Community of orchid bees (Hymenoptera: Apidae) in transitional vegetation between Cerrado and Atlantic Forest in southeastern Brazil

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Abstract

The community of orchid bees (Hymenoptera: Apidae: Euglossina) was studied at an area in the transition between the Cerrado and Atlantic Forest biomes, from March, 2010 to February, 2011 in the Barroso region, state of Minas Gerais, eastern Brazil. Orchid-bee males were collected with bait traps containing three different scents (cineole, eugenol and vanillin) and with entomological nets for collecting bees on flowers. A total of 614 orchid-bee males were collected using aromatic traps, belonging to four genera and 15 species. Twenty-five female specimens belonging to two genera and at least three species were collected on flowers. *Eulaema* (*Apeulaema*) *nigrita* Lepeletier, 1841 was the most abundant species (50% of collected specimens), followed by *Euglossa* (*Euglossa*) *truncata* Rebêlo & Moure, 1996 (28%). Cineole was the most attractive compound (66.5% of males and 13 species), followed by eugenol (16% and 9 species) and vanillin (13.5% and 4 species). *Eulaema* (*Apeulaema*) *marcii* Nemésio, 2009 and *Eufriesea auriceps* (Friese, 1899) were attracted to all scents, whereas *Euglossa* species were collected only in cineole and eugenol.

Keywords: Apoidea, Atlantic Forest, Cerrado, Hexapoda, Inventory.

Comunidade de Euglossina (Hymenoptera: Apidae) em área de transição entre Cerrado e Mata Atlântica no sudeste do Brasil

Resumo

A comunidade de abelhas-das-orquídeas (Hymenoptera: Apidae: Euglossina) foi estudada em uma área de transição entre o Cerrado e a Mata Atlântica, de março de 2010 a fevereiro de 2011, na região de Barroso, estado de Minas Gerais, sudeste do Brasil. Foram utilizadas armadilhas aromáticas utilizando-se três tipos de iscas (cineol, eugenol e vanilina) e redes entomológicas para a captura de abelhas em flores. Foram coletados 614 machos de Euglossina nas armadilhas aromáticas, pertencentes a quatro gêneros e quinze espécies, e vinte e cinco espécimes em flores, pertencentes a dois gêneros e três espécies. *Eulaema* (*Apeulaema*) *nigrita* Lepeletier, 1841 foi a espécie mais comum (50% dos espécimes coletados), seguida por *Euglossa* (*Euglossa*) *truncata* Rebêlo & Moure, 1996 (28%). O cineol foi a isca mais atrativa (66,5% dos machos e 13 espécies), seguido pelo eugenol (16% e 9 espécies) e vanilina (13,5% e 4 espécies). *Eulaema* (*Apeulaema*) *marcii* Nemésio, 2009 e *Eufriesea auriceps* (Friese, 1899) foram atraídas por todas as essências, enquanto as espécies de *Euglossa* foram coletadas somente em armadilhas contendo cineol ou eugenol.

Palavras-chave: Apoidea, Cerrado, Hexapoda, inventário, Mata Atlântica.

1. Introduction

The distribution of orchid bees (Hymenoptera: Apidae: Euglossina) is restricted to the Neotropics, occurring from northern Argentina to southern United States (Dodson et al., 1969, Dressler, 1982a; Michener, 2000). They can be found in different biomes, but they are most diverse and abundant in humid forests (Dressler, 1982a; Kimsey, 1982; Ackerman, 1983; Roubik and Hanson, 2004). They comprise more than 200 described species, distributed into five genera (Nemésio and Rasmussen, 2011), two of which are exclusively cleptoparasites (revision in Nemésio and Silveira, 2006a). Peculiar characteristics of orchid bees include metallic colors, long glossa and, in males, metatibiae specialized in collecting and storing aromatic substances (Dressler, 1982a). These insects are able to fly long distances in search for resources, making them key pollinators in Neotropical ecosystems (Janzen, 1971).

Orchid-bee males collect aromatic substances produced by certain plant families, especially Orchidaceae, but also some species of Amaryllidaceae, Araceae, Gesneriaceae, Apocynaceae, Solanaceae, Bignoniaceae, Euphorbiaceae, Haemodoraceae, Iridaceae and Theaceae (Dressler, 1982a; Ramírez et al., 2002). The function of these compounds in their biology is still little known (Eltz et al., 1999), though some authors have related them to reproductive activity (Dressler, 1982a; Peruquetti et al., 1999; Silveira et al., 2002).

