

UNUSUAL NESTING OF THE CARPENTER BEE *Xylocopa ordinaria* IN THE SEMI-ARID CAATINGA AND PREFERENCE FOR POLLEN FROM PORICIDAL FLOWERS

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ABSTRACT. The large carpenter bee *Xylocopa ordinaria* is widespread in Brazil, especially in humid regions. Our aim was to analyze the nesting substrates and pollen sources used by bees of this species in the semi-arid Northeast Region of Brazil. We analyzed eight nests from the Catimbau National Park, Pernambuco, Brazil: six were built in inflorescence scapes of the terrestrial endemic bromeliad *Encholirium spectabile*

and two in dead woody branches of the shrub *Hyptis fruticosa*. Female *X. ordinaria* seem to use non-woody substrates when dead wood of trees with thick branches is scarce and where they occur sympatrically with species of the subgenus *Monoxylocopa*. Females of these latter species provide pre-excavated cavities gnawed into the smooth bromeliad scapes, which are reused by females of *X. ordinaria*. Flowers with poricidal anthers are the most important pollen resources for *X. ordinaria* in the Caatinga; around two-thirds of the pollen in brood cells was from species of Cassiinae (*Chamaecrista*, *Senna*) and *Solanum* (Solanaceae). The unbranched galleries in bromeliad scapes do not appear to reduce the number of offspring of *X. ordinaria*, since these nests contained similar numbers or more brood cells than nests built in thick substrates of dead wood by these and other species of the subgenus *Neoxylocopa*. The high proportion of pollen from flowers of a few species with poricidal anthers indicates a floral preference of *X. ordinaria* for these pollen-only flowers.

KEYWORDS: Xylocopini, semiarid, pollen, nidification, *Encholirium spectabile*.

INTRODUCTION

Large carpenter bees (*Xylocopa* Latreille) are widely distributed in tropical and subtropical regions (Hurd & Moure, 1963; Gerling et al., 1989; Moure et al., 2007). Nests are generally founded solitarily, but nests containing more than one female have been found in a number of species (Michener 1985; Velthuis & Gerling, 1983; Camillo & Garófalo, 1989; Wittmann & Scholz, 1989; Hogendoorn & Velthuis, 1993). In such nests overlapping generations with daughters helping to raise offspring is often found.

Nearly all bees of the genus *Xylocopa* are food generalists. They can collect pollen by vibration in pollen flowers with poricidal anthers, for which they are effective pollinators (Endress, 1994; Oliveira-Rebouças & Gimenes, 2004; Burkart et al. 2011; 2013). However, there are no direct estimates of floral preferences by carpenter bees, that is, the relationship between the availability of flower types and the frequency of visits to pollen flowers with poricidal anthers has not been analyzed. Flowers of numerous nectar rewarding species are also effectively pollinated by carpenter bees when they gather nectar, such as those of passion flowers, for example (Sazima & Sazima 1989; Varassin & Silva, 1999; Benevides et al 2009). In contrast, these bees are often cited as nectar robbers of large flowers by perforating the corolla tubes from the outside with their stiff galeae (e.g. Correia et al 2006; Carvalho et al 2007; Milet-Pinheiro & Schlindwein 2008; Marchi and Alves-dos-Santos 2013; Schlindwein et al. 2014). They do not pollinate these flowers because they do not contact the anthers during visits (Milet-Pinheiro and Schlindwein 2009, plus the pollen from these illegitimate visits does not appear in larval provisions).

Carpenter bees nest in various dry plant substrates such as twigs, branches and trunks of dead wood (Hurd & Moure, 1963; Sakagami & Laroca, 1971; Gerling et al., 1989), where they dig galleries to keep brood cells. In thick woody substrates they may dig branched galleries that can facilitate the simultaneous rearing and care of a large number of brood cells during each reproductive event (Gerling et al. 1989). Other species nest in plant substrates with small diameters where they dig unbranched galleries, such as *X. (Stenoxycopa) artifex* Smith 1874 (Hurd & Moure, 1960), *X. (Monoxylocopa) abbreviata* Hurd and Moure, 1963 (Ramalho et al., 2004) and *X. (Monoxylocopa) macambirae* Zanella and Silva, 2010 (Zanella & Silva, 2010).

