Orchid Bees of forest fragments in Southwestern Amazonia

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Abstract: Bees of the tribe Euglossini are known as orchid-bees. In general, areas with more vegetation cover have greater abundance and diversity of these bees. This study investigated the effects of forest fragmentation on assemblages of the euglossine bees in the region of Rio Branco municipality, State of Acre, and surrounding areas. Ten forest fragments with varying sizes were selected for the study and were classified as urban or rural. The bees were sampled between December 2005 and August 2006. A total of 3,675 bees in 36 species and 4 genera were collected. In general abundance and richness of bees did not differ statistically between urban and rural fragments. The index of edge in fragments was a predictor of richness and diversity of bees. The connectivity estimated was also an adequate predictor for richness. Fragments with greater similarity in relation to their landscape structure were also more similar in relation to faunal composition.
Keywords: *Euglossini, conservation, diversity, Acre State.*

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Resumo: As abelhas pertencentes à tribo Euglossini são conhecidas como abelhas das orquídeas. Em geral, áreas com maior cobertura de vegetação apresentam maior abundância e diversidade dessas abelhas. Esse estudo investigou os efeitos da fragmentação florestal sobre as assembleias de abelhas Euglossini na região do município de Rio Branco, Acre e arredores. Os fragmentos florestais com tamanhos variados foram selecionados para a área de estudo e classificados como urbanos e rurais. As abelhas foram coletadas entre dezembro de 2005 e agosto de 2006. Um total de 3.675 machos pertencentes a quatro gêneros e 36 espécies foi coletado. De modo geral, abundância e riqueza de Euglossini não foram estatisticamente diferentes entre fragmentos urbanos e rurais. O índice de borda do fragmento foi preditor de riqueza e diversidade das abelhas. A conectividade estimada também foi preditora da riqueza. Fragmentos com maior similaridade em relação à estrutura paisagística foram também mais similares em relação à composição faunística.
Palavras-chave: *Euglossini, conservação, diversidade, Estado do Acre.*

Introduction

Deforestation in the state of Acre has continually increased in the last decades, resulting in forest fragmentation (Salimon & Brown 2000). One of the main consequences of forest fragmentation is edge effects and these effects are responsible for biotic and abiotic alterations in the ecosystem (Lovejoy et al. 1986, Murcia 1995, Kapos et al. 1997, Nascimento & Laurance 2006). According to Kapos et al. (1997) and Turton & Freiburger (1997), the effects on the microclimate are limited to between 15 and 60 m of edge. However, for the biota, the effects can reach longer distances (Lovejoy et al. 1986, Laurance & Bierregaard Junior 1997).

The connectivity between fragments does not depend exclusively on the distance between them, but also on the existence of corridors that facilitate movement of species and the resistance level of the matrix, that also hinders this movement (Rosenberg et al. 1986).

Insects are highly susceptible to forest fragmentation effects (Didham et al. 1996). For this reason, many researchers are using this group as bioindicators of preserved and disturbed areas (Rosenberg et al. 1986, Davies & Margules 1998, Davis 2000).

Euglossine bees are commonly known as orchid bees, encompassing slightly over 200 described species distributed into five genera (Dressler 1982, Nemésio & Rasmussen 2011). According to Roubik (1989), Euglossine males and females pollinate and collect food from at least 23 botanical families. The males also visit flowers from other families, especially Orchidaceae, from which they collect fragrance substances. Thus, the Euglossine play a very important role in seed production and maintenance of reproductive isolation and genetic variability of botanical populations (Roubik & Hanson 2004).

Generally, areas with more forest cover have more abundance and diversity of Euglossini (Dressler 1982, Roubik 1989). For this reason, these bees are considered as bioindicators with respect to the conservation status of the respective area (Morato 1994).

Due to the ecological importance of the euglossine bees the effects of forest cover loss in fragmented landscapes upon their assemblies is of utmost relevance. These studies may provide subsidies for the management and biology of native and cultivated botanical species of economic potential and that are pollinated by these bees. The objective of this work was to investigate the effects of forest fragmentation and of loss of vegetative cover on Euglossine bees' assemblages in the region of Rio Branco, Acre, Brazil.

Materials and Methods

1. *Study areas*

The state of Acre is located in the extreme west of the northern region of Brazil. It is comprised of an area of 164,221.36 Km^2, approximately 4% of the Amazon Region and 1.9% of the Brazilian area (Acre 2006). The annual average temperature varies between 22° and 24 °C and the annual total average precipitation varies between 1,600 and 2,750 mm, January being the rainiest month and July the driest (Duarte 2005). Open Rain Forest, bamboos, palm trees and dense forest predominate in the region (Silveira 2005, Acre 2006).

