

## Orchid bee community (Hymenoptera, Apidae) at an altitudinal gradient in a large forest fragment in southeastern Brazil

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**Abstract.** Male orchid bees were attracted to chemical baits and collected monthly during one year at three sites situated at different altitudes (850, 1,200, and 1,350 m) above sea level in an 11,233 ha forest fragment in southeastern Brazil. At the lowest elevation, 175 bees were caught, whereas 40 bees were collected at the intermediate elevation and only 19 bees were captured at the highest elevation. Abundance of orchid bees was lower at high elevations: the number of bees collected at 850 m was almost 10 times greater than that at 1,350 m. Surprisingly, however, richness was apparently not influenced by the altitude of the sites, because the number of species was fairly constant along the gradient (eight in the intermediate site and seven in the remaining two sites). There was a high degree of abundance by two species, *Euglossa truncata* Rebêlo & Moure and *Eulaema nigrata* Lepeletier, which accounted for 73% of all bees captured and a high degree of bait fidelity for eugenol and cineole, respectively.

**Key words:** Apidae, Atlantic Forest, Brazil, conservation, Euglossina.

**Resumo:** Machos de abelhas euglossinas foram atraídos por iscas aromáticas e amostrados mensalmente durante um ano em três sítios de coleta situados a diferentes altitudes (850, 1.200 e 1.350 m) em um fragmento florestal de 11.233 ha no sudeste do Brasil. No ponto situado à mais baixa altitude, 175 abelhas foram coletadas, ao passo que 40 espécimes foram capturados no ponto situado à altitude intermediária e 19 indivíduos no ponto mais alto. O número total de abelhas capturadas (n = 234) demonstra que a abundância de euglossinas é baixa em altitudes mais elevadas e essa tendência é óbvia quando os três pontos de coleta são analisados: a abundância no ponto mais baixo foi quase 10 vezes maior do que aquela observada no ponto mais elevado. Por outro lado, a riqueza parece não ter sido afetada, visto que o número de espécies (oito no ponto intermediário e sete nos outros dois pontos) permaneceu constante entre os pontos de coleta. Duas espécies foram as mais abundantes: *Euglossa truncata* Rebêlo & Moure e *Eulaema nigrata* Lepeletier, que, juntas, responderam por 73% de todas as abelhas capturadas. Essas espécies demonstraram uma enorme fidelidade às iscas de eugenol e cineol, respectivamente.

**Palavras-chave:** Apidae, Brasil, conservação, Euglossina, Mata Atlântica.

### INTRODUCTION

Since aromatic compounds were discovered (DODSON *et al.*, 1969) to attract male orchid bees (Hymenoptera: Apidae: Euglossina), this group of Neotropical bees has become a favorite in ecological studies, especially those regarding abundance and diversity relative to fragment size (*e. g.* POWELL & POWELL, 1987; BECKER *et al.*, 1991; BEZERRA & MARTINS, 2001; BEMBÉ, 2002; TONHASCA JR. *et al.*, 2002; NEMÉSIO

& SILVEIRA, 2007) and to edge effects (*e. g.* MORATO, 1994; NEMÉSIO & SILVEIRA, 2006).

It is a well known phenomenon that abundance and richness of life forms tend to decrease as latitude and altitude increase (*e. g.* BEALS, 1969; RICKLEFS, 1973; BEGON, 1990; NAKASHIZUKA *et al.*, 1992; VÁZQUEZ G. & GIVNISH, 1998). Studies in Central America (ACKERMAN, 1983; ROUBIK & ACKERMAN, 1987) and the Amazon (PEARSON & DRESSLER, 1985; MORATO *et al.*, 1992; OLIVEIRA & CAMPOS, 1995; NEMÉSIO & MORATO,

