




## Visit frequency of Euglossine bees (Hymenoptera: Apidae) to mature fruits of *Vanilla planifolia* (Orchidaceae)

## Frecuencia de visita de Euglosinos (Hymenoptera: Apidae) a frutos maduros de *Vanilla planifolia* (Orchidaceae)

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### Abstract

**Background and Aims:** Visitation and fragrance collection in fruits of the genus *Vanilla* by Euglossine bees (*Eulaema* spp.) have previously been documented. However, in *Vanilla planifolia*, the most commonly cultivated species, this behavior has not yet been recorded. Thus, the objective of this study was to identify Euglossine visitors of the mature fruits of *V. planifolia* and to identify the frequency of these visitations.

**Methods:** We held 11 observations set within a month (from March 6 to April 6, 2021) in an experimental *Vanilla planifolia* plantation with mature fruits of vanilla in Veracruz, Mexico. Each observation lasted for ten hours (from 8:00 to 18:00), representing a total of 110 hours sampling effort. During our observations we collected individuals of Euglossine bees directly from the mature fruits of vanilla to identify them at species level. We also recorded the frequency of Euglossini visits to mature fruits of *V. planifolia*.

**Key results:** We identified five species belonging to three Euglossini genera visiting mature fruits of *V. planifolia*: *Euglossa hemichlora*, *E. variabilis*, *Eulaema cingulata*, *E. polychroma*, and *Exaerete frontalis*. The genus *Eulaema* had 72% of visits to *V. planifolia* fruits. Visitation frequency was dominated by *Eulaema polychroma* with 54% of total recorded visits (n=211).

**Conclusions:** For the first time, Euglossine bees have been registered collecting scents in mature fruits of *V. planifolia*. *Eulaema polychroma* was the species with the highest percentage of visits to mature fruits *V. planifolia* to collect fragrances.

**Key words:** *Euglossa*, *Eulaema*, *Exaerete*, scent, vanilla.

### Resumen

**Antecedentes y Objetivos:** Se ha reportado la visita y recolección de fragancias en frutos del género *Vanilla* por abejas euglosinas (*Eulaema* spp.). Sin embargo, en *Vanilla planifolia* aun no se ha registrado este comportamiento. Por lo tanto, los objetivos del presente trabajo fueron identificar a los euglosinos que visitaban los frutos maduros de *V. planifolia*, así como la frecuencia de su visita.

**Métodos:** Se llevaron a cabo 11 muestreos durante un mes (6 de marzo al 6 de abril de 2021) en una plantación experimental de *Vanilla planifolia* con frutos maduros de vainilla en Veracruz, México. Cada muestreo tuvo una duración de diez horas (08:00 a 18:00 hrs), representando en total 110 horas de esfuerzo de muestreo. Durante los muestreos se colectaron individuos de abejas euglosinas directamente de los frutos maduros de vainilla para identificarlos a nivel de especie. También se registró la frecuencia de visita por parte de los euglosinos a los frutos maduros de *V. planifolia*.

**Resultados clave:** Se identificaron cinco especies pertenecientes a tres géneros de Euglossini que visitaban los frutos maduros de *Vanilla planifolia*: *Euglossa hemichlora*, *E. variabilis*, *Eulaema cingulata*, *E. polychroma* y *Exaerete frontalis*. El género *Eulaema* representó 72% de las visitas a los frutos de *V. planifolia*. A su vez, la frecuencia de visita estuvo dominada por *Eulaema polychroma* con 54% del total de las vistas registradas (n=211).

**Conclusiones:** Por primera vez se registran abejas Euglosinas colectando fragancias de los frutos maduros de *V. planifolia*. *Eulaema polychroma* es la especie con el mayor porcentaje de visita a los frutos maduros de *V. planifolia* para recolectar fragancias.

**Palabras clave:** *Euglossa*, *Eulaema*, *Exaerete*, fragancias, vainilla.

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## Introduction

Orchid bees depend strongly on resources like resins and scents for the construction of nests and attracting mates, respectively (Roubik and Hanson, 2004). It is also known that orchid bees collect scents from non-floral sources, like sap from plant wounds, fruits, and cadavers of other male Euglossine bees (Roubik and Hanson, 2004), as well as from fungi (Cappellari and Harter-Marques, 2010). Scent collection is exclusively performed by male Euglossine bees (Dodson et al., 1969; Roubik and Hanson, 2004). This process consists of scraping the structure surface with their front tarsi followed by fluttering, while the chemical transfers from the front tarsus to the middle tarsi and then to the posterior tibia. Afterwards, the bees land on the source of the scent scraping the surface, repeating this behavior for up to one hour (Roubik and Hanson, 2004). This process of scent collection by male Euglossine bees has been studied for at least five decades (e.g., van der Pijl and Dodson, 1966; Dressler, 1967). More recent studies have focused on the interactions between Euglossine bees and orchid flowers and their fragrances (e.g., Ramírez et al., 2002; Roubik and Hanson, 2004; Hentrich, 2008; Hetherington-Rauth and Ramírez, 2016; Nunes et al., 2017; Milet-Pinheiro et al., 2018; Pansarin et al., 2018).