The collection of information on the relationships between orchid-bee males and the several different species of Orchidaceae led to the discovery of a series of organic compounds that are highly attractive to these bees (Vogel, 1966; Dodson et al., 1969). After the chemical synthesis of these substances as "baits", assessment studies have been carried out on males of these species in order to obtain data on: diversity and abundance (e.g. Nemésio and Silveira, 2006b, 2007a, 2010), stratification (e.g. Oliveira and Campos, 1996; Martins and Souza, 2005), period of activity (e.g. Santos and Sofia, 2002), fragmentation effect (e.g. Powell and Powell, 1987; Tonhasca et al., 2002, 2003; Sofia and Suzuki, 2004), taxonomic studies (e.g. Dressler, 1982b, c, d; Kimsey, 1982; Nemésio, 2007, 2009, 2010a) and biogeographic distribution (e.g. Nemésio and Silveira, 2007b; Rasmussen, 2009; Nemésio, 2010a, b, 2011a, b, 2013a-d; Nemésio and Vasconcelos, 2013).

Although some studies have been carried out in the state of Minas Gerais in areas of Cerrado (Nemésio and Faria Jr., 2004; Alvarenga et al., 2007), Atlantic Forest (Peruquetti et al., 1999; Nemésio, 2003; Nemésio and Silveira, 2006b) and in remnants of semideciduous vegetation (Nemésio and Silveira, 2007a, 2010; Nemésio, 2008), the knowledge on this group is still incipient in many areas of Minas Gerais, particularly its southern portion.

As such, the main goal of the present study was to inventory for the first time the orchid-bee community in transition areas between the Cerrado and Atlantic Forest biomes in the Campo das Vertentes region, state of Minas Gerais, Brazil, in order to provide information on the geographic distribution of orchid bees at the area.

2. Material and Methods

2.1. Study area

The research was carried out in transition areas between the Cerrado and Atlantic Forest in the region known as Mata do Baú (21°12'24" S; 43°55'44" W), a 400-ha private area, located in the municipality of Barroso, state of Minas Gerais, Brazil. This region is located in an area featuring semideciduous seasonal forest, riparian vegetation and savanna-like fields, which are undergoing anthropic interventions related to economic cycles of mining, agriculture, cattle raising, industry, and in the past were affected by logging in order to feed lime kilns (Menini-Neto et al., 2004; Souza, 2006). The climate in the region is classified as Cwb - mesothermic with well-defined seasons (Oliveira-Filho and Machado, 1993). The mean annual temperature ranges from 13.1 °C to 23.7 °C; mean annual rainfall is 1,390 mm, varying from 800 mm to 1,900 mm. Elevations range from 900 m (Rio das Mortes) to 1,200 m above sea level (Morro Boa Vista) (Menini-Neto et al., 2004).

2.2. Sampling

The collections of orchid-bee males were carried out using traps, according to the method described by Campos et al. (1989) with changes proposed by Morgado (2006). The compounds used to attract orchid-bee males were: cineole, eugenol and vanillin. These scents have been cited as efficient in collecting orchid-bee males in Minas Gerais (Peruquetti et al., 1999; Nemésio and Faria Jr., 2004; Alvarenga et al., 2007). Samplings were carried out every other week, from March, 2010 to February, 2011, from 09:00 h to 16:00 h, totaling a sampling effort of 168 collection hours per trap.

Nine traps were used, with three replications for each aromatic compound, arranged linearly and interspersed, eight meters from one another, and fixed in the vegetation about two meters above the soil. The baits were inspected every hour, when the trapped bees were removed and the scents were refilled. Collected bees were killed in ethyl acetate and pinned for posterior identification, and deposited in the Laboratório de Taxonomia de Abelhas, Universidade Federal de Uberlândia (UFU).

Concomitantly to the collections using aromatic traps, orchid bees were sampled in the field, using entomological nets, in accordance with the methodology described by Sakagami et al. (1967), which basically consists of capturing bees on flowers or in flight, but with some modifications with regard to time (from four to seven hours) and the interval between each collection (from weekly to every other week).

2.3. Data analysis

In order to calculate the total diversity of the study area and between aromatic compounds, the Shannon-Wiener index (H') was calculated (Magurran, 2004). In order to better interpret the results of the diversity index, the equitability index (J') was used as well (Pieolu, 1975). The comparison of the orchid-bee fauna collected in Minas Gerais state was done by grouping analysis (UPGMA) using the Bray-Curtis distance coefficient.

Only species identified to species level were used in the similarity analysis. Species listed only as "sp." in Nemésio and Silveira (2006b, 2007a) and in the present study were not included in the analysis. Peruquetti et al. (1999) sampled two different areas, the region of Viçosa and the Parque Estadual do Rio Doce (PERD). Nevertheless, Nemésio and Silveira (2006b) carried out a more extensive orchid-bee sampling in the latter area some years later and we here used the data from Nemésio and Silveira (2006b) for PERD. Thus, only the data for Viçosa were here used from Peruquetti et al. (1999). All the sites

used in the current analysis are indicated in the captions of Figure 1.