Sampling was done in ten forest fragments located in the municipality of Rio Branco and surrounding areas, in the state of Acre. These fragments were characterized according to their location as urban forest or rural forest (Table 1). Fragment sizes varied from 60 to 3,665 ha and the shortest and longest distance between sampling points were 2 km and 48 km, respectively.

2. *Sampling*

Sampling was performed during the moist season (of greater activity for most species) and extended to the dry season, during the months of December 2005 to September 2006, similarly to the sampling procedure used in the Amazon state by Morato (1994). Sampling efforts were approximately 36 hours in each fragment. The bees were attracted by use of six odoriferous substances: vanillin, cineol (eucalyptol), eugenol, methyl salicylate, benzyl acetate and skatole (Oliveira & Campos 1996).

In each fragment three sampling points were selected and that were 300 m distant from each other. At points 1 and 3, sets of six traps consisting of 500 mL mineral water bottles were placed. At point 2 sets with six odoriferous baits made of cotton swabs were placed and the collection were made with entomological nets. At the three points, the traps or baits were tied with a nylon thread, at 1 m distance from each other and at approximately 1.5 m height from the ground surface.

In each fragment, 6 collection were made with entomological nets in the period of 7:00 AM to 1:00 PM, interval of greater activity of these bees in tropical forests (Dodson et al. 1969). In each fragment, the traps were set up in the first day of sampling and removed in the last, remaining in place during the 6 days of collection and being re-charged with the odoriferous substances daily. Bees were killed with ethyl acetate and deposited at the Collection of the Universidade Federal do Acre (UFAC).

3. *Geoprocessing*

The fragments polygons were mapped by use of CBERS images from 2005 and the sites were GPS (Global Positioning System) referenced. The distances between fragments were estimated by imagery analysis by ArcGis 9.0 Software. Areas (ha) and perimeters (Km) of the fragments were estimated by their respective polygons.

In this study, edge was analyzed through an index, which by definition is the relation between the perimeter and the area of each

Table 1. Location and classification of the forest fragments sampled in the municipality of Rio Branco and surroundings, Acre.

Site	Site code	Classification	Coordinates
Humaitá Reserve	HUM	Rural	9° 45' 17" S and 67° 40' 15" W
Catuaba Experimental Farm	CAT	Rural	10° 4' 40" S and 67° 37' 35" W
Forestry School	ESF	Rural	9° 59' 58" S and 67° 59' 14" W
Bujari Private Area	BUJ	Rural	9° 49' 02" S and 67° 58' 18" W
Pro-Indian Commission of Acre Area	CPI	Rural	10° 00' 29" S and 67° 54' 6" W
Zoobotanical Park	PZ	Urban	9° 57' 21" S and 67° 52' 22" W
Military Circle	CML	Urban	9° 57' 24" S and 67° 48' 16" W
Horto Florestal	HOR	Urban	9° 56' 41" S and 67° 49' 45" W
Chico Mendes Park	PCM	Urban	10° 02' 8" S and 67° 47' 44" W
Environmental Protection Area of Amapá	APA	Urban	10° 1' 29" S and 67° 48' 33" W
Urban Center of Rio Branco	CURB	Urban	9° 58' 19" S and 67° 48' 27" W

fragment. Connectivity was defined as the inverse of the average distance between the sampled fragment edge and the edge closest to all existing surrounding fragments within an up to 5 km radius.

4. *Data analysis*

Correlations were calculated by Pearson (r) coefficient and simple linear regressions (Sokal & Rohlf 1995). Diversity indices of Shannon-Wiener (H') and of individual dominance of Berger-Parker (Magurran 1988) were calculated for all fragments studied.

The similarity between fragments in relation to the Euglossine fauna and the landscape structure of the fragments was calculated through the Bray-Curtis index (Beals 1984, Ludwig & Reynolds 1988). In the latter, a data matrix standardized by the standard deviation of the variables was used. The matrix generated by Bray-Curtis index as related to the faunistic composition was also correlated with a similarity matrix generated by the qualitative index of Jaccard (Pielou 1984).

The faunistic similarity and landscape structural matrices between the areas were correlated with the matrix of the spatial distance between them. The significance of the coefficients of these correlations was tested by Mantel permutation test (Sokal & Rohlf 1995). One thousand permutations were used for the calculation of Z, as recommended in Fortin & Gurevitch (1993).

Based on their faunistic similarity and landscape structural matrices, forest fragments were grouped in dendrograms by the UPGMA method (Pielou 1984, Ludwig & Reynolds 1988).

By definition, landscape structural similarity is the similarity between the fragments in relation to area size, perimeter, edge index, connectivity, standard deviation of the connectivity and number of surrounding fragments and the quantity of forest cover existing within the radius of up to 5 km from the sample collection point.

