ECOLOGY, BEHAVIOR AND BIONOMICS

Orchid Bee Fauna (Hymenoptera: Apidae: Euglossina) of Atlantic Forest Fragments inside an Urban Area in Southeastern Brazil

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Neotropical Entomology 36(2):186-191 (2007)

Fauna de Abelhas Euglossinas (Hymenoptera: Apidae: Euglossina) em Fragmentos de Mata Atlântica em uma Área Urbana no Sudeste do Brasil

RESUMO - Machos de abelhas euglossinas foram atraídos por compostos aromáticos e coletados em quatro fragmentos de Mata Atlântica em parques da cidade de Belo Horizonte, MG. Mil trezentos e vinte e cinco espécimes pertencentes a quartorze espécies foram coletados em um ano. Os dados das áreas amostradas no presente estudo foram comparados através de análises de correlação. Os resultados das análises indicaram que a abundância de abelhas euglossinas é maior em fragmentos maiores, embora não tenha havido correlação entre a riqueza e o tamanho dos fragmentos. Os dados apresentados sugerem que fragmentos de mata em uma grande metrópole podem ser importantes para a conservação da fauna dessas abelhas.

PALAVRAS-CHAVE: Insecta, composto aromático, conservação

ABSTRACT - Male orchid bees were collected by chemical baiting in four forest fragments in parks of the city of Belo Horizonte, Minas Gerais, southeastern Brazil. One thousand three hundred and twenty-five males belonging to 14 species were captured within one year. The capture data were compared through correlation tests. The data suggest that abundance of orchid bees tend to increase with fragment size, although no correlation between species richness and fragment size was obtained. The results presented herein suggest that forest fragments in a large city may be of importance concerning conservation of orchid-bee faunas.

KEY WORDS: Insecta, Euglossine bee, chemical baiting of males, conservation

Euglossina (Hymenoptera: Apidae, Apini) is a strictly Neotropical group of bees occurring from northern Argentina to northern Mexico (Pearson & Dressler 1985, but see Minckley & Reyes 1996 and Skov & Wiley 2005). Their males are remarkable for collecting aromatic compounds at flowers and storing them in special organs in their posterior tibiae (Dodson *et al.* 1969). The biological function of those compounds is not known, although they are believed to act in the recognition of males by females during mating (Eltz *et al.* 1999).

The orchid bees are shy, fast-flying bees, rarely collected at flowers. For this reason, only the discovering of the aromatic compounds attractive to males (Dodson *et al.* 1969) made it possible to study the composition and seasonality of their local faunas (e.g. Janzen *et al*. 1982, Ackerman 1983, Pearson & Dressler 1985, Tonhasca Jr. *et al*. 2002).

Male orchid bees are the main (and frequently the only) pollinators of the plants from which they collect aromatic compounds, including several hundreds of species of Orchidaceae (revised by Dressler 1982). For this reason, the conservation of orchid bees is an important issue when conservation of such plants is considered. To act effectively on orchid bee conservation, however, it is necessary that knowledge is acquired on the faunistic composition of forests as well as on the effects of the size of forest patches on the abundance and diversity of local faunas of those bees.

The regional faunas of orchid bees in Brazil are still poorly known, except for a few samplings in the Amazon and Atlantic Forest biomes (e.g. Morato *et al.* 1992, Rebêlo & Garófalo 1991, Bezerra & Martins 2001). The vast "Cerrado" (Brazilian savanna) regions in central Brazil, as well as the Pantanal are virtually unknown and several areas within the Amazon and Atlantic Forest biomes remain to be sampled. The orchid bee fauna of Minas Gerais state, southeastern Brazil, is poorly sampled (Peruquetti *et al.* 1999), and data on the forests in the Belo Horizonte region, where Cerrado and Atlantic Forest habitats originally met, are lacking.

Our goals in this work were, then, (i) to sample the orchid bee fauna of this part of the Atlantic Forest domain, that was virtually unknown, and (ii) to assess the effects of fragment size on species richness and bee abundance and the effect of distance between two fragments on their faunistic similarity.