2.4. Taxonomy

Taxonomy follows Nemésio and Rasmussen (2011). Species listed as *Eulaema cingulata* (Fabricius, 1804), *Euglossa (Euglossa) cordata* (Linnaeus, 1758) and *Euglossa townsendi* Cockerell, 1904 in previous studies in Minas Gerais are here treated as *Eulaema* (*Apeulaema*) *marcii* Nemésio, 2009, *Euglossa* (*Euglossa*) *carolina* Nemésio, 2009 and *Euglossa* (*Euglossa*) *aratingae* Nemésio, 2009, respectively, following Nemésio (2009) and Nemésio and Rasmussen (2011).

3. Results

A total of 639 specimens belonging to 15 species in four genera (Table 1) were collected, 614 of them attracted to chemical bait traps, and 25 on flowers (Table 1). Cineole attracted the largest number of individuals and species (429 specimens and 13 species), followed by eugenol (104 specimens and nine species) and vanillin (87 specimens and four species). *Eulaema marcii* and *Eufriesea auriceps* were attracted by all three compounds, whereas *Euglossa* species were collected only in cineole and eugenol (Table 1).

Eulaema nigrita was the most abundant species (50.5% of the specimens), followed by *Eg. truncata* (28%). The remaining species combined accounted for only 21.5% of the collected specimens. Twenty-five female specimens were actively collected on flowers. Sixteen of them belonged to *El. nigrita*, eight to *Euglossa* sp., and one specimen belonged to *El. seabrai* Moure, 1960.

The diversity and equitability indices, in both collection methods - traps and entomological nets - were H' = 1.54 and J = 0.57. However, considering only collections using traps, the indices obtained were H' = 1.48 and J = 0.58, respectively. Among the compounds used, the highest H' value was obtained for cineole (H' = 1.34) and the lowest for vanillin (H' = 0.84). With regard to equitability, the highest value was recorded for vanillin (J = 0.60) and the lowest for cineole (J = 0.52).

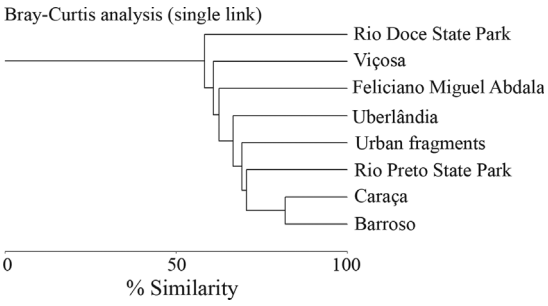

Figure 1 - Similarity among the faunas of orchid-bee males from eight studied areas in Minas Gerais, eastern Brazil. Data retrieved from the regions of Viçosa (Peruquetti et al., 1999), "RPPN Feliciano Miguel Abdala" (Nemésio, 2003), Rio Preto State Park (Nemésio and Faria Jr., 2004), Rio Doce State Park (Nemésio and Silveira, 2006b), Uberlândia (Alvarenga et al., 2007), urban fragments in Belo Horizonte (Nemésio and Silveira, 2007a), Serra do Caraça (Nemésio, 2008) and Barroso (this study).

Based on the similarity analysis among the orchid-bee faunas of different assessments carried out in Minas Gerais, it was possible to observe the formation of two groups - one formed by the region of 'Parque Estadual do Rio Doce' (Nemésio and Silveira, 2006b), and another one by the other areas (Figure 1). The greatest similarity was observed in the composition of species in Barroso (this study) and Caraça (Nemésio, 2008), with nearly 82% similarity (Figure 1).

4. Discussion

The composition of the orchid-bee community in transitional forest areas in the municipality of Barroso is similar to other assessments of orchid bees in the Neotropical region, with most species represented by low numbers of individuals, whereas few species are dominant (Oliveira and Campos, 1995; Rebêlo and Garófalo, 1997; Nemésio and Faria Jr., 2004; Sofia et al., 2004; Nemésio and Silveira, 2006, 2007a; Alvarenga et al., 2007; Aguiar and Gaglianone, 2008; Silveira et al., 2011), with prevalence of species with wide distribution in the Atlantic Forest (Nemésio, 2009). All species here collected were listed by Nemésio (2009) in areas regarded as Atlantic Forest in the state of Minas Gerais.

Orchid-bee richness in this work was higher using aromatic traps, when compared to other assessments performed in Brazil (Rebêlo and Garófalo, 1997; Santos and Sofia, 2002; Nemésio, 2003; Sofia et al., 2004; Nemésio and Faria Jr., 2004; Martins and Souza, 2005; Alvarenga et al., 2007; Farias et al., 2008). Nevertheless, this comparison must be analyzed with caution, as any variation in sample effort, collector skills and the very local floristic structure can be significant with regard to richness and diversity of collected species (Nemésio, 2012).