In this work, species that presented more than 11 individuals were considered as common species.

Partial correlations of first order were calculated between the faunistic similarity, the structural similarity and the spatial distance between the fragments (Sokal & Rohlf 1995). This procedure was performed to verify the influence of a variable on the correlation between two others.

Results

In this study 3,675 euglossine males belonging to 4 genera and 36 species were collected (Table 2). *Eulaema cingulata* (Fabricius) (24.6%), *Eulaema meriana* (Olivier) (14.6%), *Euglossa amazonica* Dressler (10.5%), *Eulaema nigrita* Lepeletier (9.7%), *Eulaema pseudocingulata* (Oliveira) (7.2%) e *Euglossa modestior* Dressler (6%) were the most abundant and were present in all fragments. The richness and abundance of euglossine males in the sampling areas correlated significantly (r = 0.78; p = 0.005; df = 9). The more abundant species occurred in a greater number of fragments.

From the total number of individuals, 1,945 (52.9%) were collected in urban fragments and 1,730 (47%) in rural fragments. Approximately 51.4% of the individuals belonging to the genus *Eulaema* Lepeletier and 42.4% of those from *Exaerete* Hoffmannsegg were collected from rural fragments whereas 62.3% of *Euglossa* Latreille and 63.1% of *Eufriesea* Cockerell came from urban fragments. Among the most abundant species *Eufriesea surinamensis* (Linnaeus) and *Euglossa prasina* Dressler occurred exclusively in the urban fragments (Table 2). There was no significant difference in richness between the urban and rural fragments.

The data referring to the fragments' area, perimeter, edge, connectivity, connectivity standard deviation, number of surrounding fragments, as well as the abundance, richness, diversity and dominance of euglossine bees are presented in Table 3. The correlations between landscape variables with richness, abundance and diversity are presented in Table 4. Significant correlations were obtained between richness and edge index (r =–0.85; p = 0.001; df = 9) (Figure 1a) and diversity and edge index (r =–0.74; p = 0.009; df = 9) (Figure 1b).

None of the most abundant species correlated positively with the fragments' edge index. Fragment perimeter correlated with abundances of *Euglossa despecta* Moure (r = 0.62; p = 0.04), *Euglossa cognata* Moure (r = 0.89; p = 0.00), *Eulaema mocsaryi* (Friese) r = 0.61; p = 0.04) and *Exaerete frontalis* (Guérin-Méneville) (r = 0.911; p = 0.00). Fragment area correlated with abundance of *Euglossa despecta* (r = 0.76; p = 0.06), *Euglossa cognata* (r = 0.84; p = 0.00), and *Exaerete frontalis* (r = 0.91; p = 0.00). Connectivity was correlated with abundance of *Euglossa bidentata* Dressler (r = 0.85; p = 0.00), *Euglossa imperialis* Cockerell (r = 0.68; p = 0.01), *E. cingulata* (r = 0.76; p = 0.02), *E. mocsaryi* (r = 0.62; p = 0.04) and *Exaerete smaragdina* (Guérin-Méneville) (r = 0.91; p = 0.00). *Euglossa allosticta* Moure was the only species that correlated positively with the number of surrounding fragments (r = 0.74; p = 0.00).

The Catuaba Experimental Farm, Zoobotanical Park, Amapá's Area of Environmental Protection and Humaitá Reserve were the fragments that presented the greatest richness (Table 3). Catuaba Experimental Farm, Amapá's Area of Environmental Protection,