2004, 2006a, 2006b) have demonstrated that, in fact, areas located in low latitudes present a more diverse fauna of orchid bees than sites located in higher latitudes in the Atlantic Forest domain (REBÊLO & GARÓFALO, 1991, 1997; SANTOS & SOFIA, 2002; TONHASCA JR. *et al.*, 2002; SOFIA & SUZUKI, 2004; SOFIA *et al.*, 2004; NEMÉSIO & SILVEIRA, 2006, 2007). On the other hand, no study to date has focused on the possible effects of altitude on the abundance and richness of these important pollinators of New World plants (see DRESSLER, 1982), with the exception of few studies dealing with Apoidea in general (*e.g.* SILVEIRA & CURE, 1993) and a recent study dealing with only one highly seasonal orchid bee species (UEHARA-PRADO & GARÓFALO, 2006).

The main goal of this paper is, thus, to carry out a first attempt to characterize the effects of altitude on the abundance and richness of the orchid bee fauna. Additionally, the orchid bee fauna of Reserva Particular do Patrimônio Natural da Serra do Caraça (RPPN Caraça), where this study was carried out, was inventoried for the first time.

#### MATERIALS AND METHODS

Data were collected at three sites at different elevations at Reserva Particular do Patrimônio Natural da Serra do Caraça (RSC), a large (11,233 ha) forested area 60 km from the city of Belo Horizonte. The dominant forest in the region is the semideciduous forest, called "low mountain rain forest" by RIZZINI (1979), with an elevation of 300-800 m. The forest canopy reaches 15-25 m and trunks vary from 40 to 60 cm in diameter. There are relatively few epiphytes and lianas, but the understory is well developed. Denser stands of larger trees grow in the humid ravines (see VASCONCELOS, 2000; CANELAS & BERTOLUCI, 2007). The forest gets sparser and shorter as the altitude increases, being substituted at the top of the tallest hills by patches of Cerrado or 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 first sampling site (Site-1; 20°02'37" S, 43°30'17"W) was situated at 850 m above sea level, the second site (Site-2; 20°04'31" S, 43°30'37"W) at ca. 1,200 m and the third site (Site-3; 20°05'44" S, 43°29'44"W) at ca. 1,350 m.

#### Sampling

Male orchid bees were captured monthly at a single fixed spot at each site, between 1000 and 1600 h, during one year, between May 1999 and April 2000. Each month the samplings were carried out simultaneously, one researcher placed at each site. Five chemicals (benzyl acetate, 1,8-cineole, eugenol, methyl *trans*-cinnamate, and vanillin) were used to attract the bees. They were imbued 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, the local, date and time of the day of each collection were recorded. All specimens were identified and deposited at the entomological collection of the Taxonomic Collections of the Universidade Federal de Minas Gerais, Belo Horizonte, Brazil.

#### Data analysis

Although several authors have grouped the whole community of orchid bees of a given area to assess preference and daily patterns of collections at aromatic scents, here I chose to analyze individual species separately. Only species of which at least 20 individuals were collected were considered, since samples containing less than this number would be heavily subject to artifacts. Nonetheless, all species collected during the present study and their abundances are presented.

#### Taxonomy

Taxonomy of orchid bees at generic and specific levels follows NEMÉSIO (2009).

## RESULTS

Two hundred and thirty four orchid bee males belonging to nine species were attracted and collected during the twelve-month period of this study at the three selected sites. The majority of bees (175 out of 234, or 75% of the total) were caught at the site located at the lowest elevation (Tab. 1). Forty specimens (17% of the total) were collected at the site-2 (1,200 m) and only 19 orchid bees (8 % of the total) were collected at the site situated at the highest elevation. In contrast, richness was fairly stable among the three sites (seven, eight, and seven species, respectively, Tab. 1). The abundance of species was different at each site: at site-1, *Euglossa truncata* Rebêlo & Moure, 1996 represented 58% of the total community, at site-2, *Eulaema nigrita* Lepeletier, 1841 represented 43 % of the total community and, at site-3, *Euglossa fimbriata* Rebêlo & Moure, 1996 (26%) and *El. nigrita* (21%) were the two dominant species.

