http://dx.doi.org/10.1590/1519-6984.25712 Original Article

The orchid-bee fauna (Hymenoptera: Apidae) of a forest remnant in the southern portion of the Brazilian Amazon

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Received: November 26, 2012 – Accepted: July 23, 2013 – Distributed: November 30, 2014
(With 1 figure)

Abstract

The orchid-bee fauna of the region of Porto Velho, in the state of Rondônia, Brazil, close to the southernmost limits of the Amazon Basin, was surveyed for the first time using five different scents as baits to attract orchid-bee males. Five hundred and twenty-one males belonging to five genera and 29 species were collected with bait traps during 26 non-consecutive days from November, 2011 to January, 2012. *Eulaema nigrita* Lepeletier, 1841 and *Eulaema meriana* (Olivier, 1789) were the most common species in the region and, together, represented almost 50% of all collected bees. Although the observed richness conforms to similar inventories in the region, the diversity (H'= 2.43) found in the present study is one of the highest ever recorded for orchid bees in the Amazon Basin.

Keywords: Amazon Forest, Apidae, Euglossina, euglossine bees.

A fauna de abelhas-das-orquídeas (Hymenoptera: Apidae) de um remanescente florestal no extremo sul da Amazônia brasileira

Resumo

A fauna de abelhas euglossinas da região de Porto Velho, estado de Rondônia, Brasil, próxima ao limite setentrional da Bacia Amazônica, foi amostrada pela primeira vez com o uso de cinco diferentes compostos aromáticos para atrair machos dessas abelhas. Quinhentos e vinte e um machos pertencentes a cinco gêneros e 29 espécies foram coletados em armadilhas durante 26 dias não consecutivos entre novembro de 2011 e janeiro de 2012. *Eulaema nigrita* Lepeletier, 1841 e *Eulaema meriana* (Olivier, 1789) foram as espécies mais comuns na região e, juntas, representaram quase 50% do total de abelhas capturadas. Embora a riqueza observada no presente estudo seja semelhante a de outros inventários na Amazônia brasileira, a diversidade encontrada (H'= 2,43) é uma das mais altas já verificadas para a região.

Palavras-chave: Floresta Amazônica, Apidae, Euglossina, abelhas euglossinas.

1. Introduction

Orchid bees (Hymenoptera: Apidae: Euglossina) are among the most important pollinators in Neotropical forests and a growing body of evidence has suggested they play a relevant role in the ecosystems where they live (reviewed by Dressler (1982a) and Roubik and Hanson (2004)). Males of these bees are known to visit flowers of orchids and other plant species seeking for aromatic compounds that are supposedly used in courtship (e.g. Eltz et al., 1999). Synthetic aromatic scents that mimic the floral fragrances attractive to male orchid bees have been used since the late 1960's (Vogel, 1966; Dodson et al., 1969) as powerful tools in field studies involving these bees (e.g. Nemésio and Silveira, 2006, 2007, 2010; Rasmussen, 2009; Abrahamczyk et al., 2011). These studies eventually led to the discovery of a previously unknown astonishing diversity among orchid bees (e.g. Dressler, 1982b, c, d). The continued use of synthetic fragrances has improved our knowledge on more precise geographic distributions of many orchid-bee species (e.g. Nemésio, 2010, 2011a, b).

Although many orchid-bee inventories and ecological studies with these bees have been carried out in the Amazon Basin since the 1980's (e.g. Pearson and Dressler, 1985; Dressler, 1985; Powell and Powell, 1987; Becker et al., 1991; Morato, 1994; Oliveira and Campos, 1996; Bembé, 2002; Nemésio and Morato, 2004, 2006; Rasmussen, 2009; Storck-Tonon et al., 2009, 2011; Abrahamczyk et al., 2011; Nemésio et al., 2014), the orchid-bee fauna of the state of Rondônia, southwestern Amazonia, is virtually unknown. The region of Porto Velho, state of Rondônia, is of particular interest due to its singular location, at the southern limits of the Amazon and in the transition between lowland rainforest and the "Cerradão", a more xeric, savanna-like vegetation with tall trees. In fact, there is a large gap in our knowledge concerning the orchid-bee fauna occurring from the southern Amazon Basin to Central Brazil. Preliminary studies in the region have revealed even new species to occur in the area (see Nemésio and Ferrari, 2012).