Chemical baits are being used to attract and identify Euglossine bees. One of the main attractors used is eucalyptol (Dodson et al., 1969; Dressler, 1982; Silva and Rebêlo, 2002; Ferreira et al., 2011; Silva, 2012; Castro et al., 2013; Ribeiro et al., 2015), and vanillin has also been used in chemical baits for euglossines (Williams and Dodson, 1972; Dressler, 1982; Dressler, 1993; Rebêlo and Silva, 1999; Ramírez et al., 2002; Silva and Rebêlo, 2002; Melo et al., 2009; Ferreira et al., 2011; Silva, 2012; Castro et al., 2013; Hinojosa-Díaz and Engel, 2014; Pansarin et al., 2018; Coswosk et al., 2019; Dec and Alves-Dos-Santos, 2019). However, relatively few orchid species naturally produce flowers with vanillin scent (Williams and Dodson, 1972; Gerlach and Schill, 1991). This scent is produced by vanilla fruits, rather than by flowers.

Lubinsky et al. (2006) reported *Eulaema cingulata* Fabricius, 1804 collecting scents from fruits of *Vanilla grandiflora* Lindl. (= *V. pompona* subsp. *grandiflora* (Lindl.) Soto Arenas) and *E. cingulata* has been recorded being

attracted to vanillin in chemical baits (e.g., Ramírez et al., 2002; Silva and Rebêlo, 2002; Melo et al., 2009; Silva, 2012; Coswosk et al., 2019; Dec and Alves-Dos-Santos, 2019). However, this has not yet been observed in *Vanilla planifolia* Andrews. Considering that mature fruits of *V. planifolia* naturally produce vanillin, we hypothesized that *E. cingulata* will be the species with the highest visiting frequency to collect scents from the mature fruits of *V. planifolia*. Therefore, the objective was to identify Euglossine species and visitation frequency to mature fruits of *V. planifolia*.