Due to the relatively large contribution of site-1 in the total sampling, *Eg. truncata* represented 48% of all the orchid bees captured at RPPN Caraça.

One-half of the total specimens were collected from September to December 1999 (Tab. 2). The peak in activity of male orchid bees at RPPN Caraça was recorded in November. No bees were collected in April 2000 and only two specimens (both *El. nigrita*) were collected in March.

Only two species were collected in sufficient numbers (>20 specimens) to consider further: *Eg. truncata* and *El. nigrita*. All 113 *Euglossa truncata* males captured at RPPN Caraça were attracted to eugenol. *Eulaema nigrita* was predominantly attracted to cineole (52 out of 57 specimens). The remaining five specimens of *El. nigrita* were attracted to vanillin.

The daily peak of activity of *El. nigrita* was recorded between 1200 and 1300 h (Tab.3), whereas most *Eg. truncata* were collected between 1100 and 1200 h (Tab.4).

**Table 1.** Total number of specimens of each orchid bee species collected at each site at Reserva Particular do Patrimônio Natural da Serra do Caraça from May 1999 to April 2000.

Species	Site 1 850 m	Site 2 1,200 m	Site 3 1,350 m	Total
<i>Eufriesea violacea</i> (Blanchard, 1840)	03	00	00	03
<i>Euglossa fimbriata</i> Rebêlo & Moure, 1996	08	01	05	14
<i>Eg. leucotricha</i> Rebêlo & Moure, 1996	00	01	02	03
<i>Eg. melanotricha</i> Moure, 1967	04	02	02	08
<i>Eg. securigera</i> Dressler, 1982	14	01	01	16
<i>Eg. stellfeldi</i> Moure, 1947	00	08	02	10
<i>Eg. truncata</i> Rebêlo & Moure, 1996	102	08	03	113
<i>Eulaema marcii</i> Nemésio, 2009	08	02	00	10
<i>El. nigrita</i> Lepeletier, 1841	36	17	04	57
<b>Total (No. ind.)</b>	<b>175</b>	<b>40</b>	<b>19</b>	<b>234</b>

**Table 2.** Number of specimens of each orchid bee species collected at Reserva Particular do Patrimônio Natural da Serra do Caraça from May 1999 to April 2000.

	M	J	J	A	S	O	N	D	J	F	M	A	T
<i>Ef. violacea</i>	-	-	-	-	-	2	1	-	-	-	-	-	3
<i>Eg. fimbriata</i>	7	-	1	-	1	2	-	2	-	1	-	-	14
<i>Eg. leucotricha</i>	-	-	2	1	-	-	-	-	-	-	-	-	3
<i>Eg. melanotricha</i>	-	-	2	-	-	1	3	1	-	1	-	-	8
<i>Eg. securigera</i>	1	-	4	2	-	3	4	1	-	1	-	-	16
<i>Eg. stellfeldi</i>	1	-	1	-	-	-	3	1	-	4	-	-	10
<i>Eg. truncata</i>	21	9	4	8	10	13	23	11	2	12	-	-	113
<i>El. marcii</i>	3	-	-	-	-	4	-	-	2	1	-	-	10
<i>El. nigrita</i>	3	1	6	2	2	13	8	8	4	8	2	-	57
<b>Total (No. ind.)</b>	<b>36</b>	<b>10</b>	<b>19</b>	<b>13</b>	<b>13</b>	<b>38</b>	<b>42</b>	<b>24</b>	<b>8</b>	<b>28</b>	<b>2</b>	<b>-</b>	<b>234</b>

**Table 3.** Daily fluctuation of the population of *Eulaema nigrita* Lepeletier, 1841 (in number of specimens) at Reserva Particular do Patrimônio Natural da Serra do Caraça from May 1999 to April 2000.

