The orchid-bee faunas (Hymenoptera: Apidae) of 'Parque Nacional do Monte Pascoal', 'Parque Nacional do Descobrimento' and three other Atlantic Forest remnants in southern Bahia, eastern Brazil

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Abstract

The orchid-bee faunas of 'Parque Nacional do Monte Pascoal', 'Parque Nacional do Descobrimento' and three other Atlantic Forest remnants ranging from 1 to 300 ha in southern Bahia, eastern Brazil, were surveyed. Baits with seventeen different scents were used to attract orchid-bee males. Four thousand seven hundred and sixty-four males belonging to 36 species were actively collected with insect nets during 300 hours from November, 2008 to November, 2009. Richness and diversity of orchid bees found in this study are the highest ever recorded in the Atlantic Forest domain. *Eufriesea dentilabris* (Mocsáry, 1897) and *Eufriesea violacea* (Blanchard, 1840) were collected at the 'Parque Nacional do Monte Pascoal', the first record of these species for the state of Bahia and the northernmost record for both species. Females *Exaerete dentata* (Linnaeus, 1758) were also collected at 'Parque Nacional do Monte Pascoal' and old records of *Eufriesea aeneiventris* (Mocsáry, 1896) in this area makes this site the richest and most diverse concerning its orchid-bee fauna in the entire Atlantic Forest and similar to areas in the Amazon Basin.

Keywords: Atlantic Forest, conservation, Euglossina, euglossine bees, Hexapoda.

A fauna de abelhas-das-orquídeas (Hymenoptera: Apidae) do Parque Nacional do Monte Pascoal, do Parque Nacional do Descobrimento e de três outros remanescentes de Mata Atlântica no sul da Bahia, leste do Brasil

Resumo

As faunas de abelhas-das-orquídeas do Parque Nacional do Monte Pascoal, do Parque Nacional do Descobrimento e de três outros fragmentos de Mata Atlântica, com áreas de um a trezentos hectares, foram amostradas no sul da Bahia, leste do Brasil. Iscas com 17 diferentes fragrâncias atrativas a machos de abelhas-das-orquídeas foram utilizadas. Um total de 4.764 machos, pertencentes a 36 espécies, foram ativamente coletados com o auxílio de redes entomológicas durante 300 horas, entre novembro de 2008 e novembro de 2009. A riqueza e a diversidade de abelhas euglossinas encontradas no presente estudo são as mais altas já registradas em todo o domínio da Mata Atlântica. *Eufriesea dentilabris* (Mocsáry, 1897) e *Eufriesea violacea* (Blanchard, 1840) foram coletadas no Parque Nacional do Monte Pascoal, sendo estes os primeiros registros dessas espécies no Estado da Bahia e também o registro mais ao norte conhecido para ambas. Fêmeas de *Exaerete dentata* (Linnaeus, 1758) também foram coletadas no Parque Nacional do Monte Pascoal e antigos registros de *Eufriesea aeneiventris* (Mocsáry, 1896) neste sítio fazem deste Parque a área com a maior riqueza e a maior diversidade de abelhas euglossinas de toda a Mata Atlântica, mostrando-se similar a áreas da Bacia Amazônica.

Palavras-chave: Mata Atlântica, conservação, Euglossina, abelhas euglossinas, Hexapoda.

1. Introduction

Orchid bees (Hymenoptera: Apidae: Euglossina) are important pollinators in Neotropical forests (reviewed by Dressler, 1982a) and consequently key organisms in ecosystems where they live. These bees became a favourite in ecological studies (e.g. Nemésio and Silveira, 2006b, 2007a, 2010; Rasmussen, 2009; Abrahamczyk et al., 2011) due to the ease of collecting their males, which are heavily attracted to synthetic aromatic compounds that mimic natural floral fragrances (Vogel, 1966; Dodson et al., 1969).

Studies involving orchid bees in the Brazilian Atlantic Forest, one of the earth's biological "hotspots" (Myers, 1988; Mittermeier et al., 1999; Galindo-Leal and Câmara,

2003), only began some twenty years after similar studies in Central America and in the Amazon Basin (e.g. Raw, 1989; Rebêlo and Garófalo, 1991, 1997). The region of the southern state of Bahia, the portion of the Atlantic Forest with the highest levels of endemism for many taxonomic groups (e.g., Dean, 1995; Pacheco et al., 1996; Thomas et al., 1997, 1998; Sambuichi et al., 2008; Laurance, 2009), has only very recently received attention to its orchid-bee fauna (Melo, 2005; Nemésio, 2011a, 2012b, 2013a, c; Nemésio et al., 2012).