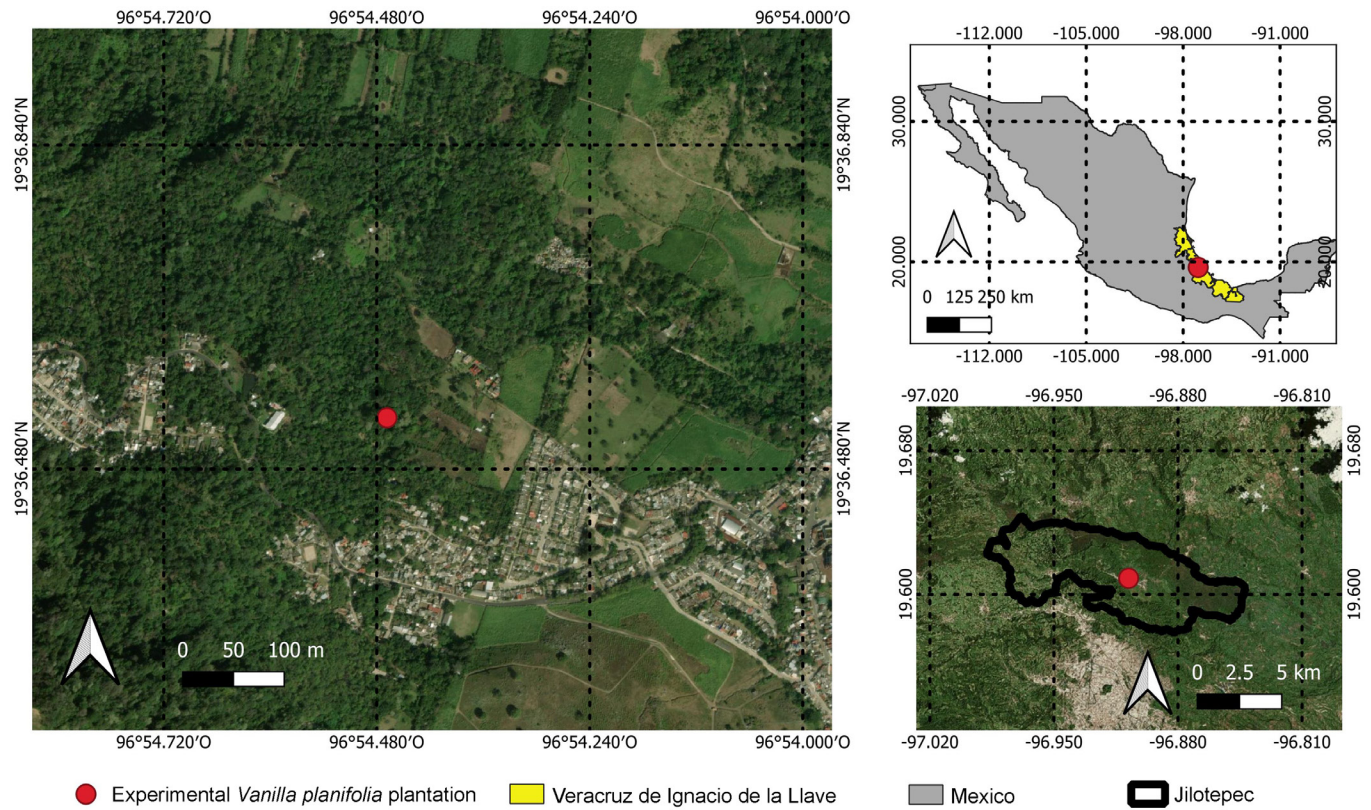
## Materials and Methods

The study was carried out in an experimental *Vanilla planifolia* plantation established in 2013, which has trees of *Inga vera* Willd. and shrubs of *Coffea arabica* L. as live tutors. This plantation is located in Jilotepec, Veracruz, Mexico, at 1000 m above sea level (Fig. 1). Eleven observations were done within a month (March 6 to April 6, 2021) every fourth day. Mature fruits were approximately 12 months old (2020 bloom). Each observation lasted ten hours (8:00 to 18:00), representing a total of 110 hours sampling effort. During our observations we collected individuals of Euglossine bees directly from *V. planifolia* mature fruits to identify them at species level. Species identification and sex determination were done for each of the collected specimens. Euglossine bees were identified using the taxonomic keys of Roubik and Hanson (2004) and Estrada de L. (2018). We also registered Euglossine bee visit frequency to mature *V. planifolia* fruits and their behavior through the observations. These visits were recorded with photographs and video using a Nikon D3100 digital SLR camera (Nikon, Tokyo, Japan). Visit frequency data were analyzed using a  $\chi^2$  in R v. 4.0.3 (R Core Team, 2020).

## Results

We collected five species (15 individuals) visiting the mature fruits of *V. planifolia* to collect scents. They belonged to three genera of Euglossine bees (*Euglossa* Latreille, 1802; *Eulaema* Lepeletier, 1841; and *Exaerete* Hoffmannsegg, 1817) (Fig. 2). The five species were *Euglossa hemichlora* Cockerell, 1917; *E. variabilis* Friese, 1899; *Eulaema cingulata*, *E. polychroma* Mocsáry, 1899 and *Exaerete*





**Figure 1:** Map of the experimental *Vanilla planifolia* Andrews plantation in Jilotepec, Veracruz de Ignacio de la Llave, Mexico.