Time of day (h)	M	J	J	A	S	O	N	D	J	F	M	A	T
10-11	-	-	-	-	-	2	-	2	-	3	-	-	7
11-12	1	-	2	-	-	3	4	2	-	-	-	-	12
12-13	1	-	2	2	1	1	2	2	2	1	1	-	15
13-14	1	-	-	-	-	3	1	2	1	4	-	-	12
14-15	-	1	2	-	-	2	1	-	-	-	1	-	7
15-16	-	-	-	-	1	2	-	-	1	-	-	-	4
<b>Total</b>	<b>3</b>	<b>1</b>	<b>6</b>	<b>2</b>	<b>2</b>	<b>13</b>	<b>8</b>	<b>8</b>	<b>4</b>	<b>8</b>	<b>2</b>	<b>-</b>	<b>57</b>

**Table 4.** Daily fluctuation of the population of *Euglossa truncata* Rebêlo & Moure, 1996 (in number of specimens) at Reserva Particular do Patrimônio Natural da Serra do Caraça from May 1999 to April 2000.

Time of day (h)	M	J	J	A	S	O	N	D	J	F	M	A	T
10-11	1	2	-	1	-	-	-	1	-	2	-	-	7
11-12	5	-	-	1	2	5	5	4	1	4	-	-	27
12-13	8	-	2	4	1	-	5	-	-	1	-	-	21
13-14	3	3	-	2	1	4	8	-	-	2	-	-	23
14-15	2	3	1	-	4	4	4	3	1	2	-	-	24
15-16	2	1	1	-	2	-	1	3	-	1	-	-	11
<b>Total</b>	<b>21</b>	<b>9</b>	<b>4</b>	<b>8</b>	<b>10</b>	<b>13</b>	<b>23</b>	<b>11</b>	<b>2</b>	<b>12</b>	<b>-</b>	<b>-</b>	<b>113</b>

## DISCUSSION

### Effects of elevation on the orchid bee fauna

The first noticeable feature of these sampled sites at relatively high elevation is the low number of specimens collected. In other studies carried out simultaneously (from 1999 to 2000) in other areas in the state of Minas Gerais (NEMÉSIO & SILVEIRA, 2006; NEMÉSIO & SILVEIRA, unpub. data), the number of captured specimens was much higher than in the present study. One study carried out at two sites on a single day in August 1999 at RPPN Feliciano Miguel Abdala, in Caratinga, Minas Gerais (NEMÉSIO, 2003), recorded 122 orchid bee individuals from 1000 to 1500 h, in an area (957 ha) ten times smaller than that sampled in the present study. It should be stressed that three sites were sampled every month during one year from 1000 to 1600 h, representing a sampling effort of 216 hours. The total number of captured bees (234) roughly results in one bee caught per sampled hour, a very low abundance.

These data show that the general pattern of reduced abundance at higher altitudes is true for orchid bees and is reinforced by the dramatic reduction in abundance from site-1, located at 850 m, relative to the next elevation, at 1,200 m. Abundance was almost 10 times greater at site-1 than at site-3, at 1,350 m. Since the samplings were carried out simultaneously each month, it is not possible to argue abiotic factors such as temperature or humidity variation from day to day to explain this huge variation. The tendency here observed agrees with that recorded by SILVEIRA & CURE (1993), but that study had a broad focus on various groups of bees, and did not compare different gradients. Nonetheless, no faunistic impoverishment was observed to be related to altitudinal elevation.