Eulaema nigrita, a widely distributed species, was the most abundant in this study, as in other studies in the Atlantic Forest and Cerrado domains (Neves and Viana, 1997; Peruquetti et al., 1999; Bezerra and Martins, 2001; Tonhasca et al., 2002, Alvarenga et al., 2007; Nemésio and Silveira, 2007a). According to Morato (1998), Tonhasca Jr. et al. (2002) and Nemésio and Silveira, 2006b), this species can be considered a bioindicator of disturbed areas (*contra* Bezerra and Martins, 2001). If this hypothesis is correct, our data show that the sampled areas should be considered as open or disturbed areas, at least concerning orchid-bee preferences. The group Caraça-Barroso (see Figure 1) was then successively grouped to other areas characterized by open vegetation (Cerrado) or smaller forest remnants. The large Parque Estadual do Rio Doce (36,000 ha) shared only about 53% similarity with all the remaining areas, reinforcing its distinctness within the orchid-bee fauna of Minas Gerais (see Nemésio and Silveira, 2006b).

Table 1 - List of Euglossini species captured with eugenol (Eu), cineole (Ci), vanillin (Va) and on flowers (Fl) from February, 2010 to March, 2011 at Mata do Baú, Barroso, Minas Gerais.

Species	Eu	Ci	Va	Fl	Total
Eufriesea auriceps (Friese, 1899)	4	8	7	-	19
Eufriesea dentilabris (Mocsáry, 1896)	-	1	-	-	1
Eufriesea violacea (Blanchard, 1840)	-	13	6	-	19
Euglossa (*Euglossa*) *aratingae* Nemésio, 2009	-	5	-	-	5
Euglossa (*Euglossa*) *carolina* Nemésio, 2009	3	2	-	-	5
Euglossa (*Euglossa*) *fimbriata* Moure, 1968	5	8	-	-	13
Euglossa (*Euglossa*) *leucotricha* Rebêlo & Moure, 1996	3	1	-	-	4
Euglossa (*Euglossa*) *securigera* Dressler, 1982d	6	3	-	-	9
Euglossa (*Euglossa*) *truncata* Rebêlo & Moure, 1996	67	112	-	-	179
Euglossa sp. (female)	-	-	-	8	8
Euglossa (*Glossura*) *stellfeldi* Moure, 1947	7	11	-	-	18
Eulaema (*Eulaema*) *seabrai* Moure, 1960	-	-	-	1	1
Eulaema (*Apeulaema*) *marcii* Nemésio, 2009	1	17	9	-	27
Eulaema (*Apeulaema*) *nigrita* Lepeletier, 1841	-	242	65	16	323
Exaerete smaragdina (Guérin-Méneville, 1844)	3	5	-	-	8
Total individuals	99	428	87	25	639
Total species	9	13	4	3	15

Cineole was the most attractive compound; this result corroborates those found by almost all previous authors (Ackerman, 1983; Rebêlo and Garófalo, 1991; Morato et al., 1992; Rebêlo and Cabral, 1997; Rebêlo and Garófalo, 1997; Alvarenga et al., 2007; Mendes et al., 2008; Storck-Tonon et al., 2009), reinforcing the importance of its use in orchid-bee inventories. Although the use of aromatic compounds to collect orchid bees proved to be efficient in several studies, the use of more than one sampling method, such as active flower search or nest traps can increase sampling efficiency, as data obtained through one method can complement those obtained through another (Rebêlo and Garófalo, 1997; Nemésio, 2012).

It is important to highlight the record in this study of a female specimen of *Eulaema seabrai* captured on flower, representing the second record of that species in Minas Gerais (see Nemésio and Silveira, 2004) and reinforcing the importance of multiple sampling methods to better inventory orchid-bee faunas.

The similarity among areas reflects the relative abundances of their shared species. The highest similarity values were found in the semideciduous forest areas at 'Serra do Caraça' (Nemésio, 2008) and the region between the Cerrado and Atlantic Forest (present study), with 82% of similarity. This can be explained by the somewhat similar vegetation structure of both areas, or even by the geographical proximity between them, as well as historical and biogeographic factors. According to Bezerra and Martins (2001), it is expected that orchid-bee communities are similar in neighboring geographic regions, with similar climate, vegetation and topography.

Although the use of traps proved efficient in attracting orchid-bee males, the limitation of this method should be emphasized when compared to active collection with entomological nets. Nemésio and Morato (2004, 2006), during studies in the Amazon region, demonstrated that there could be a bias in collections using traps, as specimens of smaller species (particularly of *Euglossa* spp.) tend to escape more easily than larger bees, resulting in a higher rate of specimens of *Eulaema* spp. Recently, Mattozo et al. (2011) confirmed Nemésio and Morato's (2004, 2006) hypothesis in areas of Atlantic Forest. Future studies adding other aromatic compounds and methodology variations may contribute to better detail our understanding of the diversity of orchid bees in the region.

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