

POPULATION DYNAMICS OF EUGLOSSINAE BEES (HYMENOPTERA, APIDAE) IN AN EARLY SECOND-GROWTH FOREST OF CAJUAL ISLAND, IN THE STATE OF MARANHÃO, BRAZIL

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(With 5 figures)

ABSTRACT

A study was conducted in an early second-growth forest aiming at knowing the richness, relative abundance, seasonal distribution, and hourly frequency of euglossine bees, and their association with scent baits. Male bees were attracted to cineole, vanillin, methyl salicylate, and eugenol. The baits were hooked 1.5 m high and 6 m from one another. The specimens were collected from December 1997 to November 1998, once a month, from 7:00 to 17:00 h. A total of 339 male euglossine bees were caught, accounting for 19 species and four genera. The most common species was *E. cordata*, making up 69.9% of the individuals, followed by *E. truncata* (2.3%), *E. violaceifrons*, and *E. smaragdina* (2.1%). The most attractive scent was cineole, which baited 87% of the specimens and 73.7% of the species. Vanillin, the second most visited bait, lured 7.6% of the specimens and 26.3% of the species. *E. surinamensis* was only collected with this bait. Methyl salicylate and eugenol baited combined 2.6% of the specimens. However, by species numbers Methyl salicylate attracted 21% whereas eugenol was attractive for 15.8% of them. In general, the species were more abundantly found in the rainy season (January-June). The hourly activity data showed that the euglossine bees were attracted to the baits all day long, but at a higher frequency in the morning period, peaking between 8:00 and 10:00 h.

Key words: Euglossinae, Cajual Island, scent baits, Maranhão.

RESUMO

Dinâmica de população de abelhas Euglossinae (Hymenoptera, Apidae) em uma área de capoeira da ilha de Cajual, Estado do Maranhão, Brasil

Realizou-se o presente estudo em uma área de capoeira, objetivando conhecer a riqueza, a abundância relativa, a distribuição sazonal, a frequência horária e a associação de espécies de Euglossinae com as iscas odoríferas. As abelhas (machos) foram atraídas por iscas de cineol, vanilina, salicilato de metila e eugenol, as quais encontravam-se a 1,5 m do solo e a uma distância de 6 m uma das outras. As coletas foram realizadas de dezembro/97 a novembro/98, uma vez por mês, das 7 às 17 horas. Foram amostrados 339 machos, distribuídos em 19 espécies e 4 gêneros. A espécie mais abundante foi *E. cordata*, representada por 69,9% dos indivíduos, seguida por *E. truncata* (2,9%), *E. violaceifrons* e *E. smaragdina* (2,1%). O composto mais atrativo foi o cineol, que atraiu 87% dos indivíduos e 73,7% das espécies. Vanilina atraiu 7,6% dos indivíduos e 26,3% das espécies, sendo a segunda isca mais visitada. *E. surinamensis* foi capturada somente nessa essência. Salicilato de metila e eugenol atraíram juntos 2,6% dos indivíduos. Salicilato de metila atraiu 21% das espécies, eugenol, 15,8%. Em geral,

as espécies apresentaram maior frequência nos meses chuvosos (janeiro-junho). Os machos frequentaram as essências durante todo o dia, porém com maior frequência no período matutino, cujo pico observado foi entre 8 e 10 horas.

Palavras-chave: Euglossinae, Ilha do Cajual, iscas-odores, Maranhão.

INTRODUCTION

The studies on euglossine bees conducted in Maranhão State were reviewed by Rebêlo & Silva (1999), who presented a list of the known species in northern Maranhão, using an ecological and biogeographical approach. These authors focused on the diversity of ecosystem and climate found in the state, linking this to regional distribution of the species. They found of euglossine bees in the whole northern part of Maranhão, and also pointed out that species richness was higher in the Amazonian part of the State.

Over the past thirty years, the developmental and settling process in the northern part of Maranhão led to unparalleled deforestation of primary vegetation (forests, savannas, and transitional areas). The anthropogenic activity has modified regional ecology, directly influencing the distribution pattern of local fauna, including euglossine bees. Due to this progressive alteration, knowledge of the fauna in the several environments of the State is of great relevance.