Fifty species of carpenter bees are known to occur in Brazil, of which only seven occur in the Caatinga (Silveira et al., 2002; Moure et al., 2007), a succulent thornshrub savannah of the semi-arid Northeast Region of the country (Gomes et al., 2006).

We studied nest construction and food provisions of *Xylocopa (Neoxylocopa) ordinaria* Smith 1874, a widely distributed species in South America, in Catimbau National Park in the Caatinga (Silveira et al., 2002; Moure et al., 2007). In regional coastal restingas, this species can build branched or unbranched galleries, depending on the nesting substrate. Furthermore, pollen of several plant species have been found in its larval food, confirming

the polylectic nature of this species (Bernadino & Gaglianone, 2008; 2013).

Considering the relative scarcity of large trees in the studied caatinga and the peculiarity of its seasonal vegetation, we were interested in determining the nesting substrates used by this species and the most important pollen sources it uses to rear its offspring. We contextualize possible factors that influence these choices and their probable effects on the production of broods.

MATERIAL AND METHODS

Study site

The study was carried out in Catimbau National Park (CNP) (08°32'47" S; 037°14'17.4" W), in the municipality of Buíque, Pernambuco, Brazil. The mean annual temperature of the study site is 25°C, with annual precipitation ranging from 650 to 1,100 mm; the rainy season is from April to June (SADMET / INMET, 2018). The climate is semi-arid tropical with marked seasonality. The elevation of the park ranges from 400 to 1400 m, with the local relief comprising abrupt rocky slopes, sandstone formations, "chapadas" and sedimentary plains characterized by nutrient-poor sandy soils. The park encompasses a vegetation mosaic composed mainly of caatinga (tropical steppe savannah - deciduous shrubs and small dispersed trees), with some elements of the flora of the Atlantic Forest and the regional savannah (Rodal et al 1998).

Nest construction by *Xylocopa ordinaria*

The field nidification was conducted during the rainy season from February to July 2007.

We collected eight nest of *X. ordinaria* in inflorescence scape of *E. spectabile*. On the field, we cut the branche or the inflorescence scape close to the end (base bottom) and transport to Plebeia Laboratory (IB-UFPE) where we put in the freezer for 40 minutes maximum. Then, each nest was opened longitudinally: all bee and larvae were collected and transferred to a transparent recipient identified. Each brood food was disposed in a identified test tube with glicerine. Each nest had it entrance closed with plastic tape before removed to avoid the scape of the adult bee. In the laboratory, we opened the nests and measured the total length of the dug galleries, the diameter and length of the brood cells, diameter of the nest entrance and the thickness of the walls between brood cells (Figure 1A, B).

Nest construction observation starts with four females of *X. ordinaria* monitored while they inspected potential nesting substrates. But only one female was continuously observed from the beginning of nest construction until completion of provisioning food for the third brood cell. This latter female occupied a former nest of *X. (Monoxylocopa) macambirae*

Zanella and Silva in the inflorescence scape of *Encholirium spectabile* Mart. ex Schult. and Schult. F. (Bromeliaceae), a terrestrial bromeliad with spiny leaves and endemic to the Caatinga. Nest providing cell observations were carried out from 05:30 am to 17:30 pm during seven consecutive days (29th of March to 4th of April 2007) during which we recorded the duration of foraging flights, the type of floral resource transported to the nest, the duration of nectar dehydration and the duration of nest construction activities.

Pollen analysis of food stored in the brood cells

Pollen analysis were conducted from four nests (n=4) collected at PNC from February to July 2007. Nest were opened longitudinally direction and brood provision content were collected, one brood cell per nest. The food contents were transferred to vials containing ethanol 70%. After centrifuging, the ethanol was removed and acetolyzed (Erdtman, 1960). Four microscope slides of pollen per brood cell were prepared with glycerinated gelatin.

The relative frequency of pollen types in food provisions was determined by counting 1.000 pollen grains per sample under a microscope. The percentage similarity index, PS (Schoener, 1968), was used to estimate diet similarity between the *X. ordinaria* females. In addition, we compiled data of flower visits of *X. ordinaria* from the study site and from other sites sampled in the Caatinga from the database of our working group "Plebeia", and from published studies.