Material and Methods

Study sites. Data were collected in four forest fragments in the urban area of the city of Belo Horizonte, in which metropolitan area more than three million inhabitants live. Belo Horizonte is at the border of two major Brazilian biomes, the Atlantic Forest and the Cerrado (Brazilian savanna). The dominant forest in the region is the semideciduous forest, called "low mountain rain forest" by Rizzini (1979), which occurs in elevations between 300 m and 800 m. In these forests, the canopy reaches 15 m to 25 m and trunks 40 cm to 60 cm in diameter, there are relatively few epiphytes and lianas and the understory is well developed. Trees grow taller and wider and spacing between them is reduced in the humid ravines. On the other hand, the forest gets sparser and shorter as the altitude increases, being substituted at the top of the tallest hills by patches of Cerrado or (above 1,000 m) by rocky fields. The regional climate is the AW of Köppen (tropical with rainy summers and a dry winter with mean annual temperature of 18°C). The fragments studied were the following:

1. *Parque das Mangabeiras.* Located in the southern edge of the city [19°56'55" S, 43°54'12" W; altitude ≈ 1,100 m]. It is surrounded by urbanized land on its northern and western borders and is limited, in its southern border, by a mountain range (Serra do Curral). It has a total area of 237 ha, of each 90 ha are covered by forest and surrounded by 82 ha of "cerrado" (Brazilian savanna), 44 ha of fields (natural and, mostly, anthropogenic) and 21 ha of constructed area. The sampling site is at about 1,100 m above sea level, 70 m inside the forest fragment.

2. *Estação Ecológica* of the Universidade Federal de Minas Gerais. Located in the northern region of the city [19°52'42" S, 43°58'18" W; altitude ≈ 850 m], it is a 102 ha area covered by a patch of developed secondary forest surrounded by disturbed forest and disturbed artificial fields. It is totally inserted in the urban matrix of the city. The sampling site was located at the border of the forest, at the edge of a marsh.

3. The external area of the *Museu de História Natural* e Jardim Botânico of the Universidade Federal de Minas Gerais. Located at the eastern region of the city [19°53'25" S, 43°54'47" W; altitude ≈ 820 m], completely inserted in the urban matrix of the city. The sampling site was located 50 m inside the forest fragment, which has 60 ha.

4. *Parque Ursulina* de Andrade Melo. Located in the northwestern area of the city [19°53'14" S, 43°59'31" W; altitude ≈ 850 m]. Most of its 24.2 ha area is covered by a well-developed secondary forest. The surrounding area is in the process of urban occupation. The sampling site was a clearing about 70 m from the border of the forest.

The areas between the fragments are all urbanized with a few vegetation patches represented by small parks and public gardens in between (Fig. 1).

Sampling. Male orchid bees were collected at a single fixed spot in each site, between 11:00h and 14:00h, once every month, between April 1997 and March 1998. Five aromatic compounds (benzyl acetate, 1,8-cineole, eugenol, methyl *trans*-cinnamate, and vanillin) were used to attract the bees, since in preliminary tests in this region these baits were the most attractive to male orchid bees. The baits were imbibed in cotton waddings hanging from branches at about 1.5 m above the soil surface and distant from each other at least 2 m. Bees attracted to these lures were captured with entomological nets, killed with ethyl acetate and pinned. The substance to which each bee was attracted and the local, day and time of the day it was collected were recorded. All specimens collected are deposited at the Entomological Collection of the department of zoology of the Universidade Federal de Minas Gerais. Bees were identified with the aid of taxonomic keys and by comparison with specimens previously identified by specialists.

Data analysis. The influence of the size of forest fragments on the abundance and on the species richness of their orchid bee fauna was tested by means of the Spearman rank correlation test. The similarity among the four sites, according to their faunistic composition, was estimated by the percent similarity index of Renkonen, recommended by Wolda (1981) for small samples. Based on those similarities, the areas were grouped using UPGMA (Sneath & Sokal 1973). Two sets of data were used: (i) all the orchid bee species, and (ii) only species of Euglossa, since the high incidence of Eulaema nigrita in Atlantic Forest areas may mask some important correlations among Euglossa species. The possible relationship between the distances between sample sites and the similarity of their faunas was tested using the Spearman rank correlation test.