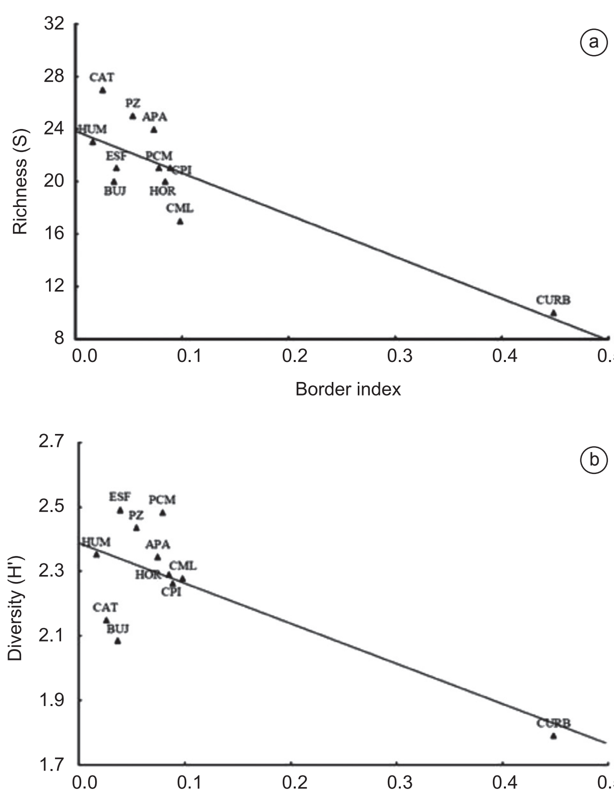

Figure 1. (a) Relation between Euglossine richness (S) and fragment borders in Southwest Amazonia (y = - 31.92x + 23.85; p = 0.001; r^2 = 0.73). (b) Relation between Euglossine diversity (H') and fragment border index of the southwest Amazonia (y = - 1.25x + 2.39; p = 0.009; r^2 = 0.54). HUM = Humaitá Reserve; CAT = Catuaba Experimental Farm; ESF = Forestry School; BUJ = Bujari Private Area; CPI = Pro-Indian Commission of Acre Area; PZ = Zoobotanical Park; CML = Military Circle; HOR = Horto Florestal; PCM = Chico Mendes Park; APA = Environmental Protection Area of Amapá and CURB = Urban Center of Rio Branco.

Table 2. Abundance and richness of Euglossine bees in forest fragments in the Southwest Amazonia. R = Rural; U = Urban; HUM = Humaitá Reserve; CAT = Catuaba Experimental Farm; ESF = Forestry School; BUJ = Bujari Private Area; CPI = Pro-Indian Commission of Acre Area ; PZ = Zoobotanical Park; CML = Military Circle; HOR = Horto Florestal; PCM = Chico Mendes Park; APA = Environmental Protection Area of Amapá and CURB = Urban Center of Rio Branco.

Species	HUM (R)	CAT (R)	ESF (R)	BUJ (R)	CPI (R)	Total (R)	PZ (U)	CML (U)	HOR (U)	PCM (U)	APA (U)	CURB (U)	Total (U)	TOTAL
Eufriesea flaviventris (Friese, 1899)							2	3	1	2			8	8
Eufriesea ornata (Mocsáry, 1896)	1	1				2								2
Eufriesea pulchra (Smith, 1854)	1	2	2	1	1	7	1				1		2	9
Eufriesea superba (Hoffmannsegg, 1817)		5				5	1		2				3	8
Eufriesea surinamensis (Linnaeus, 1758)							4	4	1	2			11	11
Euglossa allosticta Moure, 1969	1	1	10	1	6	19	7	7	13		4	1	32	51
Euglossa amazonica Dressler, 1982	12	34	38	22	48	154	26	10	14	17	162	3	232	386
Euglossa analis Westwood, 1840							1						1	1
Euglossa augaspis Dressler, 1982	6	6	2	1	6	21		1	2	9	9	2	23	44
Euglossa avicula Dressler, 1982		2				2								2
Euglossa bidentata Dressler, 1982	5	18	3	1	2	29	3			1	2		6	35
Euglossa cognata Moure, 1970	9	4	6	3	1	23	4	1		3	1		9	32
Euglossa crassipunctata Moure, 1968	1					1								1
Euglossa despecta Moure, 1968	9	1		4	3	17			1	3	2		6	23
Euglossa gaianii Dressler, 1982							1						1	1
Euglossa ignita Smith, 1874	4	11	7	6	11	39	16	5	4	25	85		135	174
Euglossa imperialis Cockerell, 1922	1	25	1	1	1	29	2			2	11		15	44
Euglossa intersecta Latreille, 1838		2	1			3								3
Euglossa iopyrrha Dressler, 1982	1					1								1
Euglossa magnipes Dressler, 1982		1				1					3		3	4
Euglossa mixta Friese, 1899	3	20	7	5	6	41	29		3	11	2		45	86
Euglossa modestior Dressler, 1982	13	5	4	5	11	38	13	45	19	47	49	12	185	223
Euglossa mourei Dressler, 1982	9	17	14	6	8	54	17	11	18	6	28		80	134
Euglossa orellana Roubik, 2004		6			1	7					6		6	13
Euglossa prasina Dressler, 1982							1		1		11		13	13
Euglossa securigera Dressler, 1982	1			1		2		1	1				2	4
Eulaema bombiformis (Packard, 1869)		4	5	7	7	23	4	2	2	2	5		15	38
Eulaema cingulata (Fabricius, 1804)	84	303	40	107	102	636	95	36	28	11	88	9	267	903
Eulaema meriana (Olivier, 1789)	27	71	45	46	59	248	85	44	41	33	68	19	290	538
Eulaema mocsaryi (Friese, 1899)	13	15	5	7	10	50	13	6	0	2	8	1	30	80
Eulaema nigrita Lepeletier, 1841	4	29	14	11	32	90	69	42	81	21	22	32	267	357
Eulaema pseudocingulata Oliveira, 2006	3	13	8	34	17	75	63	41	37	13	25	11	190	265
Exaerete dentata (Linnaeus, 1758)							0			1			1	1
Exaerete frontalis (Guérin, 1844)	9	7	2			18	1		1	1	1	1	5	23
Exaerete lepeletieri Oliveira & Nemésio, 2003	1	7	5		1	14	10		6		4		20	34
Exaerete smaragdina (Guérin, 1844)	5	55	5	8	8	81	12	9	8	4	9		42	123
Abundance	223	665	224	277	341	1,730	480	268	284	216	606	91	1,945	3,675
Richness	23	27	21	20	21	30	25	17	20	21	24	10	31	36