Approximately 60 orchid-bee species are known from the Atlantic Forest (Nemésio and Silveira, 2007b; Nemésio, 2009), which makes its orchid-bee fauna the least rich of the three largest Neotropical forest biomes (see Nemésio and Silveira, 2007b). Nonetheless, the region of southern Bahia, also known as 'Hileia Baiana', has been shown to hold more than half of the entire Atlantic Forest orchid-bee richness, and some areas, such as the 'Reserva Biológica de Una', with ca. 30 species (Nemésio, 2013a), can hold almost as many species as several Amazonian sites. Recent studies in southern Bahia have also found some new species (Moure, 1996; Nemésio, 2011c, d, 2012a; Nemésio and Engel, 2012) and some species previously unknown to occur at the area (Nemésio 2011a, e).

Organisms endemic in severely deforested biomes, as happens to be the case with the Atlantic Forest, are more prone to population declines and even to extinction (Collinge, 1996; Tocher et al., 1997). Concerning orchid bees, it has been suggested that some species with restricted geographic distributions within the Atlantic Forest domain may be severely affected by their habitat loss (Nemésio, 2009, 2010a, b, 2011b; Faria Junior and Melo, 2011; Nemésio et al., 2012). Thus, despite recent samplings in southern Bahia, more surveys are still needed to correctly assess the orchid-bee fauna of this region and accurately establish the geographic distributions of its species. This goal could not be achieved if the largest forest remnants of Atlantic Forest in the region were not surveyed.

The main goal of this study, thus, is to provide distributional and taxonomic data on the orchid bees of southern Bahia by surveying the two largest forest preserves at this region, the national parks of Monte Pascoal (22,383 ha) and Descobrimento (21,213 ha), and three forest remnants of different sizes (ranging from 1 to 300 ha) situated between both parks, for their orchid-bee faunas. Given the difference in size among the forest remnants, it was also tested how reduction in forest area affects richness and diversity of orchid bees.

2. Material and Methods

2.1. Study sites

This study was conducted in five forest remnants in the southern part of Bahia state: (i) 'Parque Nacional do Monte Pascoal' (PNMP), a 22,383-ha preserve situated in the municipality of Porto Seguro; (ii) 'Parque Nacional do Descobrimento' (PND), a 21,213-ha preserve situated in the municipality of Prado; and three forest patches situated in the municipality of Itamaraju, between Porto Seguro and Prado, with total areas of 1 ha (F1), 150 ha (F150) and 300 ha (F300) (see Figure 1). Most of PNMP still consists of pristine forest, since it is the oldest preserve in the region (established in 1961), but it has been severely impacted by the Pataxó Indians who invaded the area in 1999 and still live there, where they hunt (with fire guns) and cut down trees for wood; PND consists of secondary forests in various successional stages, since pastures and other crops happened to emerge in the area before the establishment of the preserve, in 1999, but pristine forested areas can also be found in the preserve, particularly at its northernmost and easternmost portions; F1 is a small forest area surrounded by a pasture matrix and only a few hundred metres from Itamaraju town, with strong anthropogenic pressures; F150 is a private area ('Fazenda Flor do Monte') surrounded by pastures and located some 20 km southwest of the PNMP; F300 is an area belonging to the Pataxó Indians who inhabit the region, also surrounded by pasture and other crops, about 10 km from PNMP and connected to other forest patches (Figure 1). The three forest patches F1, F150, and F300 consist mostly of secondary forests and are under severe anthropogenic impact. Collections were carried out from November, 2008 to November, 2009 at PNMP and F300, and from November, 2008 to January, 2009 at PND, F1 and F150. The vegetation of the region is essentially dense Atlantic Rain Forest [Central Lowland Forest according to Thomas and Carvalho (2003)]. Precipitation in the area is about 1,300 mm/year (Thomas and Carvalho, 2003).

2.2. Sampling

Twenty hours of active sampling with insect nets were performed in each of the selected sites in the areas. Collections were carried out at any time from 07:00h to 17:00h, in consecutive or non-consecutive days until 20 hours of collection were reached. Usually, it took two to three days to sample each site for 20 hours, but due to meteorological conditions, more than three days were necessary for some sites. Three sites were sampled at both PNMP and PND, and one site at F1, F150 and F300. At PNMP each site was sampled twice (once during the rainy season and once during the drier season) and at F300 the single site was sampled four times (twice during the rainy season, once at the beginning of the drier season and once at the end of the drier season), totalling 300 hours, following the methodology proposed by Nemésio (2010a, b, 2011a, b): PNMP site-1 (16° 53' 07" S and 39° 24' 47" W, ca. 136 m a.s.l.), PNMP site-2 (16° 52' 57" S and 39° 24' 39" W, ca. 100 m a.s.l.), and PNMP site-3 (16° 52' 41" S and 39° 24' 56" W, ca. 60 m a.s.l.) were sampled from November, 2008 to January, 2009, and again in April, October and November, 2009; PND site-1 (17° 07' 40" S and 39° 19' 11" W, ca. 50 m a.s.l.) and PND site-2 were sampled in late December, 2008; PND site-3 (17° 06' 12" S and 39° 17' 01" W, ca. 80 m a.s.l.) was sampled in early January, 2009; F1 (17° 01'25"S and 39° 31' 34" W, ca. 30 m a.s.l.) was sampled from late November to early December, 2008; F150 (16° 59' 57" S and 39° 33' 21" W, ca. 100 m a.s.l.) was sampled from late December, 2008, to early January, 2009; F300 (16° 54' 51" S and 39° 31' 17" W, ca. 25 m a.s.l.) was sampled twice from late November, 2008 to mid-January, 2009, then in April, 2009 and again in early