Results

A total of 1,325 male orchid bees belonging to 14 species were collected at the four areas in Belo Horizonte (Table 1). Besides the 12 species recorded at Parque das Mangabeiras, posterior additional samplings at this site revealed the presence of *Eulaema cingulata* (Fabricius) and *Eufriesea violascens* (Mocsáry) at the same plot were previous samplings have been done. *Eufriesea nigrohirta* (Friese) was also collected at flowers at Parque das Mangabeiras. Thus, the total number of species known to exist in this site is 15. A specimen of *Ef. violascens* was also seen visiting eugenol at Parque Ursulina, but could not be collected.

When only the 675 specimens of the 11 species of *Euglossa* are considered (51% of all Euglossina collected), the contribution of the Parque das Mangabeiras to the total number of bees collected increases from 41% to 58%. Only at the Estação Ecológica the dominant species of *Euglossa* represented more than 50% of the individuals collected of this genus. At the other areas, the dominant species represents around one third of the specimens captured. Moreover, the dominant species of *Euglossa* at each site was not the same. The same 10 of the 11 species of *Euglossa* were recorded at Parque das Mangabeiras and Parque Ursulina. Of those, *Euglossa leucotricha* Rebêlo & Moure and *Euglossa townsendi* Cockerell were collected only at these sites. At the Museu de História Natural, eight species were captured, one of each, unidentified. Seven species were collected at the Estação Ecológica.