Table 3. Structural characteristics, richness and abundance of Euglossine bees in forest fragments of Southwest Amazonia.

Collection Location	Perimeter (Km)	Area (ha)	Edge Index	Connectivity (Km)	Connectivity Standard Deviation (Km)	Number of surrounding fragments	Richness (S)	Abundance (N)	Dominance (D)	Diversity (H')
Humaitá Reserve	58.55	3,665	0.02	0.54	864.56	8	23	223	0.38	2.35
Catuaba Experiemental Farm	32.76	1,281	0.03	1.09	683.73	12	27	665	0.46	2.15
Forestry School	27.33	698	0.04	0.76	905.68	15	21	224	0.20	2.49
Bujari Private Area	10.67	290	0.04	0.46	126.98	9	20	277	0.39	2.08
Pro-Indian Commission of Acre Area	6.13	69	0.09	0.47	118.94	14	21	341	0.30	2.26
Zoobotanical Park	11.95	221	0.05	0.64	1216.61	12	25	480	0.20	2.44
Military circle	11.70	119	0.10	0.63	1155.34	8	17	268	0.17	2.28
Horto Florestal	5.15	61	0.08	0.43	1257.14	19	20	284	0.29	2.29
Chico Mendes Park	5.17	65	0.08	0.40	1334.27	9	21	216	0.22	2.48
Environmental Protection Area of Amapá	8.90	120	0.07	0.41	1035.14	12	24	606	0.27	2.35
Urban Center of Rio Branco	0.37	0.83	0.45	0.30	1232.02	12	10	91	0.35	1.79

Table 4. Relation between landscape variables from the forest fragments in Southwest Amazonia and Euglossine richness, abundance and diversity.

Predicting variable	Predicted variable	r	p	g.l.
Area	Richness	0.34	0.307	9
	Abundance	–0.01	0.963	9
	Diversity	0.14	0.68	9
Perimeter	Richness	0.46	0.155	9
	Abundance	0.1	0.757	9
	Diversity	0.25	0.45	9
Edge index	Richness	–0.85	0.001	9
	Abundance	–0.47	0.145	9
	Diversity	–0.74	0.009	9
Connectivity	Richness	0.57	0.061	9
	Abundance	0.54	0.08	9
	Diversity	0.19	0.568	9
Number of surrounding fragments	Richness	0.02	0.944	9
	Abundance	0.09	0.779	9
	Diversity	0.05	0.877	9

Zoobotanical Park and Pro-Indian Commission of Acre Area possessed the greatest abundance of euglossine males. The greatest dominance was verified for Catuaba Experimental Farm, Bujari Private Area, Humaitá Reserve and the Urban Center of Rio Branco. The lowest species diversity was verified for the Urban Center of Rio Branco, when compared with the other fragments (Table 3).

The urban fragments presented the greatest average landscape structural similarity among themselves (81.5%) when compared with the rural fragments (72.5%). The average similarity between all fragments was 75.1%. Among the urban fragments, Chico Mendes Park and Environmental Protection Area of Amapá were the most similar (92.4%) and the most different were those of Environmental Protection Area of Amapá and Urban Center of Rio Branco (72.8%). Among the rural fragments, the most similar were the Forestry School and Catuaba Experimental Farm (86.9%) and the least similar were the Pro-Indian Commission of Acre Area and Catuaba Experimental Farm (63.4%). Considering all fragments, Chico Mendes Park and Bujari Private Area were the most similar (93.8%) and the most different were Humaitá Reserve and Urban Center (52.9%). The formation of two groups as related to the landscape structure of the fragments is depicted by a dendogram (Figure 2a).

In relation to faunistic similarity, the rural fragments presented greater average similarity among themselves (61.9%) than the urban (51.7%). The average similarity between all fragments was 50.5%. The fragments with most similarity with respect to euglossine male composition were Pro-Indian Commission of Acre Area and Bujari Private Area (81.2%) and the least similar were Urban Center of Rio Branco and Catuaba Experimental Farm (21.4%).