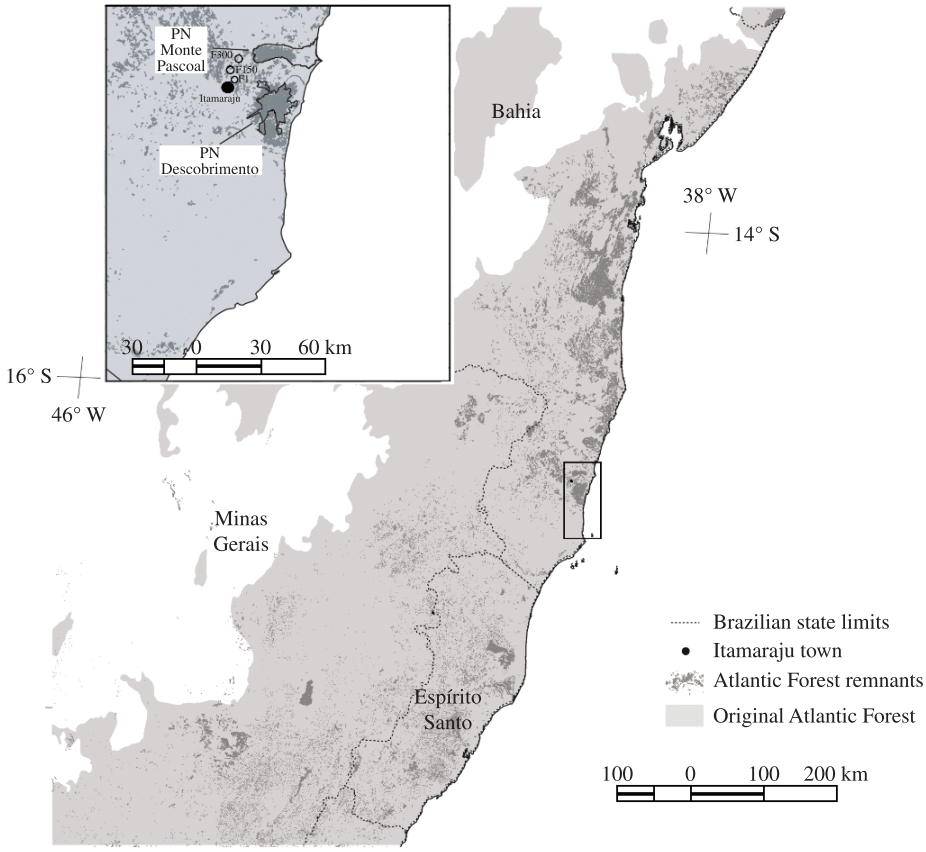

Figure 1. Map of southern state of Bahia showing the location of the five areas sampled in this study.

October and early November, 2009. At PNMP, sites 1 and 3 were located in areas with pristine, well developed forest, whereas site 2, for comparison, was located in an area in early to intermediate successional stage, close to the edge. At PND, sites 1 and 2 were located in areas with pristine forest, whereas site 3 was located in an area in early to intermediate successional stage. At each site, 17 scent baits were placed *ca.* 2.0 metres apart from each other at about 1.5 m above the ground. These baits were made of cotton wadding soaked with one of the following substances, known or believed to be attractive to orchid bees: benzyl acetate, benzyl alcohol, *r*-carvone, 1,8-cineole, *p*-cresol acetate, dimethoxybenzene, eugenol, β-ionone, methyl benzoate, methyl *trans*-cinnamate, heneicosane, methyl salicylate, skatole, tricosane, *p*-tolyl acetate, vanillin, and a mixture (1:1) of methyl *trans*-cinnamate and *p*-tolyl acetate. Baits with cineole, the most volatile compound, were recharged every hour. Bees arriving on the baits during the sampling period were collected with insect nets and killed with ethyl acetate. They were pinned and labelled as belonging to the project 'Euglossina da Hileia Baiana' and deposited at the Entomological Collection of the 'Universidade Federal de Minas Gerais' (UFMG).