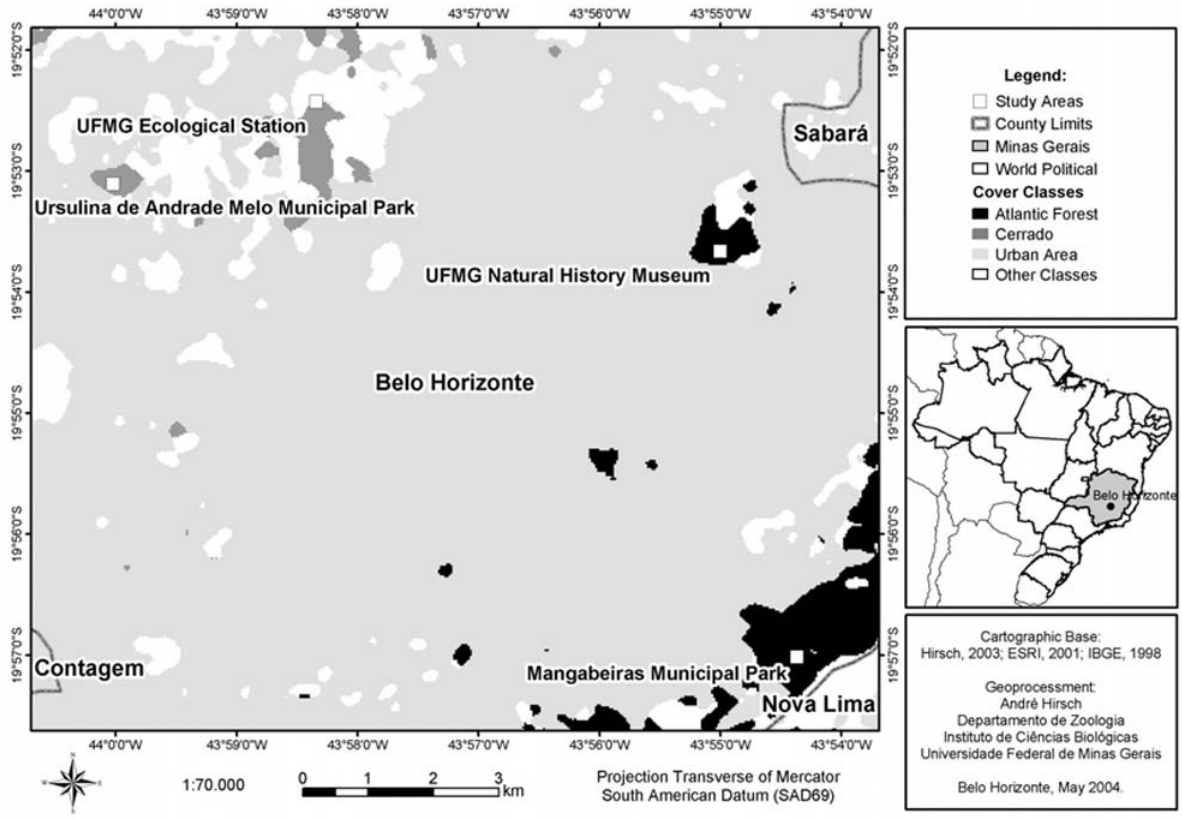

Fig. 1. Map of the study area, showing the four fragments sampled for orchid bee fauna.

The data suggest that abundance of orchid bees tend to increase with fragment size ($r_s = 1.00$; $n = 4$; $P < 0.05$). On the other hand, correlation between species richness and fragment size was not significant ($r_s = 0.75$; $n = 4$; $P > 0.05$).

The Estação Ecológica and Parque Ursulina are the sites with the most similar faunas, both considering all Euglossina (Fig. 2a) or only the species of *Euglossa* (Fig. 2b). They also are the closest areas among the four sites studied (Fig. 1).

The distances between fragments are negatively but not significantly correlated with the similarity between their faunas, both when all Euglossina or when only *Euglossa* are considered, although the correlation coefficients are relatively high (respectively, $r_s = - 0.54$ and $r_s = - 0.77$; $n = 6$; $P > 0.05$).

Discussion

Orchid bee species richness. Since *Eulaema seabrai* Moure was recently recorded for the region (Nemésio & Silveira 2004), the total number of orchid bee species known to occur in the Metropolitan Region of Belo Horizonte is 17. This figure is relatively high as compared to those of other areas sampled in the Atlantic Forest domain, especially when one considers that the fauna here sampled is dispersed in small fragments inserted in an urban matrix with elevations over 800 m. That number of species is similar, for instances, to the species richness recorded in eastern Minas Gerais state (ca. 20 species – at the Parque Estadual do Rio Doce, a 36,000 ha remnant of Atlantic Forest – Nemésio & Silveira 2006) and in Desengano region, Rio de Janeiro state (21 species in a 22,000 ha area – Tonhasca Jr. *et al.* (2002), and superior to the species richness in fragments in João Pessoa city, Paraíba state, northeastern Brazil (estimated in 11 species – Bezerra & Martins 2001), in forest remnants in northeastern São Paulo state (estimated in 11 species – Rebêlo & Garófalo 1991), in the Reserva Particular do Patrimônio Natural da Serra do Caraça – a large (> 10,000 ha) remnant of tropical semideciduous forest ca. 60 km to the east of Belo Horizonte – (estimated in 10 species, Nemésio 2004). On the other hand, samplings in the Amazonian region and in Central America have yielded between 27 and 50 orchid bee species (e.g. Ackerman 1983, Pearson & Dressler 1985, Roubik & Ackerman 1987, Morato *et al.* 1992). Studies on local faunas have demonstrated that orchid bee species richness is highest at Tropical Evergreen Forests, situated in lower latitudes. Also, there is a tendency towards the changing of the bee fauna as altitudes go higher (e. g. Silveira & Cure 1993).

Thus, the results presented here suggest that forest fragments in large urban areas may effectively support viable populations of orchid bees and the conservation status of these areas should be considered with great care. However, it also should be considered that mere presence of a species does not mean that its preservation is granted. Since the history of the

Table 1. Frequency (%) and total number of males of each species of Euglossina collected at Parque das Mangabeiras (PM), Museu de História Natural e Jardim Botânico da UFMG (MHN), Estação Ecológica da UFMG (EE) and Parque Ursulina de Andrade Melo (PU), in the municipality of Belo Horizonte, Minas Gerais state, Brazil. Baits = baits attractive to each species. B = benzyl acetate, C = cineole, E = eugenol, M = methyl cinnamate, V = vanillin. ALL = attracted to all the five baits.