One of the areas most disturbed by anthropic intrusion is the coastal zone where Cajual Island, the target study site, is located. There, the primary

vegetation has been changed into an early second-growth forest called “capoeira”. This study aims to determine species richness, relative abundance, daily and annual distribution, and association of the euglossine bees with the essences used employed as bait, as well as to compare Cajual Island with other previously studied areas.

MATERIAL AND METHODS

Study area

Cajual Island is located in the inner Maranhão Gulf, western coast of Maranhão State, between 02°26'S and 44°03'W and about 18 km from São Luís, the state capital (Fig. 1). The island has about 6,000 ha and is approximately 4 km away from the municipality of Alcântara, to which it belongs.

The island is part of the Environmental Protection Area of Maranhão's western seashore and was recently incorporated into the Western Hemisphere Shorebird Reserve Network (WHSRN). Cajual Island has muddy and sandy beaches and is surrounded by an extensive estuarine area, the waters thereof, among other factors, offer optimal conditions for mangrove development.

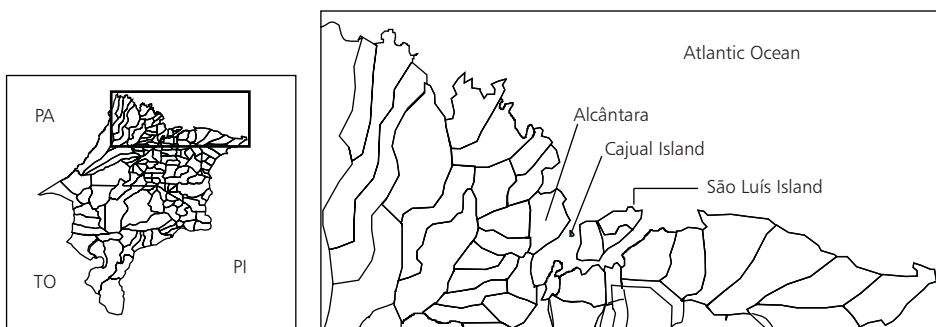


Fig. 1 — Map of the Maranhão State showing Cajual Island, where this research was done.

The island's vegetation originally comprised moist tropical broadleaf forest and mangrove (IBGE, 1984). As a consequence of economic activity of the population, originally from inland maranhão (small farmers and fishermen), a mixed forest, made up of second-growth forest, babassu palm forest, and other vegetal formations, replaced the original vegetation. Environmental impacts are represented chiefly by agricultural areas, grazing land, and wood extraction for both home building and coal production.

Sampling

The scent compounds used for baiting bees were cineole, vanillin, methyl salicylate, and eugenol. Baits were hooked 1.5 m high and set 8 m from one another. Pellets were soaked with their respective essence every two hours.

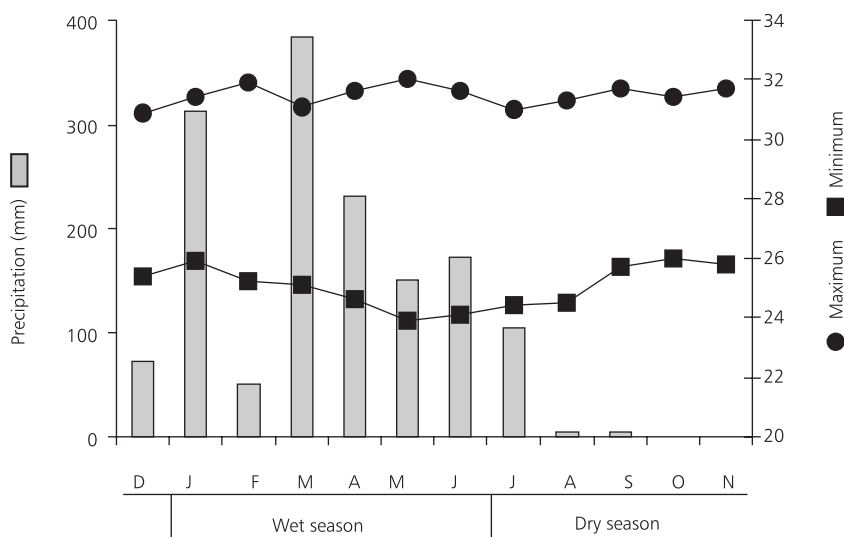
Captures were carried out from December 1997 to November 1998, once a month, between 7:00 and 17:00 h. The bees attracted to baits were collected with entomological nets, put into gas chambers containing ethyl acetate, and then

deposited in plastic bags labeled with the name of the collector, day, place, hour and bait on which each bee was captured. In the laboratory, the specimens were identified and placed in the entomological collection of the Department of Pathology, Federal University of Maranhão.