2.3. Data analysis

Diversity was estimated through the Shannon-Wiener diversity index (H'), as $H' = - \Sigma p_i \ln (p_i)$, where p_i is the proportion of total number of species made up of the ith species (Pielou, 1975). Evenness (E) was estimated through the formula $E = H'/ \ln (S)$, where S is the species richness. Spearman rank correlation tests were used to estimate the effect of forest size (area in ha) on bee richness and diversity (sites within each area were grouped together). The similarity in faunistic composition among all five areas (sites within each area were combined together) was estimated by the percent similarity index of Renkonen, recommended by Wolda (1981) for small samples and strongly recommended by Balmer (2002) since it deals with relative abundances of species. Based on those similarities, the areas were grouped using UPGMA (Sneath and Sokal, 1973).

2.4. Taxonomy

Taxonomy follows Nemésio and Rasmussen (2011) with the additions provided by Hinojosa-Díaz et al. (2012), Nemésio (2012a) and Nemésio and Engel (2012).

3. Results

Four thousand seven hundred and sixty-four males belonging to 36 species were collected in all five areas (Tables 1-4). All 36 species were collected at 'Parque Nacional do Monte Pascoal' (Table 1), whereas the other four forest areas (smaller than PNMP) presented subsets

of PNMP's fauna in decreasing order according to their area: 29 species were collected at PND (the second largest area) (Table 2), 26 at F300 (Table 3), 22 at F150 and only seven species were collected at F1 (Table 4). Similar trends were observed when diversity and evenness are considered: diversity ranged from H' = 0.57 (F1, the smallest area) to H' = 2.62 (PNMP, the largest area), and evenness ranged from E = 0.29 (F1) to E = 0.79 (F300)

Table 1. Diversity, evenness, species richness and number of specimens of each orchid-bee species collected at sites 1 to 3 at the 'Parque Nacional do Monte Pascoal', state of Bahia, eastern Brazil, in rainy and dry seasons after 20 hours of sampling in each site.

Species	Rainy season			Dry season			Total
	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3	
Eufriesea atlantica Nemésio, 2008	00	01	00	00	00	00	01
Eufriesea dentilabris (Mocsáry, 1897)	01	00	00	00	00	00	01
Eufriesea surinamensis (Linnaeus, 1758)	01	04	00	00	00	01	06
Eufriesea violacea (Blanchard, 1840)	01	00	00	00	00	01	02
Euglossa amazonica Dressler, 1982b	00	01	02	00	00	01	04
Euglossa aratingae Nemésio, 2009	00	00	01	00	00	00	01
Euglossa augaspula Hinojosa-Díaz, Nemésio & Engel, 2012	00	01	31	01	05	01	39
Euglossa avicula Dressler, 1982	00	13	08	03	02	01	27
Euglossa bembei Nemésio, 2011d	00	02	03	00	00	00	05
Euglossa carolina Nemésio, 2009	07	103	179	04	88	60	441
Euglossa clausi Nemésio and Engel, 2012	02	18	37	00	05	03	65
Euglossa cognata Moure, 1970	01	09	39	07	04	15	75
Euglossa cyanochlora Moure, 1996	00	00	00	00	02*	00	02
Euglossa despecta Moure, 1968	02	04	32	12	35	18	103
Euglossa fimbriata Moure, 1968	04	09	18	00	00	01	32
Euglossa hemichlora Cockerell, 1917	00	00	04	00	00	00	04
Euglossa ignita Smith, 1874	19	24	129	19	54	92	337
Euglossa imperialis Cockerell, 1922	32	39	63	43	83	99	359
Euglossa leucotricha Rebêlo and Moure, 1996	00	03	00	00	00	00	03
Euglossa liopoda Dressler, 1982	00	00	02	00	00	00	02
Euglossa marianae Nemésio, 2011b	02	05	36	03	13	10	69
Euglossa milenae Bembé, 2007	01	02	01	00	01	00	05
Euglossa mixta Friese, 1899	01	06	28	05	13	17	70
Euglossa monnei Nemésio, 2012a	00	00	01	00	00	01	02
Euglossa pepei Nemésio and Engel, 2012	00	00	01	00	00	01	02
Euglossa pleosticta Dressler, 1982	01	10	09	01	02	02	25
Euglossa roubiki Nemésio, 2009	54	46	72	09	33	37	251
Euglossa securigera Dressler, 1982	00	12	26	00	00	00	38
Euglossa viridis (Perty, 1833)	00	00	01	00	00	01	02
Eulaema atleticana Nemésio, 2009	03	14	29	00	06	04	56
Eulaema marcii Nemésio, 2009	33	27	29	09	10	22	130
Eulaema nigrita Lepeletier, 1841	07	48	67	08	27	13	170
Eulaema niveofasciata (Friese, 1899)	11	13	20	07	04	12	67
Exaerete frontalis (Guérin-Méneville, 1844)	03	04	02	01	00	01	11
Exaerete salsai Nemésio, 2011c	00	01	00	00	00	00	01
Exaerete smaragdina (Guérin-Méneville, 1844)	01	01	00	00	00	00	02
Total	**187**	**420**	**870**	**132**	**387**	**414**	**2,410**
Species richness (S)	21	27	28	15	18	24	36
Shannon-Wiener diversity index (H')	2.20	2.62	2.67	2.22	2.25	2.27	2.62
Evenness (E)	0.72	0.79	0.80	0.82	0.78	0.71	0.73

Table 2. Diversity, evenness, species richness and number of specimens of each orchid-bee species collected at sites 1 to 3 at the 'Parque Nacional do Descobrimento', state of Bahia, eastern Brazil, after 20 hours of sampling in each site.