Species	Baits	Sampling sites				Total (N)
		PM	MHN	EE	PU	
Euglossa annectans Dressler	ALL	17.4	11.8	3.1	5.3	153
Euglossa cordata (L.)	C	0.2	–	1.2	1.8	7
Euglossa fimbriata Rebêlo & Moure	C, E, M	23.8	5.6	7.7	9.5	185
Euglossa imperialis Cockerell	C, M	0.9	0.3	–	0.6	7
Euglossa leucotricha Rebêlo & Moure	C	0.2	–	–	1.2	3
Euglossa melanotricha Moure	C, E, M	11.8	0.8	1.2	1.2	72
Euglossa pleosticta Dressler	C, E	0.2	1.1	0.8	0.6	8
Euglossa securigera Dressler	C, E, M	3.7	6.5	18.1	16.0	117
Euglossa townsendi Cockerell	C	0.2	–	–	3.6	7
Euglossa truncata Rebêlo & Moure	C, E, M	13.5	5.3	3.9	7.1	114
Euglossa sp. 1	C	–	0.6	–	–	2
Eulaema cingulata (Fabricius)	B, E	–	1.4	0.4	–	6
Eulaema nigrita Lepeletier	C, M, V	27.4	59.6	61.4	52.7	608
Exaerete smaragdina (Guérin)	ALL	0.7	7.0	2.3	0.6	36
N		541	356	259	169	1325

fragments sampled in Belo Horizonte is not entirely known, at least part of the orchid bee species in such forest patches may be represented by the last generations of declining populations, remnants of larger ones that previously occupied larger areas, and that are now doomed to extinction. Monitoring of such populations would be needed to check for this possibility.

Species composition. Most of the species sampled in the present study were also collected in a cerrado area in Parque Estadual do Rio Preto (PERP), northern Minas Gerais (Nemésio & Faria Jr. 2004), and details about the currently known distribution of these species are given in the above mentioned study. The other species – *Euglossa cordata* (L.), *El. cingulata*, *Ef. nigrohirta*, *Ef. violascens*, and *Exaerete smaragdina* (Guérin) – have wide distributions, except for *Eufriesea nigrohirta*, considered to be endemic to "campos rupestres" (see Nemésio 2005).

Habitat fragmentation. The data presented here suggest that size of forest fragments may influence orchid-bee species richness and, especially, bee abundance. The correlation between area and abundance may be a direct consequence of increased availability of food, nesting substrates and other space-dependent resources. On the other hand, the increase in species richness would require that increase in fragment area promote an increase in environment diversity. Thus, for example, large fragments (with the same approximate shape) would have larger areas protected from edge effects (such as higher air temperature, lower humidity and stronger winds) than small fragments. This would favor the survival of bee species directly or indirectly dependent on different specific microclimatic conditions. Accepting this hypothesis, however, requires an explanation for the high species richness recorded at Parque Ursulina, by far the smallest of the studied fragments, and calls the attention for the possible interference of other variables, which could not be accounted for in this study. Examples of such variables would be degree of environment disturbance and fragmentation history. For example, Parque Ursulina is the youngest fragment of all four, and its faunistic composition, as recorded here, may be just a snapshot of a declining fauna. Again, the corroboration of such hypothesis would require monitoring of the local populations.

