, diversidade e fenologia de abelhas (Hymenoptera, Apoidea) da caatinga, São João do Cariri, Paraíba, Brasil. Iheringia, Sér. Zoologia 83: 151-163.

Alves-dos-Santos, I. 1999. Distribuição vertical de uma comunidade de abelhas (Hymenoptera, Apoidea) do Rio Grande do Sul. Rev. Bras. Entomol. 43: 225-228.

Bawa, K.S. 1990. Plant-pollinator interactions in tropical rain Forest. Ann. Rev. Ecol. Sys. 21: 399-422.

Cane, J.H. & J.A. Payne. 1993. Regional, annual and seasonal variation in pollinator guilds: Intrinsic traits of bees (Hymenoptera, Apoidea) underline their patterns of abundance at *Vaccinium ashei* (Ericaceae). Ann. Entomol. Soc. Am. 86: 577-588.

Carvalho, A.M.C. & L.R. Bego. 1995. Seasonality of dominant species of bees in the Panga Ecological Reserve Cerrado. An. Soc. Entomol. Brasil 24: 329-337.

Carvalho, C.A.L. 1999. Diversidade de abelhas (Hymenoptera, Apoidea) e plantas visitadas no município de Castro Alves, BA. Tese de Doutorado, ESALQ -USP, Piracicaba, 104p.

Castro, M.S. 2001. Comunidade de abelhas (Hymenoptera; Apoidea) de uma área de caatinga arbórea entre os inselbergs de Milagres (12º53'S; 39º51'W), Bahia. Tese de Doutorado, USP, São Paulo, 191p.

Conceição, A.A. & A.M. Giulietti. 2002. Composição florística e aspectos estruturais de campo rupestre em dois platôs do Morro do Pai Inácio, Chapada Diamantina, Bahia, Brasil. Hoehnea 29: 37-48.

Cure, J.R., G.S. Bastos-Filho, M.J.F. Oliveira & O.F. Souza. 1990. Influência do tamanho da amostra na estimativa da riqueza em espécies em levantamentos de abelhas silvestres (Hymenoptera, Apoidea). Rev. Bras. Zool. 7: 101-110.

Faria, G.M. & J.M.F. Camargo. 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: 217-229.

Faria-Mucci, G.M., M.A. Melo & L.A.O. Campos. 2003. A fauna de abelhas (Hymenoptera, Apoidea) e plantas utilizadas como fontes de recursos florais, em um ecossistema de campos rupestres em Lavras Novas, Minas Gerais, Brasil, p.241-256. In G.A.R. Melo & I. Alves-dos-Santos (eds.), Apoidea Neotropica: Homenagem aos 90 anos de Jesus Santiago Moure. Criciúma, Unesc, 320p.

Gadagkar, R. 1991. *Belanogaster*, *Myschocyttarus*, *Parapolybia*, and independent-founding *Ropalidia*, p.149-190. In K.G. Ross & R.W. Mattheews (eds.), The social biology of wasps. New York, Cornell University Press, 678 p.

Gess, F.W. & S. Gess. 1993. Effect of increasing land utilization on species representation and diversity of Aculeata wasps and bees in the semi-arid areas of South Africa, p.83-113. In J. LaSalle & I.D. Gauld (eds.), Hymenoptera and biodiversity. Wallingford, CAB International, 348p.

Giulietti, A.M., J.R. Pirani & R.M. Harley. 1997. Espinhaço Range Region, Eastern Brazil, p.397-404. In S.D. Davis, V.H. Heywood, O. Herrera-Macbryde, J. Villla-Lobos & A.C. Hamilton (eds.), Centres of plant diversity. A Guide and strategy for their conservation. Cambridge, The Americas IUCN Publication Unity, 450p.

Giulietti, A.M., L.P. Queiroz & R.M. Harley. 1996. Vegetação e flora da Chapada Diamantina, Bahia. Anais da 4ª Reunião Especial da SBPC, Feira de Santana, 4: 144-156.

Hammer, Ø., D.A.T. Harper, & P.D. Ryan. 2001. PAST: Paleontological statistics software package for education and data analysis. Palaeontologia Electronica 4: 1-9. http://palaeo-electronica.org/2001_1/past/issue1_01.htm. Access: 10.08.2004.