Similarity between fragments as related to composition of euglossine is depicted by a dendrogram (Figure 2b). There was a point formation within two main groups. One of these groups was composed solely by urban fragments, and the Urban Center of Rio Branco was the one that differed most. The other group was composed by the rural fragments and by the urban Zoobotanical Park and Environmental Protection Area of Amapá. Within this group, Catuaba Experimental Farm and Environmental Protection Area of Amapá fragments were the most different.

The structural landscape similarity of the fragments was positively correlated with the faunistic similarity ($r = 0.41$; $t_{Mantel} = 2.29$; $p = 0.002$; $df = 53$) (Figure 3).

There was a correlation between Jaccard qualitative similarity index and the Bray-Curtis quantitative similarity index ($r = 0.63$; $p = 0.000$; $df = 53$) but there was no correlation between spatial distance of the fragments and faunistic similarity index ($r =–0.07$; $t_{Mantel} = -0.21$; $p = 0.573$; g.l = 53).

The partial correlation between faunistic similarity and distance maintaining the fragments structure constant was not significant ($r_{distance\ x\ faunistic\ similarity.\ structure} = 0.04$; $t = 0.34$; $p = 0.73$; $df = 52$). There was a partial significant correlation between faunistic similarity and structure that maintained constant distance ($r^{structure\ x\ faunistic\ similarity}_{.distance} = 0.41$; $t = 3.32$; $p = 0.00$; $df = 52$).

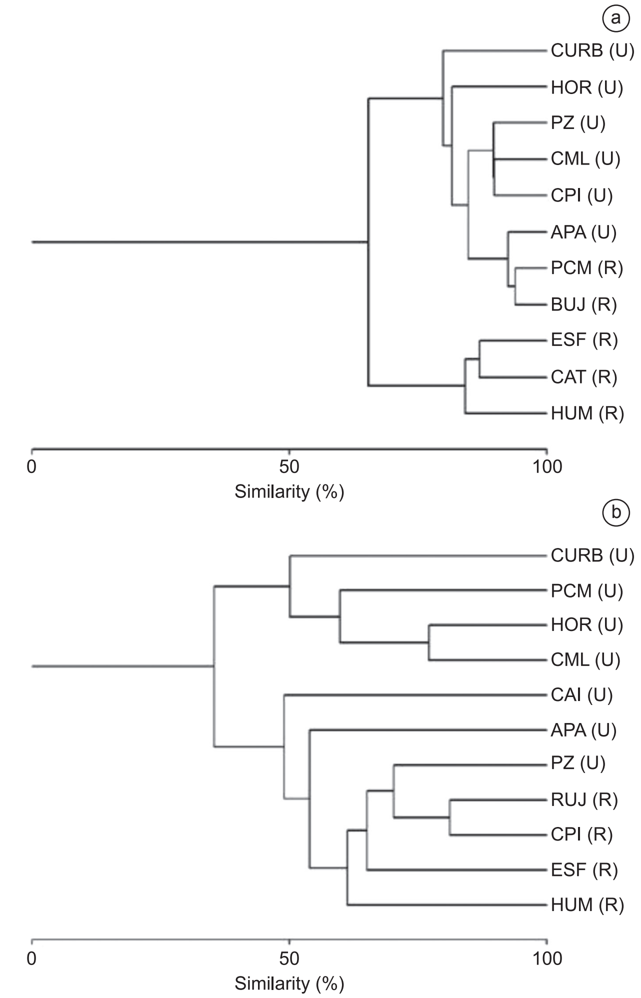

Figure 2. (a) Similarity dendogram between forest fragments of Southwest Amazonia as related to the landscape structure. (b) Similarity dendogram between the collection points as related to composition of Euglossine males. R = Rural; U = Urban; HUM = Humaitá Reserve; CAT = Catuaba Experimental Farm; ESF = Forestry School; BUJ = Bujari Private Area; CPI = Pro-Indian Commission of Acre Area; PZ = Zoobotanical Park; CML = Military Circle; HOR = Horto Florestal; PCM = Chico Mendes Park; APA = Environmental Protection Area of Amapá and CURB = Urban Center of Rio Branco.