Species	Site 1	Site 2	Site 3	Total
Eufriesea atlantica Nemésio, 2008	00	00	01	01
Eufriesea surinamensis (Linnaeus, 1758)	00	00	01	01
Euglossa amazonica Dressler, 1982b	00	05	06	11
Euglossa augaspula Hinojosa-Díaz, Nemésio & Engel, 2012	00	01	03	04
Euglossa avicula Dressler, 1982b	02	00	02	04
Euglossa bembei Nemésio, 2011	00	01	00	01
Euglossa carolina Nemésio, 2009	37	132	220	389
Euglossa clausi Nemésio and Engel, 2012	02	13	11	26
Euglossa cognata Moure, 1970	02	10	04	16
Euglossa despecta Moure, 1968	00	10	13	23
Euglossa fimbriata Moure, 1968	10	03	05	18
Euglossa ignita Smith, 1874	14	30	07	51
Euglossa imperialis Cockerell, 1922	21	19	13	53
Euglossa liopoda Dressler, 1982b	00	00	02	02
Euglossa marianae Nemésio, 2011b	03	07	04	14
Euglossa milenae Bembé, 2007	00	02	00	02
Euglossa mixta Friese, 1899	05	21	59	85
Euglossa monnei Nemésio, 2012	01	01	00	02
Euglossa pepei Nemésio and Engel, 2012	01	00	00	01
Euglossa pleosticta Dressler, 1982b	01	03	01	05
Euglossa roubiki Nemésio, 2009	38	16	14	68
Euglossa securigera Dressler, 1982b	01	01	03	05
Eulaema atleticana Nemésio, 2009	11	08	18	37
Eulaema marcii Nemésio, 2009	10	05	13	28
Eulaema nigrita Lepeletier, 1841	04	28	36	68
Eulaema niveofasciata (Friese, 1899)	06	09	06	21
Exaerete frontalis (Guérin-Méneville, 1844)	03	01	10	14
Exaerete salsai Nemésio, 2011	00	00	01	01
Exaerete smaragdina (Guérin-Méneville, 1844)	01	07	05	13
Total	**173**	**333**	**458**	**964**
Species richness (S)	20	23	25	29
Shannon-Wiener diversity index (H')	2.38	2.29	2.05	2.32
Evenness (E)	0.79	0.73	0.64	0.69

(Tables 1-4). PNMP also presented the highest abundance (ca. 20 specimens/hour), followed by PND and F150 (ca. 16 specimens/hour), F1 (ca. 12 specimens/hour) and F300 (ca. 10 specimens/hour).

Euglossa carolina Nemésio, 2009 was the most common species in all sampled areas, but its dominance ranged from 87% at F1 to only 18% and 14% at PNMP and F300 respectively (Tables 1-4). *Euglossa ignita* Smith, 1874, *Eg. imperialis* Cockerell, 1922 and *Eg. roubiki* Nemésio, 2009, three species belonging to the subgenus *Glossura* Cockerell, 1917, were also common species in four of the five areas (except F1), and at F300 *Eg. ignita* was the dominant species (Table 3).

A marked difference was found between the two areas where samplings were carried out during the rainy and drier seasons: at PNMP abundance was about 50% higher during the rainy season, whereas at F300 there was no difference in abundance. Populations of some species, however, seemed to fluctuate between seasons (Tables 1 and 3).

There were significant correlations between forest remnant size and richness ($r_s = 1.00$, $P < 0.05$) and diversity ($r_s = 0.90$, $P < 0.05$). The ordination of the sites according to their faunas showed a great overall similarity among the three largest forest areas and a decrease in similarity between these three areas and the two smallest areas. PNMP and the nearby F300 grouped together with ca. 81% similarity and then grouped to PND with ca. 65% similarity. These three areas grouped with F150 with ca. 56% similarity and, then, all four areas grouped with F1with only ca. 35% similarity (Figure 2).

Table 3. Diversity, evenness, species richness and number of specimens of each orchid-bee species collected at a 300-ha forest remnant in the municipality of Itamaraju, state of Bahia, eastern Brazil. Bees were collected during 20 hours in each sampling. Two samplings were performed during the rainy season and two samplings in the drier season (see Material and Methods for further details).