Harley, R.M. 1995. Introduction, p.1-37. In B.L. Stannard (ed.), Flora do Pico das Almas, Chapada Diamantina, Brasil. Kew, Royal Botanical Gardens, 1009p.

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

Herrera, C.M. 1987. Components of pollinator "quality": comparative analysis of a diverse insect assemblage. Oikos 50: 79-90.

Herrera, C.M. 1989. Pollinator abundance, morphology, and flower visitation rate: analysis of "quantity" component in a plant-pollinator system. Oecologia 80: 241-248.

Laroca, S. 1995. Ecologia: Princípios e métodos. Petrópolis, Vozes, 197p.

Magurran, A.N. 1988. Ecological diversity and its measurement. Cambridge, Great Britain, 179p.

Martins, C.F. 1994. Comunidades de abelhas (Hymenoptera, Apoidea) da caatinga e cerrado com elementos de campo rupestre do estado da Bahia, Brasil. Rev. Nordestina Biol. 9: 225-257.

Neff, J.L. & B.B. Simpson. 1993. Bees, pollination systems and plant diversity, p.143-167. In J. LaSalle & I.D. Gauld (eds.), Hymenoptera and biodiversity. Wallingford, CAB International, 348p.

Neves, E.L. & B.F. Viana. 2002. As abelhas eussociais (Hymenoptera, Apidae) visitantes florais em um ecossistema de dunas continentais no médio Rio São Francisco, Bahia, Brasil. Rev. Bras. Entomol. 46: 571-578.

Pinheiro-Machado, C., I. Alves-dos-Santos, F.A. Silveira, A.M.P. Kleinert & V.L. Imperatriz-Fonseca. 2002. Brazilian bee surveys: State of knowledge, conservation and sustainable use, p.115-129. In P.G. Kevan, V.L. Imperatriz-Fonseca, G.W. Frankei, C.O'Toole, C.H. Vergana & T. Feltz (eds.), Pollinating bees: A link between agriculture and conservation. Brasília, Barbara Bela Editora, 313p.

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

Richards, O.W. 1978. The social wasps of Americas (excluding the Vespinae). London, British Museum (Natural History), 580p.

Rossi, A.M. & J.H. Hunt. 1988. Honey supplementation and its development consequences: Evidence for food limitation for paper wasp, *Polistes metricus*. Ecol. Entomol. 13: 437-442.

Sakagami, S.F., S. Laroca & J.S. Moure. 1967. Wild bees biocenotics in São José dos Pinhais (PR), South Brazil – preliminary report. J. Fac. Sci. Hokkaido Univ. Ser. VI, Zoology 16: 253-291.

Santos, G.M.M. 2000. Comunidades de vespas sociais (Hymenoptera – Polistinae) em três ecossistemas do estado da Bahia, com ênfase na estrutura da guilda de vespas visitantes de flores de caatinga. Tese de doutorado, USP, Ribeirão Preto, 129p.

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

Silveira, F.A., L.B. Rocha, J.R. Cure & M.J.F. Oliveira. 1993. Abelhas silvestres (Hymenoptera, Apoidea) da Zona da Mata de Minas Gerais. II Diversidade, abundância e fontes de alimento em uma pastagem abandonada em Ponte Nova. Rev. Bras. Entomol. 37: 595-610.

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.

Varley, G.C. & G.R. Gradwell. 1970. Recent advances in insect population dynamics. Ann. Rev. Entomol. 15: 1-24.

Viana, B.F. 1999. A comunidade de abelhas (Hymenoptera, Apoidea) das dunas interiores do Rio São Francisco, Bahia, Brasil. An. Soc. Entomol. Brasil 28: 635-645.

Viana, B.F., A.M.P. Kleinert & V.L. Imperatriz-Fonseca. 1997. Abundace and flower visits of bees in cerrado of Bahia, tropical Brazil. Stud. Neotrop. Fauna Environm. 32: 212-219.

Received 13/VIII/04. Accepted 23/IX/05.