Eulaema nigrita, which has been regarded as a species "typical" of open and/or disturbed areas (Morato *et al.* 1992, Peruquetti *et al.* 1999), was the dominant species in all four fragments and its frequency tended to be highest at the smallest fragments. This may be due, thus, to the prevalence of edge conditions in these fragments. It is outstanding that the highest frequency of this species was recorded at the Estação Ecológica, which is not the smallest of the four areas but had its sampling site located at the edge of and not inside the forest. It seems thus, that frequency of *El. nigrita* may be used as indicative of environment quality in a fragmented

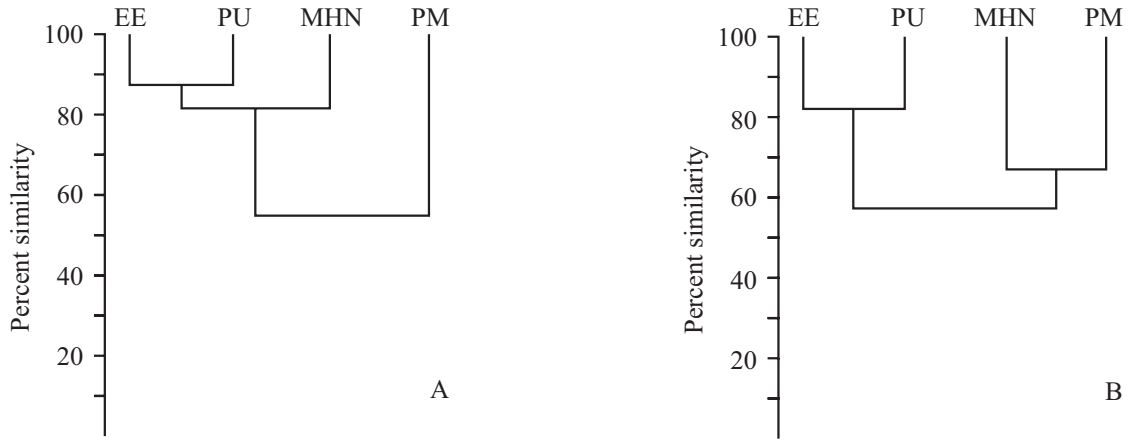

Fig. 2. Clustering of four forest fragments in the urban area of Belo Horizonte (Minas Gerais, Brazil), according to the similarity of their fauna of A) Euglossina and B) *Euglossa.* EE = Estação Ecológica; PU = Parque Ursulina; MHN = Museu de História Natural; PM = Parque Mangabeiras.

landscape. This question should be further investigated, however, since some authors (e.g. Bezerra & Martins 2001) maintain that the high frequencies of this species in Atlantic Forest remnants only reflect the natural structure of orchid bee populations.

The correlations between distances between fragments and faunistic similarities were quite high, although not significant. Since the lack of significance may be an effect of the sample size, it may be useful to consider the correlation indexes as "tendencies". In this respect, the fact that the correlation index increased when the species of *Eulaema* (said to be typical of open areas – see above) were not considered in the analysis is outstanding. What the results suggest for future analysis is the hypothesis that the urban matrix is a barrier for the dispersion of, at least, some species. As suggested in the literature, the ability to cross open areas may vary among species. Experiments with marked bees in the Amazonian forest demonstrated that some species failed in crossing only a few tens of meters of open space between two forest fragments (Powell & Powell 1987). On the other hand, Raw (1989) showed that some species could fly over urban areas from one fragment to another in Salvador city, Bahia state, northeastern Brazil, a city about the same size of Belo Horizonte and inserted in the Atlantic Forest domain.

Given the size of the studied fragments, one may consider the possibility that all the species collected in Belo Horizonte are at least tolerant to disturbance to some degree. If an extreme intolerance to the edge of forests or to open spaces exists among orchid bees and species with this characteristic existed in the Belo Horizonte region, then, these are probably locally extinct.

Acknowledgements

The Prefeitura Municipal de Belo Horizonte allowed us to sample both Parque Ursulina de Andrade Melo and (through the Park's administration) Parque das Mangabeiras. We also thank J. Damasceno, who helped with fieldwork at Parque das Mangabeiras and M. L. Oliveira, who helped with the identification of some specimens of *Euglossa fimbriata*. This study was partly supported by FAPEMIG which also granted a fellowship to AN.

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Received 03/VIII/05. Accepted 04/VII/06.