Species	Rainy season		Dry season		Total
	Sampling 1	Sampling 2	Sampling 1	Sampling 2	
Eufriesea atlantica Nemésio, 2008	05	00	00	02	07
Eufriesea surinamensis (Linnaeus, 1758)	08	00	00	06	14
Euglossa amazonica Dressler, 1982b	02	04	00	03	09
Euglossa aratingae Nemésio, 2009	01	00	00	00	01
Euglossa augaspula Hinojosa-Díaz, Nemésio & Engel, 2012	02	03	01	07	13
Euglossa avicula Dressler, 1982b	00	02	00	00	02
Euglossa carolina Nemésio, 2009	38	18	15	44	115
Euglossa clausi Nemésio and Engel, 2012	12	23	04	32	71
Euglossa cognata Moure, 1970	00	00	00	02	02
Euglossa cyanochlora Moure, 1996	00	03	00	04	07
Euglossa despecta Moure, 1968	03	03	00	10	16
Euglossa fimbriata Moure, 1968	03	00	00	08	11
Euglossa ignita Smith, 1874	22	51	46	43	162
Euglossa imperialis Cockerell, 1922	09	17	09	09	44
Euglossa milenae Bembé, 2007	01	01	00	01	03
Euglossa mixta Friese, 1899	02	03	00	03	08
Euglossa monnei Nemésio, 2012	00	00	01	01	02
Euglossa pleosticta Dressler, 1982b	02	04		05	11
Euglossa roubiki Nemésio, 2009	20	32	04	13	69
Euglossa securigera Dressler, 1982b	05	08	00	15	28
Eulaema atleticana Nemésio, 2009	04	09	03	06	22
Eulaema marcii Nemésio, 2009	25	35	27	16	103
Eulaema nigrita Lepeletier, 1841	18	34	04	22	78
Eulaema niveofasciata (Friese, 1899)	03	08	03	01	15
Exaerete frontalis (Guérin-Méneville, 1844)	01	00	02	00	03
Exaerete smaragdina (Guérin-Méneville, 1844)	02	04	04	03	13
Total	**188**	**262**	**123**	**256**	**829**
Species richness (S)	22	19	13	23	26
Shannon-Wiener diversity index (H')	2.56	2.47	1.92	2.63	2.59
Evenness (E)	0.83	0.84	0.75	0.84	0.79

4. Discussion

4.1. Faunistics, richness and diversity

The strategy of intensive sampling, using the same methods as employed here, over a few days during the season when orchid bees are most actively foraging, has been demonstrated to be adequate for surveys focusing on this group of bees (Nemésio 2010b, 2011a, b, Nemésio et al. 2012). In the present study it was also shown that species richness can also be adequately recorded through this methodology during the drier season as well. Nevertheless, it should be stressed that at the particular region where these samplings were performed, there is no well-defined "dry" season and precipitation is usually high even during the driest months. Thus, this methodology should be used in other areas with well-defined dry seasons with great care during the drier seasons.

Neves and Viana (2003) listed 33 species for the Atlantic Forest of Bahia, but Nemésio (2009, 2011a) showed that some of them are junior synonyms of other species found in the area and other species were misidentifications. Nemésio (2011a) recognised 26 species occurring in southern Bahia from Uruçuca, in the north, to Porto Seguro, in the south. This figure was raised to 29 species after the survey at 'Reserva Biológica de Una' (Nemésio, 2013a). Seven species are here added to this list: *Eufriesea dentilabris* (Mocsáry, 1897), *Ef. violacea* (Blanchard, 1840), *Euglossa aratingae* Nemésio, 2009, *Eg. hemichlora* Cockerell, 1917, *Eg. leucotricha* Rebêlo and Moure, 1996, *Eg. pepei*

Table 4. Diversity, evenness, species richness and number of specimens of each orchid-bee species collected at two forest fragments in the municipality of Itamaraju, state of Bahia, eastern Brazil, after 20 hours of sampling in each site. F1 = 1-ha forest remnant; F150 = 150-ha forest remnant (see Material and Methods for further details).

Species	F1	F150
Eufriesea atlantica Nemésio, 2008	00	01
Eufriesea surinamensis (Linnaeus, 1758)	00	01
Euglossa amazonica Dressler, 1982b	00	03
Euglossa augaspula Hinojosa-Díaz, Nemésio & Engel, 2012	00	04
Euglossa bembei Nemésio, 2011	00	01
Euglossa carolina Nemésio, 2009	206	107
Euglossa clausi Nemésio and Engel, 2012	01	35
Euglossa cognata Moure, 1970	00	01
Euglossa cyanochlora Moure, 1996	00	01
Euglossa despecta Moure, 1968	02	04
Euglossa fimbriata Moure, 1968	00	05
Euglossa ignita Smith, 1874	06	27
Euglossa imperialis Cockerell, 1922	00	03
Euglossa milenae Bembé, 2007	00	02
Euglossa pleosticta Dressler, 1982b	00	06
Euglossa roubiki Nemésio, 2009	00	09
Euglossa securigera Dressler, 1982b	08	01
Eulaema atleticana Nemésio, 2009	00	02
Eulaema marcii Nemésio, 2009	00	05
Eulaema nigrita Lepeletier, 1841	13	86
Exaerete frontalis (Guérin-Méneville, 1844)	00	01
Exaerete smaragdina (Guérin-Méneville, 1844)	01	19
Total	**237**	**324**
Species richness (S)	07	22
Shannon-Wiener diversity index (H')	0.57	2.02
Evenness (E)	0.29	0.65