The data on temperature and humidity were provided by Companhia Vale do Rio Doce (CVRD) climate station (Fig. 2). At the collecting site, information on overall cloud cover, wind speed, temperature, and relative humidity were also taken.

RESULTS

A total of 339 male euglossine bees were sampled, comprising 19 species of the following four genera: *Euglossa*, accounting for 84.4% and 9 species, *Eulaema* (10.6% and 3 species), *Eufriesea* (2.9% and 6 species), and *Exaerete* (2.1% and 1 specie) (Table 1). The most abundant species was *E. cordata*, which represented 69.9% of the individuals taken, followed by *E. truncata* (2.9%), *E. violaceifrons*, and *E. smaragdina* (2.1%).



Months	D	J	F	M	A	M	J	J	A	S	O	N
Maximum	30.9	31.4	31.9	31.1	31.6	32.0	31.6	31.0	31.3	31.7	31.4	31.7
Minimum	24.4	25.9	25.2	25.1	24.6	23.9	24.1	24.4	24.5	25.7	26.0	25.8
Precipitation	72	313	51	384	231	150	172	104	5	5	0	0

Fig. 2 — Maximum and minimum temperature values and precipitation, provided by Companhia Vale do Rio Doce (CVRD) climate station, December 1997 to November 1998.

TABLE 1
Species of euglossine attracted to scent baits on Cajual Island, Maranhão State, from December 1997 to November 1998.

Euglossinae/baits	Cineole	Vanillin	Methyl salicylate	Eugenol	Total
<i>E. cordata</i>	234	–	–	–	234
<i>E. fimbriata</i>	1	–	–	–	1
<i>E. gairanii</i>	–	–	3	–	3
<i>E. modestior</i>	2	–	–	–	2
<i>E. piliventris</i>	1	–	–	–	1
<i>E. securigera</i>	2	–	–	–	2
<i>E. townsendi</i>	2	–	–	–	2
<i>E. truncata</i>	18	16	–	–	34
<i>E. violaceifrons</i>	7	–	–	–	7
<i>E. elegans</i>	–	–	–	1	1
<i>E. magroglossa</i>	1	–	–	–	1
<i>E. mussitans</i>	1	–	–	–	1
<i>E. pulchra</i>	1	–	3	–	4
<i>E. superba</i>	–	–	1	–	1
<i>E. surinamensis</i>	–	2	–	–	2
<i>E. cingulata</i>	–	4	–	6	10
<i>E. meriana</i>	1	–	2	–	3
<i>E. nigrita</i>	20	3	–	–	23
<i>E. smaragdina</i>	4	1	–	2	7
Individuals	295	26	9	9	339
Species	14	5	4	3	19

The most effective scent was cineole, which baited 87% of the individuals and 73.7% of the species (Table 1 and Fig. 3). It was visited solely by *E. cordata*, *E. townsendi*, and *E. violaceifrons* (Table 1). Vanillin baited 7.6% of the individuals and 26.3% of the species, representing the second most attractive bait. *E. surinamensis* was captured only by this bait. Methyl salicylate and eugenol attracted together 2.6% of the individuals. Methyl salicylate alone baited 21% of the species, attracting *E. pulchra* and *E. meriana* as the most frequent species, and *E. gairanii* and *E. superba* as exclusive visitors. Eugenol baited 15.8% of the species (Table 1). Cineole was significantly more attractive than all other baits together ($\chi^2 = 185.84$ and $p < 0.01$).