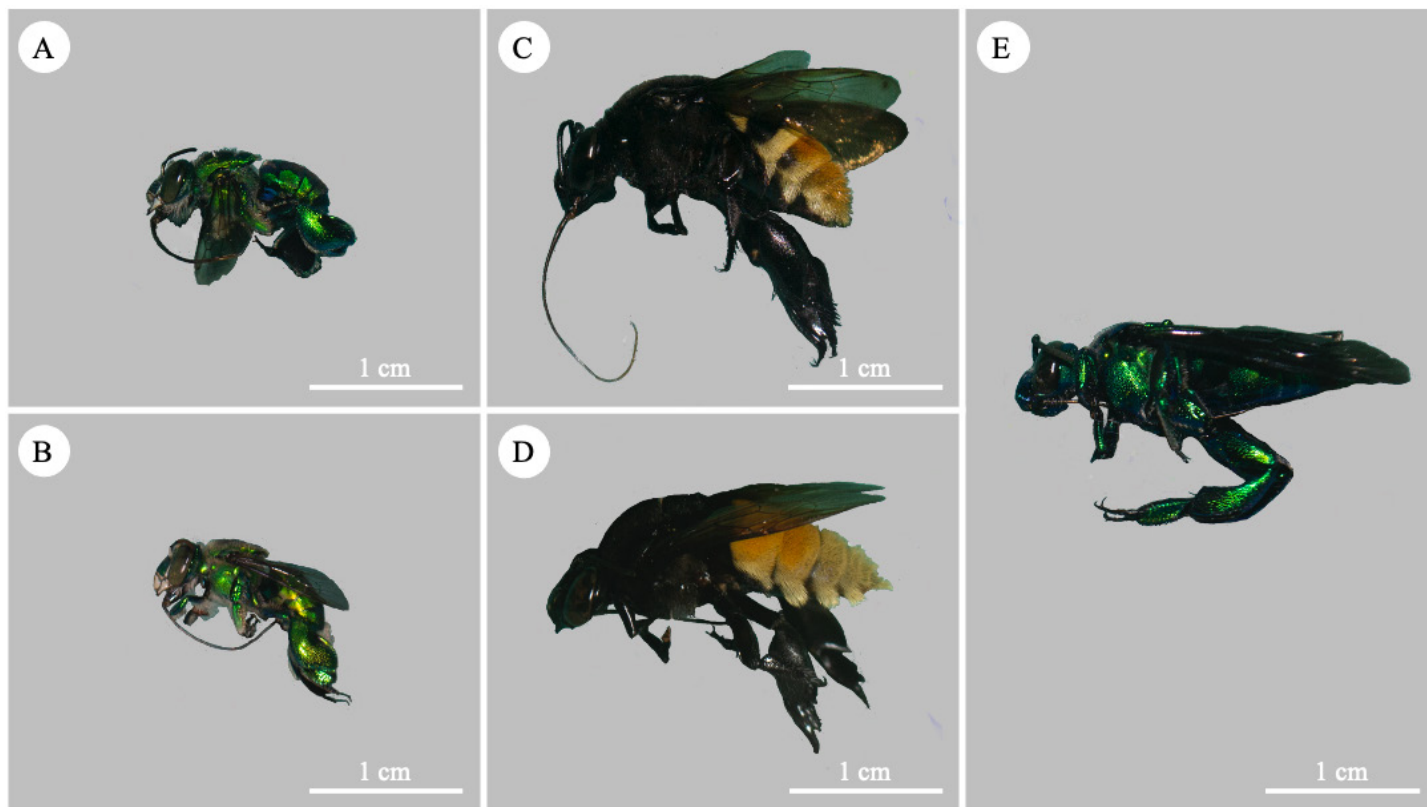


**Figure 2:** Attraction and collection of scents in mature fruits *Vanilla planifolia* Andrews. A. *Euglossa* Latreille, 1802; B. *Eulaema* Lapeletier, 1841; C. *Exaerete* Hoffmannsegg, 1817. Photos: M. A. Lozano Rodríguez.

*frontalis* Guérin-Meneville, 1845 (Fig. 3). All of them were male specimens.

The genus *Eulaema* reported 72% of the visits to *V. planifolia* mature fruits ( $n=211$ ), while *Euglossa* and *Exaerete* had 27% and 1% of these, respectively. *Eulaema polychroma* was the species with the highest visitation frequency (54% of total visits), followed by *Eulaema cingulata* with 18%. The visitation frequency for *Euglossa* was not calculated at the

species level because of the difficulty to visually distinguish them in this genus without collecting and analyzing each specimen. We were thus only able to identify two species from five individuals that we collected. We found statistically significant differences (Table 1) in the visitation frequency of Euglossine bees ( $X^2=20.65$ ;  $gl=2$ ;  $p<0.001$ ). *Exaerete frontalis* was not included in the statistical analysis because of its low visitation frequency (1%,  $n=2$ ).



**Figure 3:** Euglossine species attracted to mature fruits of *Vanilla planifolia* Andrews. A. *Euglossa hemichlora* Cockerell, 1917; B. *Euglossa variabilis* Friese, 1899; C. *Eulaema cingulata* Fabricius, 1804; D. *Eulaema polychroma* Mocsáry, 1899; E. *Exaerete frontalis* Guérin-Meneville, 1845. Photos: M. A. Lozano Rodríguez.

**Table 1:** Total visits by Euglossine bees to mature fruits of *Vanilla planifolia* Andrews recorded during this study on a vanilla plantation in Jilotepec, Veracruz, Mexico. \*Not included in the statistical analysis.