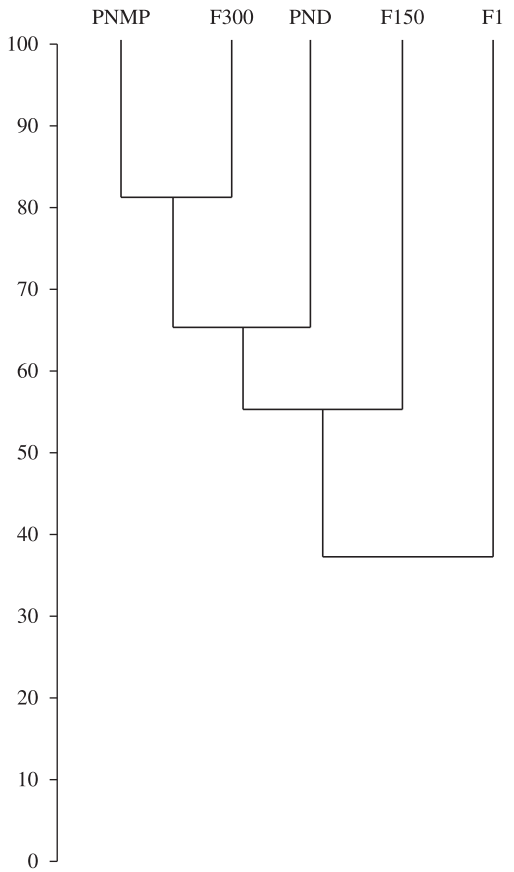

Figure 2. Clustering of the five areas at the 'Monte Pascoal' region according to the similarity of their orchid bee faunas. PNMP = 'Parque Nacional do Monte Pascoal', Porto Seguro, Bahia; PND = 'Parque Nacional do Descobrimento', Prado, Bahia; F1 = forest fragment of 1 ha, Itamaraju, Bahia; F150 = 'Fazenda Flor do Monte', a 150-ha forest fragment, Itamaraju; F300 = forest fragment of 300 ha, Itamaraju.

Nemésio and Engel, 2012, and *Exaerete salsai* Nemésio, 2011c. The species considered as *Eg. crassipunctata* Moure, 1968 in all previous studies in the Atlantic Forest is here treated as *Eg. clausi* Nemésio and Engel, 2012. This is the northernmost record of both *Ef. dentilabris* and *Ef. violacea* and the first published record of these species for the state of Bahia (in fact, R. L. Dressler had already collected *Ef. violacea* exactly at the 'Monte Pascoal' region in 1968; data from his field notes available at ftp://ftp.flmnh.ufl.edu/Public/Dressler/).

Females of the cleptoparasitic *Exaerete dentata* (Linnaeus, 1758) were also collected in the present study when searching for nests of *Eufriesea surinamensis* (Linnaeus, 1758) at PNMP, its most common host. Males of this species are usually not attracted to the synthetic scents used in orchid-bee inventories (see Nemésio and Silveira, 2006a) and, thus, were not recorded during regular samplings. Sixteen specimens of *Eufriesea aeneiventris* (Mocsáry, 1896) were collected in Itamaraju and in the neighbourhood of PNMP in October and November, 1985 [specimens deposited at 'Museu Nacional' (Rio de Janeiro) and UFMG], but were not collected in the present study. *Euglossa carinilabris* Dressler, 1982b was collected in Ilhéus and Itabuna, in the state of Bahia (Dressler, 1982b; Nemésio, in prep.), and in Santa Teresa, in the state of Espírito Santo (Faria Junior and Melo, 2007) and the present study area is exactly between both sites, suggesting it may occur in the region. *Euglossa stellfeldi* Moure, 1947 and *Euglossa truncata* Rebêlo and Moure, 1996, are known to occur in high elevations (above 800 m a.s.l.) at the border of the states of Minas Gerais and Bahia (Nemésio, 2012b), only some 50 km from PNMP, and *Eg. stellfeldi* reaches the mountains in the region of Camacan, near 'Reserva Biológica de Una' (Nemésio, in prep.). Finally, *Eulaema seabrai* Moure, 1960, another species usually not attracted to the synthetic scents used in orchid bee surveys (Nemésio and Silveira, 2004, 2006b), is known to occur in southern Bahia (Oliveira, 2008). These seven species

raise the number of orchid-bee species known to occur in southern Bahia to 42 – and 38 of them (including *Ex. dentata*, recorded in the present study, and *Ef. aeneiventris*) are known to occur sympatrically at PNMP, what makes this single area the richest and most diverse Atlantic Forest site concerning its orchid-bee fauna, far beyond 'Reserva Natural Vale' in Linhares, state of Espírito Santo, with 31 species (Bonilla-Gómez, 1999), PND, with 29 species (this study), and 'Reserva Biológica de Una', also with 29 species (Nemésio, 2013a). This figure of 38 species is only rivalled by Amazonian (e.g. Pearson and Dressler, 1985; Oliveira and Campos, 1996) and Central American (e.g. Ackerman, 1989) sites but it is still superior to many sites in the Brazilian (e.g. Nemésio and Morato, 2006; Storck-Tonon et al., 2009, 2011) and Peruvian (e.g. Rasmussen, 2009) Amazon. Although the entire Atlantic Forest domain is not especially rich in orchid-bee species when compared to the Amazon and Central American forests (see Nemésio and Silveira, 2007b), 'Parque Nacional do Monte Pascoal' presents an astonishingly rich and diverse orchid-bee fauna, comparable to the richest sites in the Neotropics.

Nowhere in the Atlantic Forest domain the effect of fragmentation, with its consequent reductions in size of remaining forest patches, is more obvious than at the 'Monte Pascoal' region. Previous studies (Bezerra and Martins, 2001; Nemésio and Silveira, 2007a, 2010) had suggested that reduction of the original forested areas could lead to a decrease in richness and diversity of orchid-bee faunas. Nevertheless, the absence of large, well preserved forest remnants in the same micro-regions that could be used as a "control" area in the aforementioned studies (i.e., an area large enough to still hold the full pool of the original species occurring in the region) made it difficult to conclude whether the observed patterns were a consequence of deforestation or a natural feature of the local orchid-bee faunas. The present data show unequivocally that reduction in size does affect not only richness, but also diversity, since few or usually one dominant species tend to respond for the majority of specimens found in these smaller areas. *Euglossa carolina*, a species typical of disturbed areas, tended to be more and more common towards the smaller forest remnants or, alternatively, those with disturbed vegetation, as happens to be the case at PND, where most of the area consists of forests in early to intermediate successional stages.

Due especially to the fluctuations in the relative abundances of *Euglossa carolina* among the different areas, similarity among them were intermediate to high, except the two smallest forest patches. Species of *Euglossa* Latreille, 1802 belonging to the subgenus *Glossura* were also key species to group the areas, since they are an important component of the local orchid-bee community.

Euglossa marianae Nemésio, 2011b, a species considered to only occur in the largest and best preserved patches of the Atlantic Forest (see Tonhasca Junior et al., 2002; Nemésio and Silveira, 2006c; Nemésio 2011b, 2013b – treated as *Eg. analis* Westwood, 1840 in the two former studies), was only recorded within PNMP and PND. Its absence from F300, an area close to PNMP, reinforces the view that *Eg. marianae* is actually very sensitive to environmental disturbances.

4.2. Conservation

Similar to many other "protected" natural areas in eastern Brazil, the situation faced by the areas here sampled is problematic (few personnel to patrol the areas; presence of hunters and wood dealers; legal problems with former owners of the land; invasion by self-declared Indians who claim the area). The most dramatic situation is that of 'Parque Nacional do Monte Pascoal', illegally occupied by self-declared Pataxó Indians who claim possession of the area. The self-declared Indians currently live around the preserve with a population of about 15,000 people. They hunt in the area with fire guns (pers. obs.), cut down trees with electric saws (pers. obs.) to sell in the region or to build handicrafts intended to be sold to tourists at the nearby famous beaches. A large part of PNMP was already deforested and its original area of more than 22,000 ha is currently covered by no more than 10,000 ha of forest. On the other hand, the remaining forest at PNMP still consists of mature trees and this mature forest still holds an impressive richness and diversity of animals, orchid bees included. Urgent measures must be taken to protect this area and restore the 'de facto' governmental control of the area. A similar fate may be soon faced by PND, since self-declared Indians have tried (and some have succeeded) to occupy and get themselves established in the area. The same negative impacts reported for PNMP also happens at PND. The presence of apparently sensitive orchid-bee species, such as *Euglossa marianae*, *Eg. roubiki*, *Eg. amazonica* Dressler, 1982 (see Nemésio, 2010b, 2011b), and *Eg. cyanochlora* Moure, 1996, and rare species only recently described, such as *Euglossa pepei* and *Exaerete salsai*, suggests that these are key areas to preserve the impressive diversity of orchid bees of the region, with many endemic species. Nevertheless, if the conservation problems listed above are not urgently solved, there will probably be nothing left, due to the accelerated damage caused to the area by local people, self-declared Indians included, and the very slow governmental response to this situation.

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