Specimens of *X. ordinaria* were deposited in the entomological collections of the Federal University of Pernambuco (UFPE), Federal University of Minas Gerais (UFMG) and Federal University of Paraíba (UFPB). Vouchers of plants of the surrounding vegetation were deposited in the Herbarium of the Federal University of Pernambuco while pollen reference slides were deposited in the pollen slide collection of the State University of Feira de Santana (LAMIV-UEFS).

RESULTS

Nest construction and architecture

Six nests of *X. ordinaria* were found in inflorescence scapes of *Encholirium spectabile* (Fig 1) and two in dead branches of the shrub *Hyptis fruticosa* Salzm. ex Benth (Lamiaceae). The latter had unbranched galleries with total lengths of 13.6 and 16.6 cm. The external diameter at the level of the nest entrance measured 29 and 34 mm. Both were fully excavated by the founding female and had no apparent markings of walls between the brood cells.

We observed that all six nests found in inflorescence scapes of *E. spectabile* had been previously excavated (personal information). The nests had unbranched linear galleries (Fig 1: C, D, F, G, H) with 3 to 11 brood cells (7.3 ± 3.3 sd, N= 8), which were built

above (4.3 ± 3.8 ; 0 - 11 brood cells) and below (3.7 ± 3.3 ; 0 - 8) the nest entrance. The average length of the galleries in *E. spectabile* scapes scape diameter at the nest entrance and the circular nest entrance are in Table 1. The walls between brood cells were made of compressed material from scraping off the gallery walls (Table 1).

Foundations of new nests were observed in the beginning of the rainy season.

Nest foundation and gallery construction, and provisioning were observed for a single female as follows. In choosing a nesting place, the female was observed repeatedly inspecting dry inflorescences of *E. spectabile*, flying around several scapes of nearby plants over the course of about three hours. The female hovered in front of different scapes touching them briefly until she finally landed on an inflorescence that contained an abandoned nest of *X. macambirae*. After remaining motionless for a few minutes at the entrance, she cleaned the entrance, removed debris and scraped the inner walls of the gallery to widen its diameter. Around eight hours later, by the end of the afternoon (17:00h), she had excavated 11 cm of the substrate (6.4 cm upward and 5.5 cm downward the entrance).

During the scraping period, the female left the nest two times, once for two and once for ten minutes at 11:50h and 16:00h, respectively, probably to forage for nectar since she returned with her abdomen distended.

Brood cell provisioning and pollen content of larval food

The day after nest foundation and gallery construction, the female started to provision the first brood cell at the end of the gallery above the entrance. Foraging flights started in the morning at 6:00 h and finished around 18:00 h under dim light conditions (Fig 2). Pollen collection flights lasted, on average, 15.5 min (± 12.3 ; 1.9 – 49.6 min), while flights when the bee returned with empty scopa (considered nectar foraging trips) lasted 14.8 min (± 11.8 ; 0.95 - 43.0 min). To complete the provisioning of a single brood cell, the female took two days and made eight to ten foraging flights for pollen and two to 14 for nectar (Fig 2 and Fig 3). Most pollen collection flights occurred in the morning (between 06 a.m. and 09 a.m.), while nectar harvesting occurred similarly at morning and afternoon (Fig 2).

After nectar foraging, females remained inside the nest for around 20 s until they appeared in the nest entrance to dehydrate nectar. To do this, females regurgitated a nectar droplet, expanded it for a few seconds between the mandibles and then swallowed it. In this manner, nectar droplets were regurgitated and swallowed repeatedly. Nectar dehydration lasted on average 27.7 min (± 12.1 min). Considering both duration of foraging flights and handling of food, females spent mostly their time dehydrating nectar and equal time foraging for nectar and pollen (Fig 2).

Larval food from the four nests (one brood cell per nest) of *X. ordinaria* contained a total of 18 pollen types (11 to 13 types per nest) (Table 2). The most common pollen types were from flowers of *Chamaecrista*, *Senna*, *Solanum* and *Hyptis*. Pollen grains from species

with poricidal anthers summed 56.1% to 72.4 % per nest.