The species were captured mostly in the rainy season (January-June) ($\chi^2 = 40.38$ and $p < 0.01$). The peaks of number of individuals were detected in

March and April, whereas peaks for number of species were in April and June (Table 2 and Fig. 4). *E. cordata* occurred year round, however it was more abundant between March and May. The low number of individuals of this species in December was partially due to rain on the sampling day. *E. nigrita*, *E. cingulata*, and *E. truncata* visited the baits in a restricted period of the year (Table 2), from February to August. The remaining species were found scattered throughout the year (Table 2). All *Eufriesea* species occurred only in the rainy season, in either one, two, or three months. The mean precipitation monthly values of rainfall correlated positively with individual abundance numbers ($r = 0.73$).

Data on the hourly activity showed that euglossine bees visited the baits all day long, but were more frequently taken in the morning period ($\chi^2 = 157.4$ and $p < 0.01$).

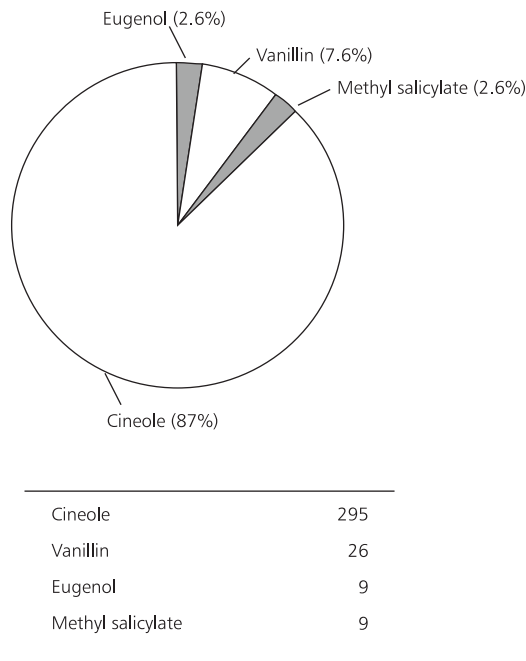


Fig. 3 — Attraction pattern of euglossine species to the odorous substances collected on Cajual Island, Maranhão, from December 1997 to November 1998.

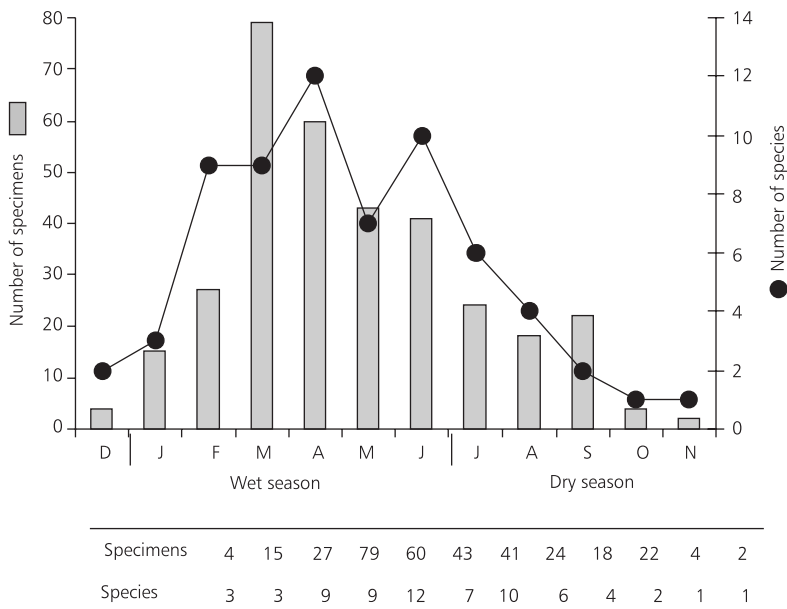


Fig. 4 — Season distribution of the euglossine bees collected on Cajual Island, Maranhão, from December 1997 to November 1998.

TABLE 2
Seasonal distribution of euglossine species collected at scent baits on Cajual Island, Maranhão, from December 1997 to November 1998.

Species/months	D	J	F	M	A	M	J	J	A	S	O	N	Total
<i>E. cordata</i>	3	10	18	65	34	28	20	14	15	21	4	2	234
<i>E. fimbriata</i>	–	–	–	–	–	–	1	–	–	–	–	–	1
<i>E. gaianii</i>	–	–	–	–	1	–	2	–	–	–	–	–	3
<i>E. modestior</i>	–	–	–	–	–	–	2	–	–	–	–	–	2
<i>E. piliventris</i>	–	–	–	–	1	–	–	–	–	–	–	–	1
<i>E. securigera</i>	–	–	–	–	–	1	–	1	–	–	–	–	2
<i>E. towsendi</i>	–	–	1	1	–	–	–	–	–	–	–	–	2
<i>E. truncata</i>	–	–	1	7	12	4	6	3	1	–	–	–	34
<i>E. violaceifrons</i>	–	–	1	–	3	1	1	1	–	–	–	–	7
<i>E. elegans</i>	–	–	–	–	1	–	–	–	–	–	–	–	1
<i>E. magroglossa</i>	–	–	–	–	1	–	–	–	–	–	–	–	1
<i>E. mussitans</i>	–	–	1	–	–	–	–	–	–	–	–	–	1
<i>E. pulchra</i>	–	–	2	1	1	–	–	–	–	–	–	–	4
<i>E. superba</i>	–	–	–	1	–	–	–	–	–	–	–	–	1
<i>E. surinamensis</i>	–	–	–	1	1	–	–	–	–	–	–	–	2
<i>E. cingulata</i>	–	1	1	1	3	3	1	–	–	–	–	–	10
<i>E. meriana</i>	–	–	–	1	–	–	1	–	1	–	–	–	3
<i>E. nigrita</i>	1	4	1	1	1	5	6	4	–	–	–	–	23
<i>E. smaragdina</i>	–	–	1	–	1	1	1	1	1	1	–	–	7
Total of individuals	4	15	27	79	60	43	41	24	18	22	4	2	339
Total of species	2	3	9	9	12	7	10	6	4	2	1	1	19

The most eclectic species was *E. cordata*, which visited the baits in all periods, with peaks observed between 8:00 and 10:00 h. corresponding to the general activity peak of euglossine bees on Cajual Island (Fig. 5). The large numbers of individuals of *E. cordata* were responsible for the activity peak in the afternoon period (14:00-16:00 h). *E. truncata* visited the baits in almost all periods, but were absent between 12:00 and 13:00 h. In general, *Eufriesea* and *Eulaema* species were limited to a short period of the day. *E. meriana* visited the baits early in the morning. At that time (6:00-7:00 h) the most frequently found species were *E. cordata*, *E. truncata*, and *Eulaema*.

DISCUSSION

The fauna of euglossine bees of Cajual Island is similar to that found in the neighboring muni-

cipality of Alcântara (Gonçalves *et al.*, 1996), about 4 km away, as well as that encountered in other areas with similar phytogeographic and climatic features in the northern part of the State (Rebêlo & Silva, 1999), however, it was quite different from that of São Luís Island bee fauna, in the Maranhão Gulf zone. This could possibly be due to the presence of residual moist forests there, which are characteristically Amazonian areas. The distance between the islands of Cajual and São Luís is approximately 18 km in a straight line by the sea, which may constitute a barrier to the migration. On the other hand, the short distance between Cajual Island and Alcântara, led us to suppose that some specimens caught on the former, would come from the latter to forage. Euglossine bees are able to fly over 5 km (Janzen *et al.*, 1982). Many species found on Cajual Island also occur in different Brazilian biogeographic areas.