The main goal of this study was to survey the orchid-bee fauna of the region of Porto Velho and, thus, provide the first data on that poorly sampled area.

2. Material and Methods

2.1. Study sites

This study was conducted in an area of dense ombrophilous forest located near the region of Cachoeira do Teotônio (08°52'30"S; 64°03'11" W; 86 m a.s.l.), Rio Madeira, in the municipality of Porto Velho, in the state of Rondônia, Brazilian Amazon (Figure 1). Although patches of primary forest are found in the area, most of the vegetation consists of secondary forest due to anthropogenic pressures, such as the common practice of deforestation.

2.2. Sampling

Five aromatic baits traditionally used in orchid-bee inventories were used in the present study: 1,8-cineole, eugenol, methyl salicylate, methyl *trans*-cinnamate and vanillin. Cotton balls soaked with these baits were placed inside plastic bottles modified according to Campos et al. (1989).

The field study was carried out from November, 2011, to January, 2012, during 26 non-consecutive days. We used one set of traps (each trap containing one of the five scents) installed at 08:00 h, at a height of approximately 1.5 metres above the soil and separated from each other by ca. two metres. The traps were checked every three hours until 17:00 h, and all specimens found trapped during the inspections were killed with ethyl acetate and later pinned for posterior identification. All collected specimens are deposited in the Invertebrate Collection of the Taxonomic Collections of the Universidade Federal de Minas Gerais (UFMG), Belo Horizonte, Brazil.