Interestingly, site-1 was not the most diverse and there were species collected in both sites situated at the highest altitudes (*Euglossa stellfeldti* Moure, 1947 and *Euglossa leucotricha* Rebêlo & Moure, 1996) which were not recorded at site-1. Due to

the low number of bees, however, no generalizations can be made regarding diversity. Both *Eg. stellfeldi* and *Eg. leucotricha*, however, were collected in forest fragments in the nearby Belo Horizonte city, some 60 km far from RPPN Caraça, in elevations similar to that of site-1 [NEMÉSIO & SILVEIRA, 2007 – *Eg. stellfeldi* listed as *Eg. annectans* Dressler, 1982, a junior synonym (see NEMÉSIO, 2009)]. ROUBIK & ACKERMAN (1987) sampled the orchid bee fauna of three sites at different altitudes (150, 500, and 900 m above sea level) in Central America and found no significant differences in species diversity. Nevertheless, in that study the site situated at the highest altitude was roughly at the same elevation of the lowest site in the present study and changes in the faunal composition are expected to occur more sharply above 1,000 m. The results of the present study contradict those obtained by UEHARA-PRADO & GARÓFALO (2006), in which most males of *Eufriesea violacea* were caught at the two highest sites. Two comments are important here: (i) the elevation range in UEHARA-PRADO & GARÓFALO'S (2006) study was smaller (700 to 1,100 m) than that of the present study, the highest site of their study being below the second highest elevation of the present study (1,200 m); (ii) only one species was examined in their study. This is an important consideration since some orchid bee species seem to be associated with higher elevations, as apparently is the case for *Euglossa stellfeldi*. This species is not found in southeastern Brazil in altitudes below 500 m, but it is common above 850 m. On the other hand, it occurs at sea level in coastal states of Paraná and Santa Catarina, which lay at higher latitudes. Although UEHARA-PRADO & GARÓFALO (2006) did not consider this possibility, it should be stressed that *Eufriesea violacea* is extremely common in southern Brazil (see WITTMANN *et al.*, 1988 and SOFIA & SUZUKI, 2004) and its occurrence in the northeastern state of São Paulo at higher altitudes would be expected if this species follows the general pattern here reported for *Euglossa stellfeldi* and reported for other bee species by SILVEIRA & CURE (1993). Thus, it would not be adequate to use the data for such a species to predict the general pattern for orchid bees.

#### Species composition.

The nine species here recorded are also present in forest fragments in the Belo Horizonte city region (NEMÉSIO & SILVEIRA, 2007), except for *Eufriesea violacea* (Blanchard, 1840), which, in turn, was already recorded in the Viçosa region (see PERUQUETTI *et al.*, 1999). *Eufriesea nigrohirta* (Friese, 1899) (two specimens of this species from RPPN Caraça are deposited at Museu de Zoologia of Universidade de São Paulo, São Paulo) and *Eufriesea auriceps* (Friese, 1899) (a few specimens of this species from RPPN Caraça are deposited at Museu Nacional, Rio de Janeiro), although known to occur at RPPN Caraça, were not recorded in the present study. Thus, eleven species are known to occur at this area. Details about the current known distribution of the species recorded at RPPN Caraça are given in NEMÉSIO & FARIA Jr. (2004), NEMÉSIO & SILVEIRA (2007) and NEMÉSIO (2009). Data on their taxonomy and biology are summarized in NEMÉSIO (2009).

#### Attractivity to chemical baits

The two most common species, *Eg. truncata* and *El. nigrita*, represented 73% of all collected bees. Thus, the chemical baits preferred by these species were naturally the most attractive in this study. All 113 *Eg. truncata* specimens were attracted to eugenol, as were some *Euglossa melanotricha* Moure, 1967, *Eg. fimbriata*, *Euglossa securigera* Dressler, 1982 and *Eulaema marcii* Nemésio, 2009. This latter species was also attracted to vanillin and benzyl-acetate. Cineole was the preferred bait by *El. nigrita*, which also visited vanillin. Only four individuals of *Eg. securigera* were attracted to methyl *trans*-cinnamate. The high fidelity of *Eg. truncata* to eugenol in the present study is remarkable. In other studies in southeastern Brazil, this species was already found to be an "eugenol bee" (e. g. REBÉLO & GARÓFALO, 1991, 1997) but, contrary to the current study, in which 100% of the specimens were attracted to eugenol, in those studies a few individuals were also attracted to cineole. The same occurred in several samplings in Belo Horizonte (NEMÉSIO & SILVEIRA, unpublished data). In contrast, in the state of Maranhão, northeastern Brazil, *Eg. truncata* was