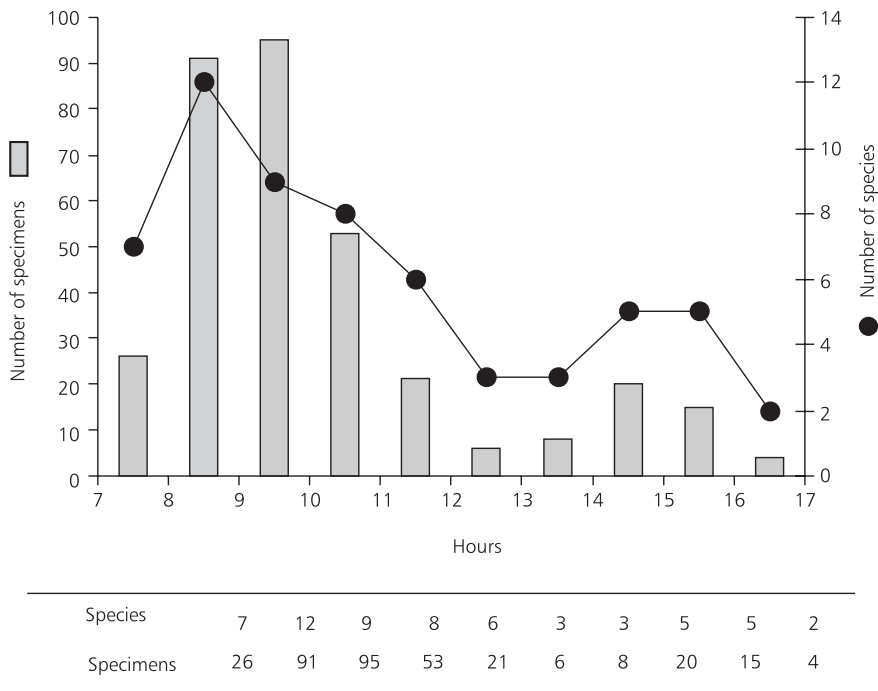


Fig. 5 — Hourly activity of the euglossine species collected on Cajual Island, Maranhão, from December 1997 to November 1998.

Thus, they seem to support a wide climatic variation, as well as geographic range. Changes in abiotic factors, such as a decrease in mean moisture rate, and an increase in temperature (28-34°C) throughout the year (data obtained at the sampling site) in addition to deforestation seemed to be no barrier to the occurrence of the species there. Conversely, these same factors markedly influenced daily activity.

E. cordata, the most abundant species, is often associated with open areas in which the air is somewhat drier (Ducke, 1902), such as savannas, xeric shrublands, river-edge vegetation, grasslands and second growth forest. It is yet to be detected in wet Amazonian areas. In inventories conducted in Central Amazonia using scent baits, this species was not found (Becker *et al.*, 1991; Morato *et al.*, 1992; Oliveira & Campos, 1995). Nevertheless, in southwestern Amazonia (Buriticupu, MA), as reported by Silva & Rebêlo (1999), as well as in sub-Amazonian areas (Wittman *et al.*, 1988; Raw, 1989; Rebêlo & Garófalo, 1991, 1997; Neves &

Viana, 1999), *E. cordata* was found in abundance using cineole. This is despite the fact that in Buriticupu, as an Amazonian Broadleaf forest (Hueck, 1972), it tolerates a 5-6 month drought period (Silva & Rebêlo, 1999) similar to those of semi-humid areas found in most of Maranhão, specially in the near portion of Piauí State.

This northwestern influence may account for the occurrence of *E. cordata* in that region. The abundance of this species in Cajual Island, and in other equivalent areas in the state (Rebêlo & Cabral, 1997; Rebêlo & Silva, 1999), strengthen the hypothesis that *E. cordata* may be a species favored by conditions in these dry and altered environments.

In general, the attraction pattern to the baits on Cajual Island was comparable to those found in most studies using scent baits.

Most of the species visited cineole, chiefly *E. cordata* (100%), corroborating the works in which this species was strongly attracted to the same essence (Raw, 1989; Rebêlo & Garófalo,

1991; Rebêlo & Cabral, 1997; Neves & Viana, 1999; Silva & Rebêlo, 1999). *E. nigrita*, another species abundantly captured in the island, was attracted by both cineole and vanillin. Similar results were found by Rebêlo & Garófalo (1991) and Silva & Rebêlo (1999).

Some exceptions to the general attraction pattern were observed. The only two individuals of *E. townsendi* limited themselves to cineole. This diverged from what was found in Central America by Ackerman (1989), who showed species visited solely methyl salicylate. *E. truncata* that this was attracted only to cineole and vanillin, the most effective scents in this study, unlike results found in northern São Paulo by Rebêlo & Garófalo (1991, 1997) and in Amazonian Maranhão by Silva & Rebêlo (1999), where cineole and eugenol were the most effective.

E. smaragdina was attracted to almost all the essences, especially cineole. In the current study, methyl salicylate was not attractive to *E. smaragdina*, which corroborates the result found for the Amazonian and eastern parts of Maranhão (Silva & Rebêlo, 1999; Rebêlo & Cabral, 1997). In the Costa Rican deciduous forests, *E. smaragdina* was attracted to all baits employed, including methyl salicylate (Janzen *et al.*, 1982). This chemical substance was also used in work carried out in the States of São Paulo (Rebêlo, pers. obs.) and Bahia (Neves & Viana, 1999), but did not attract any male euglossine bees in those areas, as also noted for other parts of the neotropical region. It is presumed that the three known orchid species producing this scent (Williams & Whitten, 1983), are distributed restrictedly and that the interface orchid-scent-euglossine must exist, in addition to other factors. The age, genetic differences among euglossine populations, and the essence's active substance and availability (Ackerman, 1989), as well as minor molecular adjustments, such as the lack of a chemical compound (Williams & Dodson, 1971), may all affect and act on geographic preferences for the scents potential attractiveness.

The bee preference for essences as baits must be carefully evaluated, as there are numerous intrinsic and extrinsic factors influencing this choice. Climatic parameters such as wind or direct insolation may affect scent volatilization level at collection sites. Cineole is a very volatile substance

(low molecular weight) compared to eugenol and for that reason is capable of generating an overwhelmingly greater attraction range, when compared to the dispersing scope of eugenol. This means that a highly volatile substance could attract an eclectic species (those attracted by several essences) from further away. However, when approaching the source the specimen could change its original route and land on an adjacent bait, whose scent is more pungent, regardless of its shorter range of attraction. An additional point is that some species associate with only one substance in a given geographic area and with more than one in other parts of their range. Thus, the term "preference" would be inexact. In this case, to assess the actual preference for any substance used as bait, a specific study for that purpose must be designed.

Among the species found on the island, *E. cordata* was the only one considered annual, even though it was clearly associated with the rainy season. In other similar areas like the municipality of Barreirinhas, *E. cordata* was also found year round (Rebêlo & Cabral, 1997).

In the semi-arid region of Bahia, euglossine males visited the baits right after the rainy season, and was believed that those visits were supported by blossoms, mild temperatures and higher humidity values observed in that period (Neves & Viana, 1999).

In the semideciduous forests of northeastern São Paulo, where the four seasons are distinct, few males landed on the baits in the colder and drier months (Rebêlo & Garófalo, 1991). Garófalo (1987) observed that *E. cordata* did not build nests during this season in São Paulo, whereas Rebêlo & Garófalo (1991) reported an increased number of individuals of *E. cordata* after this period. Climatic parameters certainly determine the occurrence of this species in the subtropics, while in the tropics, precipitation plays a marked role in the incidence of all euglossine bee species. Thus, the factors which either directly or indirectly affect the euglossine seasonal pattern are expected to vary according to the area studied.

The information on hourly activity of the species sampled at Cajual Island showed that the temperature was a decisive factor in male activity at the baits. In general, the bees arrived at the baits

early in the morning, with peaks between 8:00 and 10:00 h, decreasing afterwards, according to the temperature increase and moisture decrease by noon. These results were similar to those found by Braga (1976) in the area of Manaus, Central Amazonia. In Amazonian Maranhão, although data were restricted to the morning period, the abundance peak was occurred late in the morning, between 10:00 and 11:00 h. In that region, temperature variation is very slight (Silva & Rebêlo, 1999). In the two Amazonian areas investigated by Oliveira & Campos (1995), the euglossine males were active between 9:00 and 16:00 h, when the temperatures ranged from 24.5°C to 27°C. In São Paulo in the hotter seasons, activity at the baits began at temperatures higher than 18°C, at 8:00-9:00 h (pers. obs.), contrasting with the results found for winter, when the males started visiting the baits only after 10:00 h.

In short, no kind of endemism was observed. Most species found on Cajual Island are widely distributed in the Brazil savanna; some are common to both savanna and the wet Amazonian environment. Others are confined to the latter.

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