Pollen grains from flowers with non-poricidal anthers that summed to over 1% of the samples were restricted to *Hyptis* (Lamiaceae) and *Croton* (Euphorbiaceae) (Table 2). There was high overlap of the most common pollen types among nests (Table 2), with the exception of *Senna* pollen, which was not present in the brood cells of Nest 1; all the other pollen types with a frequency of 5% or greater were shared among the four nests.

DISCUSSION AND CONCLUSION

Nesting substrate and nest structure

In the vegetation of the semi-arid caatinga of Catimbau National Park (CNP), *X. ordinaria* females used mainly thin stems to build their nests, and preferentially the thin inflorescence scapes of the terrestrial bromeliad *E. spectabile* that were pre-excavated by the smaller carpenter bee *X. (Monoxycopa) macambirae*. Locally, the observed nests contained unbranched galleries, with brood cells constructed above and below the nest entrance.

In restinga environments (humid tropical vegetation on level terrain close to the Atlantic Coast of Brazil), this species digs nests in thick dead branches of trees (*Pera glabrata* and *Terminalia* sp) and constructs unbranched (70%) or branched (30%) galleries (Bernadino & Gaglianone, 2008; Bernadino & Gaglianone, 2013). The use of thin substrates in Catimbau National Park might be a consequence of the scarcity of larger-diameter dead wood in the surroundings. Trees with thick stems have become scarce in extensive areas of semi-arid caatinga due to the removal of vegetation for pasture, charcoal production and use as firewood, resulting in the large-scale loss of arboreal vegetation, a phenomenon also recently documented in CNP (Sfair et al, 2017).

The large female bees of the subgenus *Neoxycopa* are known to construct nests exclusively in dead wood of trees or shrubs (Camillo & Garófalo, 1982; Gimenes et al., 2006) with a diameter generally greater than 20 cm (Neves et al., 2006; Bernadino & Gaglianone, 2013), where they can build branched galleries. Until the present study, only a few small-bodied species of *Xycopa* from four subgenera, had been recorded constructing nests in inflorescence scapes or thin stems of monocots: *X. (Stenoxycopa) artifex* Smith 1874 in *Vellozia* (Velloziaceae) (Hurd & Moure, 1960; Silveira, 2002); *X. (Monoxycopa) abbreviata* (Ramalho et al., 2004) and *X. (Monoxycopa) macambirae* (Zanella & Silva, 2010) in inflorescences of *E. spectabile*; *X. (Schonnherria) bambusae* Schrottky, 1902 and *X. (Stenoxycopa) nogueirai* Hurd and Moure, 1960 in bamboo internodes (Poaceae) (Hurd & Moure, 1960; Hurd & Moure, 1963; Silveira et al., 2002; Schindwein et al., 2003); and *X. (Diaxylocopa) truxali* in stems of *Vellozia* (Velloziaceae) (Hurd & Moure, 1963; Silveira, 2002).

Small-diameter nesting substrates only allow the construction of unbranched galleries. This type of substrate, therefore, has the potential of restricting the number of offspring/reproductive events of large carpenter bees due to the delay in timing of construction and development between the first and the last brood cell in the same linear gallery (Gerling et al., 1989). However, the unbranched galleries do not appear to reduce the number of offspring of *X. ordinaria*, since nests on the bromeliad stems contained similar or greater numbers of brood cells than nests built on thicker wood substrates by this and other species of the subgenus *Neoxylocopa* (Camilo & Garófalo, 1982; Gimenes et al., 2006).

As nesting substrate, the dry and non-woody floral scapes of the terrestrial bromeliad *E. spectabile* have the disadvantage of being short lived. Moreover, among the rocky outcrops with low vegetation cover in the caatinga, this substrate is exposed to direct sunlight throughout the day and thus experiences strong fluctuations in temperature (Ramalho et al., 2004). On the other hand, the scapes pre-excavated by the smaller *Monoxylocopa* species seem to offer some compensation to *X. ordinaria* females, such as reduced time spent with nest construction, which enables a greater period of time for brood care. Considering the wide distribution of this bromeliad in the semi-arid region (Forzza, 2005), and the widespread use of its stem as nesting substrate by species of *Monoxylocopa* (Ramalho et al., 2004; Zanella & Silva, 2010), pre-excavated stems are likely to be available throughout the region. The large females of *X. ordinaria*, thus, seem to use this non-woody substrate when trees with thick branches are scarce and where they occur sympatrically with species of the subgenus *Monoxylocopa* that provide pre-excavated cavities gnawed into the smooth scapes of the endemic bromeliad.