Genus	Species	Visits	Total visits by genus
<i>Euglossa</i> Latreille, 1802	<i>Euglossa</i> spp.	58	58
<i>Eulaema</i> Lapeletier, 1841	<i>Eulaema cingulata</i> Fabricius, 1804	38	151
	<i>Eulaema polychroma</i> Mocsáry, 1899	113	
<i>Exaerete</i> Hoffmannsegg, 1817	<i>Exaerete frontalis</i> Guérin-Meneville, 1845*	2	2

## Discussion

The individuals of the three genera observed in the mature fruits of *V. planifolia* performed the typical scent collection behavior described by Roubik and Hanson (2004). This behavior has been recorded for mature fruits of *Vanilla pompona* subsp. *grandiflora* (Lubinsky et al., 2006) and *V. aff. odorata* (Madison, 1981) but, to our knowledge, the present study reported it for the first time for *V. planifolia*.

According to various studies (Williams and Dodson, 1972; Dressler, 1982; Rebêlo and Silva, 1999; Ramírez et al., 2002; Silva and Rebêlo, 2002; Melo et al., 2009; Silva, 2012; Castro et al., 2013; Hinojosa-Díaz and Engel, 2014; Coswosk et al., 2019; Dec and Alves-Dos-Santos, 2019), the use of vanillin as an attractor has been effective in approximately 179 Euglossine species. Four of these (*Euglossa variabilis*, *Eulaema cingulata*, *E. polychroma*, and *Exaerete frontalis*) have been observed naturally in our study in mature fruits of *V. planifolia*. *Euglossa hemichlora* is the only one that has not been previously reported as attracted to vanillin. Even when *E. cingulata* is the species that has been more times recorded being attracted to vanillin using chemical baits (Ramírez et al., 2002; Silva and Rebêlo, 2002; Melo et al., 2009; Silva, 2012; Coswosk et al., 2019; Dec and Alves-Dos-Santos, 2019), our field observations found *E. polychroma* as the bee with the greatest visiting frequency collecting scents from the mature fruits of *V. planifolia*. Consequently, with these results we reject our hypothesis, as *E. cingulata* was not the species with the greatest records. Even when both species can be found in Veracruz (Mexico) (Yáñez-Ordóñez and Hinojosa-Díaz, 2004; Bonet and Vergara, 2019; Juárez, 2021), our study shows that *E. polychroma* is the one who is more attracted to mature fruits of *V. planifolia*.

Euglossine bees have been reported collecting scents in fruits and pollinating *Vanilla* flowers (Soto, 1999; Lubinsky et al., 2006; Watteyn et al., 2021), and this study shows that *V. planifolia* fruits attract orchid bees to collect scents as well. Therefore, it might be the only genus in the Orchidaceae family that has this double interaction with orchid bees. In general, these bees' visitation frequency to the fragrant fruit of vanilla had not been previously studied in detail. Moreover, the potential role of orchid bees as disperser of the seeds of *Vanilla* species with aromatic fruits has been suggested (Madison, 1981; Dressler, 1993;

Lubinsky et al., 2006; van Dam et al., 2010; Cameron, 2011).

*Exaerete frontalis* was the rarest species with the lowest visiting frequency to mature fruits of *V. planifolia*. Similarly, Rebêlo and Silva (1999) and Ramírez et al. (2002) found that *Exaerete frontalis* is rarely attracted to vanillin. Parasitic genera (like *Exaerete*) have seldomly been documented to be interacting with orchids (Roubik and Hanson, 2004). However, in this study we were able to observe this unusual interaction between *E. frontalis* and the mature fruits of *V. planifolia* to collect scents.

## Conclusions

For the first time orchid bees have been registered collecting scents in mature fruits of *V. planifolia*. The genus *Eulaema* is strongly attracted to the mature fruits of *V. planifolia* to collect scents. *Eulaema polychroma* was the species with greatest attraction and interaction with the mature fruits of *V. planifolia*, even when *E. cingulata* was the species with more records of being attracted to vanillin and mature fruits of vanilla. All the species performed the typical behavior of scent collection by orchid bees. The visiting dynamics of Euglossine bees requires further studies to understand their behavior during the process of attraction-visit-collection of scent of the fruit of *V. planifolia*.

## Author contributions

MALR, CCC and MLR conceived the study design and carried out the field work. JPC carried out the data analysis. MALR, CCC and MLR wrote the manuscript. MLR, CCC, JPC and RMG revised and completed the manuscript. All authors contributed to the discussion and approval of the final manuscript.

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