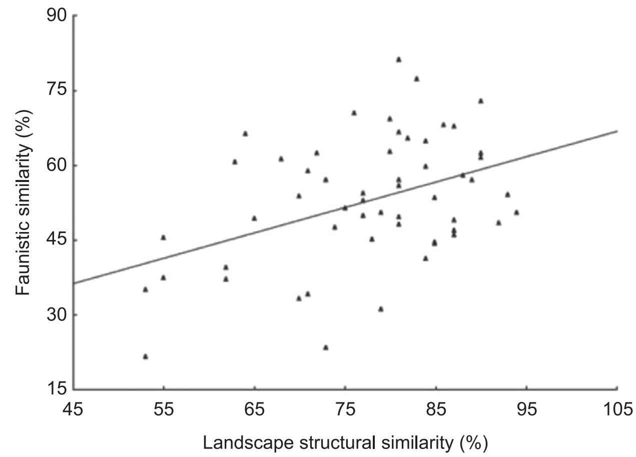

Figure 3. Relation between landscape structural similarity (%) and faunistic similarity (%) of Euglossine in forest fragments in southwest Amazonia ($y = 0.50x + 13.41$; $p = 0.00$; $r^2 = 0.17$). Each point represents one pair of compared areas.

Discussion

The fragments that presented greater abundance of euglossine males also presented the greatest richness. Becker et al. (1991) and Morato (1994) also determined greater richness at the sampling sites where abundance was greatest.

The most abundant species were amply distributed within the region, and were present in nearly all fragments. Thus, communities of euglossine bees in the region are not characterized by abundant and dominant species for a locality. According to Hanski (1982) species that present ample regional distribution are less subject to extinction.

The greatest abundance and richness of euglossine were recorded for the urban fragments. Zanette et al. (2005) determined greater richness of bees and wasps in urban ecosystems in the state of Minas Gerais. According to Saure (1996) these fragments may serve as shelter, centers for dispersion, stepping stones and green islands for rare species.

Most of the species belonging to the genera *Euglossa* and *Eufriesea* were collected from the urban fragments. Furthermore, the presence of five species exclusively in these fragments, among them *Exaerete dentata* (Linnaeus) that had not yet been recorded in the region, are evidence of the importance of these areas for the maintenance of these bees communities.

Parra-H & Nates-Parra (2007) studied the variation in communities of Euglossini in urban, rural, and conservation environments and considered *Eulaema bombiformis* (Packard) and *E. frontalis* to be associated with very conserved areas, a result that was similar to the one obtained in the present study.

The hypothesis tested herein that areas or fragments of larger size possess greater abundance and richness of euglossine bees was not corroborated. Generally, the size of the fragments was not an adequate predictor of abundance and richness of Euglossini. However, the Catuaba Experimental Farm, the second largest fragment, presented greater abundance and richness of these bees and the Urban Center of Rio Branco, the smallest area fragment, presented the lowest abundance and richness. Other studies have also demonstrated that the fragment size has no influence on abundance and richness of Euglossini (Peruquetti et al 1999, Tonhasca Junior et al. 2002, Nemésio & Silveira 2010). In contrast, Brosi (2011) found that Euglossini abundance and richness was significantly positively related to fragment area in southern Costa Rica. Nemésio & Silveira (2007), in Southeastern Brazil, verified that abundance of orchid bees tend to increase with fragment size, although no correlation between species richness and fragment size was obtained.

Becker et al (1991) sampled the same area as Powell & Powell (1987), and did not determine the existence of a relation between fragment size and abundance and richness of Euglossini. However, they registered the presence of *Eufriesea pulchra* (Smith), *E. amazonica*, *E. modestior* and *E. mocsaryi* exclusively in small fragments (1 and 10 ha). Conversely, however, this study registered the presence of *E. pulchra* in fragments of larger area, *E. mocsaryi* was only absent in the Horto Florestal and *E. amazonica* and *E. modestior* were collected in all fragments.

In the present study, as observed in those by Becker et al. (1991) and Powell & Powell (1987), *Euglossa intersecta* (Latreille), *Euglossa crassipunctata* Moure, *Euglossa iopyrrha* Dressler, *E. meriana* e *E. frontalis* were present in the larger size fragments.

Peruquetti et al (1999) recorded greater richness of Euglossini in smaller fragments in the Atlantic Forest, and inferred that the results may be explained by the model of disturbance gradients in which the environments with intermediate rates of disturbance present greater richness of species as also inferred by others (White & Pickett 1985, Pickett & White 1985).

Báldi (2008) detected greater heterogeneity of habitats in smaller areas and determined that the richness of different groups of arthropods is more influenced by the heterogeneity of habitats than the size of the area.

The Humaitá Reserve, fragment of largest area in this study, was not the one to contain the greatest abundance and richness of species. In that location, 223 individuals belonging to 23 species were collected. Nemésio & Morato (2004) collected 254 individuals belonging to 22 species in this same area, although these authors conducted eight samplings on a monthly basis and from different sites within the same area. The similarity between results from this study and that of Nemésio & Morato (2004) indicates the necessity of several collection points within the same area to determine the euglossine fauna of a fragment. Few samplings at fixed points may not be sufficient to accurately represent the populations of these bees. Nemésio & Morato (2006) collected 1024 individuals belonging to 29 species at Catuaba Experimental Farm and 720 individuals belonging to 27 species at the Zoobotanical Park. Results from the present study were similar for richness of Euglossini in both areas. Thus, the large quantity and richness of individuals collected in fragments of smaller size demonstrates the importance of conservation of small forest areas in an urban matrix. In other parts of the world, in different biomes, studies have been demonstrating the importance of these vegetation islands in urban matrices for the conservation of bees' populations (Matheson et al 1996).

The hypothesis that fragments with greater edge areas possess different abundance and richness from those with smaller edge areas was partially corroborated. The abundance of euglossine bees was not affected by fragment edge area. However, fragments that had smaller edge areas were the ones that presented greater richness and diversity of euglossine bees.

Powell & Powell (1987) verified that orchid bee visitation indices decreased after areas in the Biological Dynamics of Forest Fragments Project, Manaus, Amazonas, were isolated. Morato (1994) collected greater abundance of Euglossini in forest areas than in edge areas and in cleared areas in Central Amazonia and did not detect significant differences regarding richness of bees in any of these three environments. The results indicated that some species present certain preference patterns. According to Nemésio & Silveira (2006) the specific responses of euglossine bees are more important to evaluate edge effects than their abundance and richness.

Morato (1994) verified *Euglossa securigera* Dressler and *E. mocsaryi* preference for edge areas and cleared areas. However, in this study, presence of *E. securigera* occurred in two fragments with large edge areas, and in two with smaller areas. Presence of *E. mocsaryi* was not registered only in the Horto Florestal, fragment with the greatest edge area.

Nemésio & Silveira (2006) collected more abundance of *Euglossa analis* Westwood in the interior of the forest and of *E. cingulata* close to the edge. The only individual of *E. analis* registered in this study was collected in the Zoobotanical Park, a fragment with intermediary edge size. With respect to *E. cingulata* the majority of the individuals (70.5%) were collected in rural fragments that possess, on average, smaller edge areas than the urban ones.

In general, insects respond in a different manner to the different types of environmental disturbance (Schowalter 1985, Samways 1994). The difference between results from the present study and those of Morato (1994) and Nemésio & Silveira (2006) may be associated with factors other than edge effects. According to Armbruster (1993) the environmental heterogeneity may also explain local distribution patterns of the euglossine species.

The hypothesis that fragments with greater connectivity have greater abundance and richness of bees was partially corroborated. In general, abundance of individuals was not significantly affected by connectivity of the areas. However, the more connected fragments presented greater richness of Euglossini. Nevertheless, the quantity of surrounding fragments sampled did not interfere with species richness. This may be related to the greater flight capacity of these species (Janzen 1971, Raw 1989). Thus, small cleared areas do not constitute effective barriers for these communities.

The Catuaba Experimental Farm, the site that presented the highest connectivity, was the fragment that had the greater abundance and richness of species whereas the Urban Center of Rio Branco, area of lowest connectivity, had the lowest abundance and richness.

The great majority (74.8%) of individuals belonging to the *E. nigrita* species in this study were collected in urban fragments. The greatest and smallest proportions of this species were collected, respectively, in the Urban Center of Rio Branco and Humaitá Reserve. The presence of *E. nigrita* in the National Park of Serra do Divisor, state of Acre, was not registered by Morato (2001), and this another indication that this species does not occur within areas of conservation.

According to Janzen (1983) certain groups of animals that occur in fragments can forage in more open environments and impacted edges. Therefore, the quantity of vegetation patches in an urban matrix can be very important for the conservation of euglossine bees.

Tonhasca Junior et al. (2002) verified a decrease in faunistic similarity associated with the euglossine fauna with the increase in distance between the sampled fragments. In the present study, the closest fragments were the ones that presented most similarity in association with the landscape structure. Therefore, the distance between the fragments had no effect in the faunistic similarity between them. The closest fragments were not necessarily those with more similarity in regards to species composition.

Fragments that presented greater structural landscape similarity also possessed greater faunistic similarity. The correlation between distance and faunistic similarity between the fragments, maintaining the structural similarity of the landscape constant, was not significant. But, when the distance is maintained constant, a significant correlation was obtained between faunistic similarity and fragments structure. Hence, the structure of the fragments explains to a great extent the faunistic composition of a given site.

Other factors such as availability and diversity of food sources, nesting sites, sources of odoriferous substances and availability of mating sites may have influenced the results obtained in this study, and consequently the euglossine population structure.

Thus, forest cover and the quality of the matrix surrounding the fragments is much more important for the understanding of the effects of forest fragmentation upon the euglossine bees than the structural characteristics of the fragments that have been previously studied, such as the area. Therefore, hypotheses considering the internal structure and the floristic composition of the fragments should be evaluated in future studies.

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