Nectar dehydration

Females of *X. ordinaria* spent more than one hour a day dehydrating nectar, which is less time than that measured for euglossine bees (> 3h per day) (Pokorny et al., 2014), but much more time than that measured for other species of *Xylocopa*, such as *X. (Neoxylocopa) nigrocincta* Smith, 1854, 50 min, (Wittmann & Scholz, 1989); and *X. (Schonherria) subcyanea* Pérez, 1901, 15 min (Gimenes et al., 2006). Nectar dehydration is well known among eusocial stingless bees (Meliponini), *Apis* (Kleinert et al., 2009) and bumblebees (*Bombus*), and is related to efficient cell provisioning and exclusive long-term storage of honey for future use. In carpenter bees, females may concentrate nectar to improve the energetic value per unit weight of larval food and to preserve the embedded pollen mass against fungal proliferation.

A highly dehydrated larval food may also be a pre-requisite for rearing a brood in a fragile non-woody substrate.

Pollen sources for larvae

Our study reveals that flowers with poricidal anthers are the most important pollen resources for *X. ordinaria* in the Caatinga; around two-thirds of the pollen in the brood cells was from species of Cassiinae (*Chamaecrista*, *Senna*) and *Solanum* (Solanaceae). Based on the compilation of records on pollen-rewarding flowers of *X. ordinaria* in several areas of the Caatinga, and other vegetation types in Brazil, we conclude that buzz-pollinated flowers, especially Casiinae, are always among the main pollen resources for this species (Table 2). This is also true for some other regional species of carpenter bees [*Xylocopa* (*Neoxylocopa*) *griseescens* Lepeletier, 1841; *X. (Neoxylocopa) cearensis* Ducke, 1910, *X. (Neoxylocopa) frontalis* (Olivier, 1789)] (Gottesberger et al 1988; Viana et al., 2002; Jacobi et al., 2005; Neves et al., 2006).

Flowers with rimose anthers, however, are the most species-rich and common among melittophilous species in CNP and other areas of the Caatinga (Gomes et al., 2006; Delgado-Junior & Alves, 2017), several of which are frequently visited by carpenter bees (Milet-Pinheiro & Schlindwein 2008). In general, these flowers are visited to collect nectar, frequently during illegitimate flower visits (Carvalho et al. 2007; Schlindwein et al. 2015). The relatively large amount of *Hyptis* pollen from non-poricidal anthers in the nests of *X. ordinaria* in CNP seems to be a special case, which can be explained by the explosive mechanism of pollen liberation by their flowers (Harley, 1971). The flowers of different species of this genus are intensely visited by female carpenter bees, mainly for the collection of nectar (Silva and Schlindwein, unpublished).

We associated most of the foraging flights during nest provisioning with nectar foraging. These field observations corroborate the fact that pollen grains of nectar sources were the most diversified and represented in small quantities in larval provisions. Species of *Hyptis* spp. and 20 other plant species were important nectar sources in CNP, several of which have been previously reported in regional field studies, such as *Anemopeagma leave* DC, *Arrabidaea limae* A.H.Gentry, *Jacaranda rugosa* A.H.Gentry, *Tabebuia impetiginosa* (Mart. ex DC.) Standl., *Passiflora alata* Curtis, and *Walteria indica* L. (Varassin & Silva, 1999; Carvalho et. al., 2007; Milet-Pinheiro & Schlindwein, 2008; see Table 1 – supplementary material).

Exploitation of a greater variety of nectar sources than pollen sources is probably related to the fact that nectar is depleted by several other bee groups and offered in small quantities per flower but with eventual renewal throughout the day. In contrast, the most important pollen sources for species of *Xylocopa* are available mainly early in the morning (Janzen, 1966; Viana et al., 2002; Gimenes et al., 2006), including many flowers with poricidal anthers. We conclude, that females of *X. ordinaria* strongly prefer pollen resources from flowers with poricidal anthers in the semi-arid Caatinga suggesting oligolectic behavior (Vossler, 2018). This preference may be related to their efficient pollen removal by sonicating

the flowers early in the morning and before being visited by other bees. The pollen diet of *X. ordinaria*, thus, is more restricted than their nectar diet, being associated with the selective availability of pollen for buzz pollinating bees. The results supports that *Chamaecrista* and *Senna* (Fabaceae) and *Solanum* (Solanaceae) are the pollen host for *X. ordinaria*

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TABLE

Nests	Nest length (cm)	Number of cells	Diameter of the nest Entrance (mm)	Length of cells (mean and standard deviation)	Diameter of cells (mean and standard deviation)	Thickness of walls between cells (mean and standard deviation)
1	19.5	8	9.1	19.3 ± 3.1	11.8 ± 1.1	2.8*
2	24.2	11	9.3	17.7 ± 3.1	11.6 ± 2.7	3.5 ± 0.8
3	16.5	3	9.7	19.6 ± 3.4	12.5 ± 0.6	3.0 ± 1.1
4	28.0	6	12.1	43.6 ± 13.2	14.2 ± 1.8	0.6 ± 0.3
5	11.2	5	10.4	17.4 ± 3.3	11.4 ± 0.4	3.7 ± 0.6
6	25.0	11	11.6	19.0 ± 3.1	12.5 ± 0.9	4.3 ± 0.4
Mean	20.7 ± 6.2	7.3 ± 3.3	10.4 ± 1.2	22 ± 10	12.5 ± 1.8	2.9 ± 1.3

Table 1- Number of brood cells and measurements of structures of the nests of *Xylocopa (Neoxylocopa) ordinaria* built in inflorescence stems of *Encholirium spectabile* (Bromeliaceae). The length of the nest is expressed in cm while the other measurements are in mm. * interior of the nest observed with only one division.

Family	Pollen morphotypes	Nest 1	Nest 2	Nest 3	Nest 4
Amaranthaceae	<i>Gomphrena</i>	0.1			
Asteraceae	<i>Eupatorium</i>	0.6		0.3	
Cactaceae	<i>Pilosocereus</i>				0.1
Caesalpiniaceae	<i>Caesalpinia</i>	0.5	1	4.1	1.8
Caesalpiniaceae	<i>Chamaecrista</i>	10.5	21.1	39.4	25
Caesalpiniaceae	Senna		33.6	24	12.7
Commelinaceae	<i>Commelina</i>	2.2			
Euphorbiaceae	<i>Croton</i>	18.1	1.5	0.6	0.4
Fabaceae	Tipo Fabaceae		0.1		
Lamiaceae	<i>Hyptis 1</i>	29.3	25	14.2	7.4
Lamiaceae	<i>Hyptis 2</i>	0.4	3.4	0.9	9.2
Mimosaceae	<i>Piptadenia</i>	0.2	0.3	0.2	
Onagraceae	<i>Ludwigia</i>				3
Poaceae	Tipo Poaceae		0.1		
Solanaceae	<i>Solanum 1</i>	33.7	5.3	6	24.6
Solanaceae	<i>Solanum 2</i>	10.5	7.8	1.9	10.1
Solanaceae	<i>Solanum 3</i>	1.4			
	Other pollen types > 5%	0.7		1.8	
	Types not-identified	1.5	0.9	5.7	5.4
Pollen number per nest		1020	1154	1091	1114
Total Pollen per poricidal anther (<i>Senna, Caesalpinia, Solanum</i>)		552 (54%)	794 (69%)	824 (76%)	828 (74%)
		Nest 1	Nest 2	Nest 3	Nest 4
Percentage similarity index (PS)	Nest 1		0.72	0.51	0.7
	Nest 2			0.72	0.62
	Nest 3				0.65

Table 2- Analyses of pollen provisions of brood cells from nests of *Xylocopa (Neoxylocopa) ordinaria* from Parque Nacional do Catimbau, in the Brazilian semi-arid Caatinga

FIGURES



Fig 1- Overview of study area with aggregate of *Encholirium spectabile* (Bromeliaceae) in Catimbau National Park, Pernambuco, Brazil. (A) Partial view of the vegetation and relief. (B) Aggregate of *E. spectabile* with new stems and green inflorescence with immature fruits. (C) Old abandoned nest with closed entrance. (D) Female *X. ordinaria* guarding nest entrance. (E) Flexible plastic wire used to measure the digging of the nest and closing of breeding cells. (F) Larva of *X. ordinaria* and pollen mass inside its cell (scale = 1mm). (G) Young female *X. ordinaria* and post-defective pupa inside the nest. (H) Nests showing the thick wall between the brood cells.

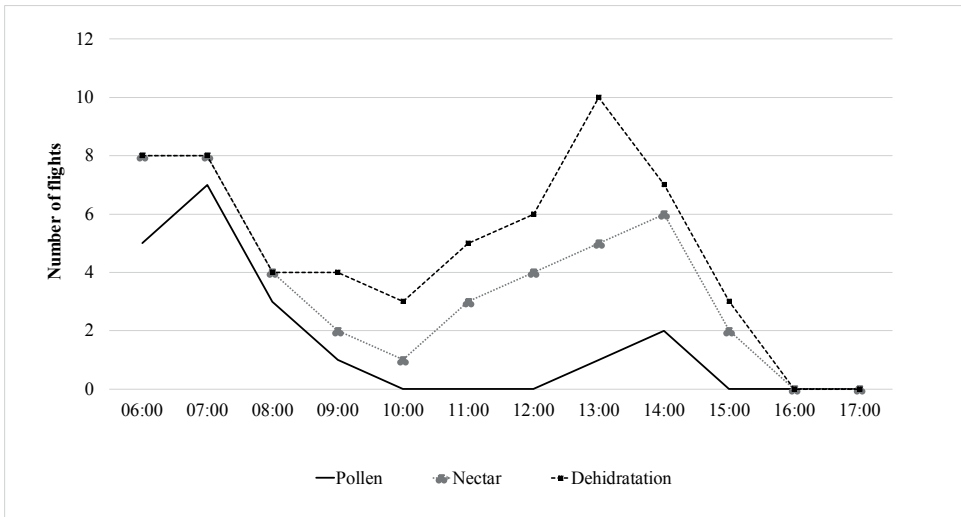


Fig 2- Hours activity and number of flights performed by female of *Xylocopa ordinaria* to provision one brood cell with nectar, pollen and dehydrating nectar during five days observation at the National Park of Catimbau, Pernambuco, Brazil

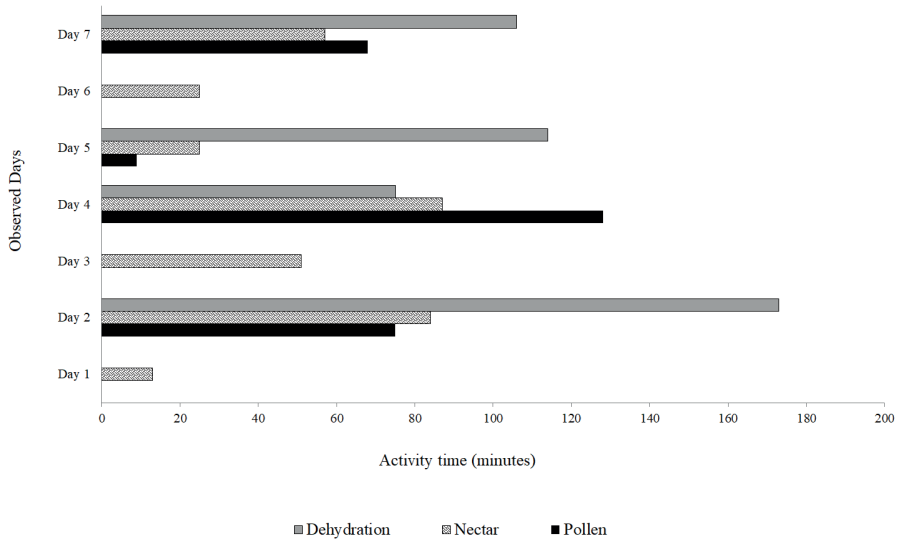


Fig 3 Time spending for female of *Xylocopa ordinaria* per day foraging for nectar, pollen and dehydrating nectar during the provision brood cell period

SUPLEMENTAR TABLE 1

Vegetal Species	Reward	Habitat	Local	Literature Consulted
APOCYNACEAE				
<i>Rauvolfia ligustrina</i>	Nectar	Caatinga	Borborema (PB)	*
ASTERACEAE				
<i>Vernonia chalybaea</i>	Nectar	Caatinga	Canindé do São Francisco (SE)	*
BIGNONIACEAE				
<i>Anemopeagma leave</i>	Nectar	Caatinga	Pq. Nac. do Catimbau (PE) / Canindé do S. Francisco (SE)	Carvalho et. al.(2007)
<i>Arrabidaea limae</i>	Nectar	Caatinga	Canindé do S. Francisco e Piranhas (SE)	Carvalho et. al.(2007)
<i>Jacaranda rugosa</i>	Nectar	Caatinga	Pq. Nacional do Catimbau (PE)	Milet-Pinheiro & Schlindwein 2008
<i>Tabebuia impetiginosa</i>	Nectar	Caatinga	Pq. Nacional do Catimbau (PE)	*
FABACEAE				
<i>Caesalpinia ferrea</i>	Pollen	Caatinga	Canindé do S. Francisco (SE)	*
<i>Caesalpinia pyramidalis</i>	Pollen	Caatinga	Pq. Nacional do Catimbau (PE)	*
<i>Chamaecrista hispídula</i>	Pollen	Caatinga	Pq. Nacional do Catimbau (PE)	*
<i>Chamaecrista ramosa</i>	Pollen	Caatinga	Pq. Nacional do Catimbau (PE)	*

Vegetal Species	Reward	Habitat	Local	Literature Consulted
<i>Parkinsonia aculeata</i>	Nectar/pollen	Caatinga	Canindé do S. Francisco (SE)	Moura et. al. (2003)
<i>Senna acuriensis</i>	Pollen	Caatinga	Canindé do São Francisco (SE)	*
<i>Senna macranthera</i>	Pollen	Caatinga	Canindé do S. Francisco-SE	*
<i>Senna spectabilis</i>	Pollen	Caatinga	Pq. Nacional do Catimbau (PE)	*
<i>Tephrosia purpurea</i>	Nectar	Caatinga	Canindé do S. Francisco (SE)	*
EUPHORBIACEAE				
<i>Cordia cf. globosa</i>	Nectar	Caatinga	Costa do Sol (PB)	*
HYDROLEACEAE				
<i>Hydrolea spinosa</i>	Nectar	Caatinga	Pq. Nacional do Catimbau (PE)	*
LAMIACEAE				
<i>Hyptis fruticosa</i>	Nectar	Caatinga	Pq. Nac. do Catimbau (PE) / Canindé do S. Francisco (SE)	*
LYTHRACEAE				
<i>Cuphea flava</i>	Nectar	Caatinga	Costa do Sol (PB)	*
MALPIGHIACEAE				
<i>Byrsonima sericea</i>	Pollen	Caatinga	João Pessoa (PB)	*
MIMOSACEAE				
<i>Piptadenia stipulacea</i>	Pollen	Caatinga	Conde (PB) / Canindé do S. Francisco (SE)	*
OXALIDACEAE				
<i>Oxalis frutescens</i>	Nectar	Caatinga	Canindé do São Francisco (SE)	*
PASSIFLORACEAE				
<i>Passiflora alata</i>	Nectar	Restinga	Guarapari (ES)	Varassin & Silva (1999)
<i>Passiflora luetzelburgii</i>	Nectar	Caatinga	Pq. Nacional do Catimbau (PE)	*
POLYGONACEAE				
<i>Triplaris gardneriana</i>	Nectar	Caatinga	Canindé do São Francisco (SE)	*
SAPINDACEAE				
<i>Serjania glabrata</i>	Nectar	Caatinga	Pq. Nacional do Catimbau (PE)	*
SIMAROUBACEAE				
<i>Simaba cuneata</i>	Nectar	Caatinga	Pq. Nacional do Catimbau (PE)	*
STERCULIACEAE				
<i>Melochia tomentosa</i>	Nectar	Caatinga	Canindé do São Francisco (SE)	*
<i>Walteria indica</i>	Nectar	Caatinga	Canindé do São Francisco (SE)	*
TURNERACEAE				
<i>Piriqueta sidifolia</i>	Nectar	Caatinga	Pq. Nacional do Catimbau (PE)	*

Suplementar Table 1. