

SHORT COMMUNICATION

Within-habitat heterogeneity of euglossine bee populations: a re-evaluation of the evidence

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Euglossine bees (Hymenoptera: Apidae: Euglossini) are considered keystone species in the neotropics because of their role as pollinators of several plant species, particularly orchids (Dodson *et al.* 1969, Roubik 1992). Pollination by male euglossine bees occurs when they visit flowers to collect fragrances, which may be used for courtship (Eltz *et al.* 1999) or attraction of other males and females (Peruquetti 2000). Synthetic products that mimic those fragrances have been used frequently in studies of euglossine bee ecology and population structure (Armbruster & McCormick 1990, Powell & Powell 1987, Roubik & Ackerman 1987). The ability of euglossine bees to disperse and find isolated flowers and distant baits (Dressler 1968, Janzen 1971) has led Janzen (1981) and Janzen *et al.* (1982) to suggest that bees attracted to fragrances come from a wide area that may include different habitats. According to this hypothesis, individuals collected at baiting stations are part of the same pool of bees. However, Armbruster (1993) found significant variation in the number of bees collected at nearby baiting stations, and he considered these differences as demonstration of within-habitat heterogeneity of the euglossine bee community. In Armbruster's model, results of bait collections are strongly affected by the concentration of resources in 'hot spots', therefore a sampling station would not necessarily represent the habitat, but only particular microhabitats.

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In this note, we present new data on the within-habitat distribution of euglossine bees attracted to synthetic baits and offer an interpretation of the data that differs from Armbruster's (1993). These observations are part of a larger study conducted to evaluate the abundance and diversity of euglossine bees in the Brazilian Atlantic Forest. The study area consisted of forests and a landscape of pastures and disturbed Forest fragments. The study was conducted at several sites from an area of approximately 230 km² around the village of Sossego do Imbé (21°53'S, 41°48'W), Rio de Janeiro State, Brazil. The data presented here refer to six occasions when samples were collected simultaneously at two or three sampling stations at three sampling sites. Distances between stations were approximately 200 m in sites 1 and 3, and 350 m in site 2. At each station a string was tied between two trees at approximately 1.5 m above the ground. The string was positioned perpendicular to the declivity, which is the usual direction of the prevailing wind. Pieces of blotting paper (7 × 7 cm) were fixed at approximately 40-cm intervals along the string, and each piece of paper was impregnated with 2 ml of one of the following chemicals: cineole, eugenol, methyl salicylate, methyl cinnamate, skatole and vanillin. Fragrances were replenished every 1.5 h except for cineole, which was replenished every 30 min because of its high volatility. Male euglossine bees that landed on the paper were captured with an insect net and transferred to plastic vials. Bees that could be identified in the field were released at the end of the sampling period, otherwise they were killed and brought to the laboratory for identification. Sampling started from 09h00 to 10h00 and continued until 15h00, weather permitting. Voucher specimens were deposited at the entomological museum of the Universidade Estadual do Norte Fluminense.

Eulaema nigrita was the dominant species for the four sampling dates in site 1 (Table 1), but their numbers were variable between sampling stations. In fact, the differences in *E. nigrita* numbers were statistically significant for all sampling dates ($P < 0.05$) according to the G-test (Sokal & Rohlf 1995). Armbruster (1993) used a similar statistical treatment (log-likelihood chi-square) to evaluate his data, which are similar to those presented in Table 1, and concluded that within-habitat assemblages of euglossine bees for four sampling dates at three locations were not related. However, we believe that statistical analyses based on frequencies are not appropriate for these data because of their sensitivity to sample sizes. For large samples, even small departures from the average are likely to be statistically significant. However, many hours of observations of species that could be identified in the field (e.g. *E. nigrita*, *E. cingulata* and *E. analis*) have shown us that clusters of individuals arrive at the fragrances in intermittent bursts during long periods of inactivity. This sporadic arrival of bees to baits is the likely result of vicissitudes such as changes in the speed and direction of wind, temperature and cloud cover. For example, during still days we frequently observed bees arriving at baits shortly after an occasional gust of wind. Because these conditions are erratic and probably highly affected by local characteristics of the terrain, particularly in the

Table 1. Number of euglossine bees collected at two or three sampling stations (A–C) at three sites. * indicates that bees were not sampled.

Site	Date	Species	A	B	C		
1	12 January 1998	<i>Eulaema nigrita</i> Lepeletier	51	38	23		
		<i>Eulaema cingulata</i> (F.)	0	11	3		
		<i>Euglossa cordata</i> grp.	2	1	0		
		<i>Euglossa sapphirina</i> Moure	0	1	0		
		<i>Euglossa securigera</i> Dressler	1	0	0		
		<i>Euglossa annectans</i> Dressler	0	1	3		
		<i>Euglossa</i> nr. <i>nigropilosa</i>	2	2	0		
1	6 March 1998	<i>E. nigrita</i>	44	34	16		
		<i>E. cingulata</i>	5	4	3		
		<i>E. annectans</i>	0	1	0		
1	18 January 1999	<i>E. nigrita</i>	20	7	11		
		<i>E. cingulata</i>	2	1	2		
		<i>E. cordata</i> grp.	5	4	7		
		<i>E. sapphirina</i>	0	0	1		
		<i>E. securigera</i>	1	0	0		
		<i>Euglossa pleosticta</i> Dressler	0	0	2		
		<i>Euglossa cybelia</i> Moure	0	0	1		
		<i>Eufriesea</i> sp.	0	0	1		
		1	14 March 1999	<i>E. nigrita</i>	29	19	*
				<i>E. cordata</i> grp.	3	3	*
<i>Euglossa fimbriata</i> Rebelo & Moure	0			2	*		
<i>E. nigrita</i>	5			5	*		
2	10 May 1998	<i>E. cingulata</i>	3	0	*		
		<i>E. cordata</i> grp.	0	1	*		
		<i>E. sapphirina</i>	3	6	*		
		<i>E. securigera</i>	1	0	*		
		<i>Euglossa chalybeata</i> Friese	1	0	*		
		<i>Euglossa analis</i> Westwood	2	0	*		
		<i>E. pleosticta</i>	1	1	*		
		<i>Euglossa</i> nr. <i>deceptrix</i>	0	1	*		
		<i>Euglossa</i> nr. <i>cyanura</i>	1	0	*		
		3	9 June 1998	<i>E. nigrita</i>	0	2	*
<i>E. cordata</i> grp.	0			1	*		
<i>E. sapphirina</i>	14			5	*		
<i>E. securigera</i>	3			12	*		
<i>E. chalybeata</i>	1			0	*		
<i>E. nr. deceptrix</i>	11			8	*		

steep hills of Atlantic Forest remnants, it would be unreasonable to expect an even distribution of individuals among sites. Additionally, the number of local captures can be affected by males' aggregation behaviour (Kimsey 1980).

A better analysis of homogeneity between samples should take into consideration the relative abundance of the species and give less importance to the numerical differences between collections. This could be accomplished for example by the Morisita index of similarity; the calculation of the index is given by Southwood & Henderson (2000), following the rationale discussed by Morisita (1959) and Horn (1966). Values of the Morisita index of similarity between sampling stations at site 1 for January 1999 were 0.94 (A–B), 0.98 (A–C) and 0.99 (B–C). For January 1998, results were 0.89 (A–B), 0.58 (A–C) and 0.26 (B–C). Data from March 1998 and March 1999 were not analysed because of the reduced number of species on those dates. Nonetheless, results from any station demonstrated

an equivalent trend at site 1: dominance of *E. nigrita* and reduced abundance of euglossine bees in March. The Morisita index of similarity values between sampling stations were 0.92 and 0.74 for sites 2 and 3, respectively. Under this approach, all sampling stations on January 1998 at site 1 and stations A and B on January 1999, as well as sampling stations at site 2 (Table 1) were highly similar. Because different species were dominant at each sampling station, similarity at site 3 was lower. The only highly discordant sample was station C at site 1 in 1999 (Table 1). Comparisons between sites on the other hand yielded considerably lower similarity, which reflected different species compositions; 0.64 between site 1 (data from 12 January 1998) and 2, and 0.07 between sites 1 and 3. The paired data in three euglossine bee collections from Tables 1, 3 and 4 from Armbruster (1993) are also similar, with Morisita index values of 0.97, 0.92 and 0.91, respectively (results from his Table 2 were excluded because most specimens were from unknown species).

The previous analyses expressed the trend shown in most of our data and in Armbruster's (1993) results; there was some variability between sampling stations in the number of individuals collected, but the euglossine bee communities within sites were similar. Most sampling stations had the same dominant species at each site, and there was considerable overlap in the species present. Roubik (2001) reached similar conclusions by comparing the abundance of dominant euglossine bee species in simultaneous samples conducted near Armbruster's (1993) site. The similarity between sampling stations is the likely consequence of the dispersal capability of euglossine bees. Large species can fly long distances over open terrain (Ackerman & Montalvo 1985, Dressler 1968), but smaller *Euglossa* are also strong flyers. Raw (1989) determined that marked *E. cordata* are able to travel 4 km over non-forested areas in a 30-d period. We recorded flight distances of marked *Euglossa* spp. of up to 1 km between sampling stations inside the forest (unpubl. data). These observations were obtained with simultaneous sampling as described above, thus bees were able to find the source of fragrances in a matter of hours.

Armbruster (1993) rightly pointed out the necessity of multiple baiting stations in studies of euglossine bee populations; repeated sampling reduces the statistical noise caused by variability in the abundance of common species as well as by the presence of rare species. However, our results of simultaneous sampling and the characteristics of euglossine bee dispersal do not suggest small-scale population heterogeneity. At the very least, there is not enough evidence for rejecting the hypothesis that numerical differences between nearby sampling stations are caused by sampling variability. The density of male euglossine bees may be higher at sites with greater resource availability, but the local concentration of resources does not prevent bees from accessing nearby areas.

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