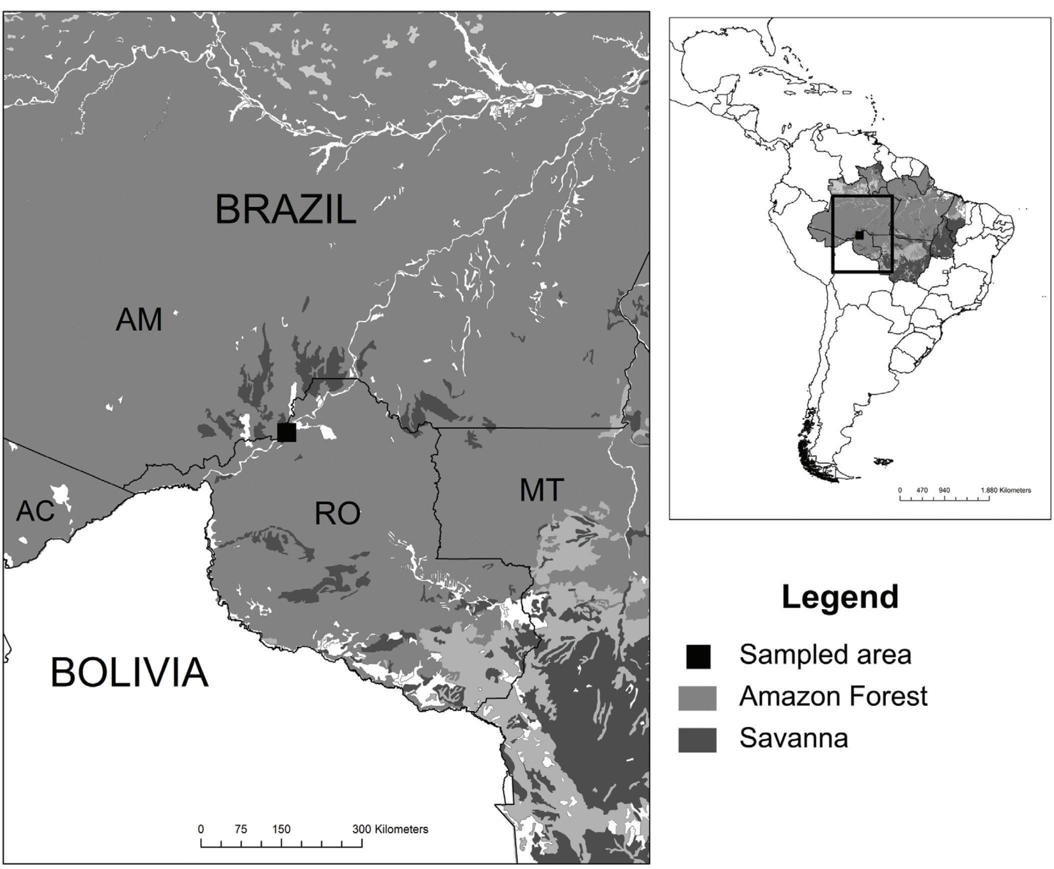

Figure 1. Map showing the exact location of the studied area in Cachoeira de Santo Antônio, Porto Velho, state of Rondônia, Brazil. Abbreviations mean Brazilian states: AC = Acre; AM = Amazonas; MT = Mato Grosso; RO = Rondônia.

2.3. Data analysis

Diversity was estimated with 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. Both diversity and evenness were calculated for each one of the five used scents separately in order to assess those more useful for future studies in the region.

2.4. Taxonomy

Taxonomy follows Nemésio and Rasmussen (2011) with the additions provided by Nemésio and Engel (2012).

3. Results

Five hundred and twenty-one orchid-bee males belonging to five genera and 29 species were collected in the present study (Table 1). *Eulaema nigrita* Lepeletier, 1841 and *El. meriana* (Olivier, 1789) were the most abundant species at Porto Velho and, together, represented 48% of all collected specimens. More than half of the species (15) were represented by four or less specimens, six of them being singletons (Table 1). Eugenol attracted the highest number of species (17), but a low number (31) of specimens. Cineole, on the other hand, attracted the highest number of specimens (187), but it attracted the second lowest number of species (13) – see Table 1. Diversity and evenness were the highest at eugenol and vanillin baits, and the lowest at

Table 1. Number of specimens of orchid-bee species collected during 26 non-consecutive days from November, 2011 to January, 2012 in Cachoeira de Santo Antônio, Porto Velho, state of Rondônia, according to bait preference: MC = methyl *trans*-cinnamate; CI = cineole; EU = eugenol; MS = methyl salicylate; VA = vanillin.

Scent	MC	CI	EU	MS	VA	Total
Species						
Aglae caerulea Lepeletier & Serville, 1825	01	00	01	00	00	02
Eufriesea ornata (Mocsáry,1896)	00	00	01	00	00	01
Eufriesea superba (Hoffmannsegg, 1817)	00	00	00	04	00	04
Euglossa (Euglossa) amazonica Dressler, 1982d	00	00	01	00	00	01
Euglossa (Euglossa) analis Westwood, 1840	00	00	02	00	00	02
Euglossa (Euglossa) bidentata Dressler, 1982b	00	01	03	00	00	04
Euglossa (Euglossa) cognata Moure, 1970	00	00	00	01	00	01
Euglossa (Euglossa) despecta Moure, 1968	00	01	00	00	00	01
Euglossa (Euglossa) magnipes Dressler, 1982d	00	00	02	00	01	03
Euglossa (Euglossa) mixta Friese, 1899	00	00	00	06	00	06
Euglossa (Euglossa) modestior Dressler, 1982d	00	01	00	00	00	01
Euglossa (Euglossa) mourei Dressler, 1982d	00	05	01	00	40	46
Euglossa (Euglossa) securigera Dressler, 1982d	00	12	02	00	01	15
Euglossa (Euglossa) townsendi Cockerell, 1904	00	01	00	00	23	24
Euglossa (Glossura) ignita Smith, 1874	03	03	01	32	03	42
Euglossa (Glossura) orellana Roubik, 2004	01	00	01	01	00	03
Euglossa (Glossurella) augaspis Dressler, 1982c	01	00	02	00	08	11
Euglossa (Glossurella) bursigera Moure, 1970	00	00	00	00	02	02
Euglossa (Glossurella) moratoi Nemésio & Engel, 2012	00	00	01	00	02	03
Euglossa (Glossurella) prasina Dressler, 1982c	00	00	00	00	02	02
Euglossa (Glossuropoda) intersecta Latreille, 1817	00	00	00	01	00	01
Eulaema (Apeulaema) cingulata (Fabricius, 1804)	00	03	05	01	14	23
Eulaema (Apeulaema) marcii Nemésio, 2009	01	00	04	00	08	13
Eulaema (Apeulaema) mocsaryi (Friese, 1899)	00	01	02	05	05	13
Eulaema (Apeulaema) nigrita Lepeletier, 1841	00	93	00	02	42	137
Eulaema (Eulaema) bombiformis (Packard, 1869)	01	00	00	12	01	14
Eulaema (Eulaema) meriana (Olivier, 1789)	08	44	01	44	15	112
Exaerete frontalis (Guérin-Méneville, 1844)	03	03	00	01	00	07
Exaerete smaragdina (Guérin-Méneville, 1844)	02	19	01	02	03	27
Total of specimens	21	187	31	112	170	521
Richness	09	13	17	13	16	29
Shannon	1.87	1.53	2.67	1.73	2.16	2.43
Evenness	0.85	0.6	0.94	0.68	0.78	0.73

cineole and methyl salicylate baits. Overall diversity was H' = 2.43 and overall evenness was 0.73.

4. Discussion

4.1. Sampling protocol

The strategy of bait trapping orchid-bees has been long used, but recent studies (Nemésio and Morato, 2004, 2006; Mattozo et al., 2011) have strongly suggested that the use of unattended traps can be less efficient and introduce more biased results than active hand-netting. According to Nemésio and Morato (2004, 2006), the larger bees of the genus *Eulaema* tend to be more abundant in collections from trapped bees than from hand-netted ones. Those authors hypothesised, as the main cause, that smaller species of *Euglossa* Latreille, 1802 tend to escape more easily than species of *Eulaema* Lepeletier, 1841. We tried to reduce these escape events by checking all the traps every three hours and collecting all specimens trapped on these occasions. Nevertheless, species belonging to *Eulaema*, together, still represented almost 60% of our sampling (see Table 1) and, if larger bees belonging to *Aglae* Lepeletier and Serville, 1825, *Eufriesea* Cockerell, 1908 and *Exaerete* Hoffmannsegg, 1817 are also counted, this number is even higher. Although species of *Eulaema* are indeed very abundant in more disturbed areas in the Amazon, particularly *El. meriana* and *El. nigrita*, future studies in the region performed under different protocols should be encouraged to confirm or re-evaluate the results found here. Comparisons with other orchid-bee samplings carried out in the Amazon under alternative methodologies should, thus, be made with great care, as pointed out by Nemésio (2012).

4.2. Faunistics, richness and diversity

The list of orchid-bee species found in the present study is quite similar to that sampled by Nemésio and Morato (2004, 2006) and Storck-Tonon et al. (2009, 2011) in the neighbouring state of Acre. The main difference refers to the number of species of *Eufriesea* collected in Acre, much higher than that observed in the present study. It should be emphasised, though, that our study was carried out over a short period, whereas those by Nemésio and Morato (2004, 2006) and Storck-Tonon et al. (2009) were performed for longer periods. Because species of *Eufriesea* are highly seasonal (see Kimsey (1982)), longer samplings have the chance of capturing species that were not active during the months we sampled at Porto Velho.

The species treated as *Euglossa chalybeata* Friese, 1925 by Nemésio and Morato (2004, 2006) is the same treated here as *Eg. orellana* Roubik, 2004. The absence of *Eg. imperialis* Cockerell, 1922 in our study is noticeable, because this species is widespread in the Neotropics, ranging from Central America (Roubik and Hanson, 2004) to southeastern Brazil (Rebêlo and Moure, 1996; Nemésio and Silveira, 2007, 2010). On the other hand, *Eg. moratoi* Nemésio and Engel, 2012 was not reported by Nemésio and Morato (2004, 2006), but it was later recorded (a single specimen) by Storck-Tonon et al. (2009) – listed as *Eg. crassipunctata* Moure, 1968.

The number of 29 species recorded in the present study is in accordance with that expected for the region. In the western Amazon of Brazil, orchid-bee samplings usually record from 16 to 38 species (Powell and Powell, 1987; Becker et al., 1991; Morato, 1994; Oliveira and Campos, 1996; Nemésio and Morato, 2004, 2006; Storck-Tonon et al., 2009, 2011). The diversity observed in the present study, however, is close to the highest ever recorded in the Brazilian Amazon, which ranged from H' = 1.36 (Becker et al., 1991) to H' = 2.52 and H' = 2.54 (Nemésio and Morato, 2006; Storck-Tonon et al., 2009, respectively – see Storck-Tonon et al. (2009): 700-701 for a summary of orchid-bee diversity along the Neotropical region). Evenness was also surprisingly high considering a sampling with bait traps. If we consider that the sampling protocol here used is the least efficient and our sampling was performed over a three-month period, both richness and diversity of orchid-bees in the region of Porto Velho are considerably high and further studies may reveal still higher richness. According to Coddington et al. (2009), the high number of singletons is suggestive that our sampling probably failed to record a reasonable number of species. Moreover, as pointed out by Nemésio (2012), sampling orchid bees through the use of chemical baits, regardless of the methodology employed (traps or insect nets), may not record all species in a given area because there are a number of species low or non-responsive to the scents ordinarily used in orchid-bee inventories. Thus, besides being more intensive, future studies should also focus on alternative methodologies, such as collecting on flowers or searching for nests, to maximise our knowledge on the local orchid-bee fauna.

4.3. Scent attractiveness

Three (cineole, methyl salicylate and vanillin) of the five scents used in the present study attracted a high number of specimens (see Table 1). Eugenol, though attracting only 31 specimens, was the scent which attracted the highest number of species. Some of the species attracted to eugenol were exclusively attracted to this scent; nevertheless, these were singletons or doubletons (see Table 1) allowing no further inferences concerning species preferences. Only *trans*-methyl cinnamate can be considered non-efficient in the present study at all. Although some uncommon species, such as *Aglae caerulea* Lepeletier and Serville, 1825, were attracted to *trans*-methyl cinnamate and although this species seems to present a strong preference for this scent (Morato, 2001; Nemésio et al., 2014), it is also attracted to eugenol (this study) and skatole (Nemésio et al., 2014). Important scents in the Amazon basin, such as benzyl acetate and skatole (Oliveira and Campos, 1996; Nemésio and Morato, 2004, 2006; Storck-Tonon et al., 2009; Nemésio et al., 2014), were not used in the present study, since these scents were not available to us prior to the field work. Nevertheless, most species attracted to these scents are also attracted to cineole, methyl-salicylate and vanillin (see Table 1 and Storck-Tonon et al. (2009): 697). Indeed, the high resemblance between our results and those presented by Nemésio and Morato (2004, 2006) and Storck-Tonon et al. (2009) is suggestive that the absence of benzyl acetate and skatole in the present study did not prevent those species highly attracted to them of showing up in one of the scents used by us.

As argued by Nemésio (2012), current orchid-bee inventories based on chemical scents to attract males are usually not accordingly designed prior to field studies. For example, the reasons for the choice of a particular set of scents to be employed is rarely presented or discussed, leading to an absolute lack of standardisation among orchid-bee inventories. We hope that the results here presented help future researchers using the above methodology for sampling orchid bees in the Amazon to choose those scents potentially more useful for their purposes.

Acknowledgements

The Brazilian government, through IBAMA and ICMBio, provided the license (#3913-1) that allowed us to sample the area. Prof. Dr. Fernando A. Silveira (Universidade Federal de Minas Gerais) kindly allowed us to use the laboratory, the orchid-bee collection and the equipment under his care during the preparation of this manuscript. Two anonymous referees made valuable comments on a first draft of this manuscript.

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