heavily attracted to cineole, and a few individuals were attracted to eugenol, vanillin, and methyl salicylate (SILVA & REBÊLO, 1999). I had the opportunity to study these *Eg. truncata* from Maranhão, through the kindness of Dr. J. M. M. Rebêlo, who sent me some specimens, and reached the conclusion they are not *Eg. truncata*, but *Eg. amazonica* Dressler, 1982.

#### Seasonal fluctuation of orchid bees

Orchid bees are more abundant in the hot and rainy season, which in the Atlantic Forest domain varies from October to March or April (e.g. REBÊLO & GARÓFALO, 1991, 1997; TONHASCA JR. *et al.*, 2002; SOFIA & SUZUKI, 2004; SOFIA *et al.*, 2004; NEMÉSIO & SILVEIRA, 2006, 2007). In the present study, however, there was a marked decrease in abundance from December on. The same phenomenon was observed in the same season at Parque Estadual do Rio Doce (NEMÉSIO & SILVEIRA, 2006) and in forest fragments in the Belo Horizonte city region (unpub. data). Although regarded as having remarkably stable populations (ROUBIK & ACKERMAN, 1987), orchid bees may respond to unpredictable climatic changes that affect their distributions from year to year.

#### Daily patterns of collecting with aromatic scents

Most data available in the literature concerning daily patterns of visits by male orchid bees to chemical baits refers to studies in low latitudes (e.g. OLIVEIRA & CAMPOS, 1996). Few data are available for higher latitudes (e.g. REBÊLO & GARÓFALO, 1991; SANTOS & SOFIA, 2002). In the present study, the two species with populations large enough to be studied, *Eg. truncata* (n = 113) and *El. nigrita* (n = 57), presented a pattern of daily activity very similar to those found for orchid bees in the northern portion of Paraná, in southern Brazil (Santos & Sofia, 2002). *Euglossa truncata* showed a more erratic pattern, with a peak between 1100 and 1200 h and another one between 1400 and 1500 h. *Eulaema nigrita* showed a more uniform pattern, with only one peak between 1200 and 1300 h. The present results, merged with those presented by SANTOS & SOFIA (2002), show that activity peak in higher latitudes is quite different from those observed in lower latitudes, where activity peaks occurred in the morning.

#### ACKNOWLEDGMENTS

I thank the administration of Reserva Particular do Patrimônio Natural da Serra do Caraça for allowing me to sample the area. I also thank A. G. Damasceno and R. Scholte, who helped with field work, and Dr. Fernando A. Silveira for his support and guidance. Dr. Jacquelyn L. Blackmer kindly read the first draft of this manuscript and made valuable comments, both concerning its scientific contents and its English. Dr. Miguel A. Monné and Dr. Sandor C. Buys allowed me to visit the orchid bee collection currently deposited at Museu Nacional, where I found some specimens of *Eufriesea auriceps*. Dr. Carlos Roberto F. Brandão and M. Sc. Rodrigo B. Gonçalves made the specimens of *Eufriesea nigrohirta* deposited at Museu de Zoologia of USP available to me. Dr. José Manuel M. Rebêlo sent me some specimens of *Euglossa* from Maranhão, which were very helpful. These specimens are currently deposited at the Taxonomic Collections of the Universidade Federal de Minas Gerais. This study was partly supported by the Brazilian Ministry of the Environment and CNPq, through PROBIO (process #380678/1999-3), which also provided me with support through a fellowship.

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Recebido: 09/02/2007  
Revisado: 12/12/2007  
Aceito: 25/04/2008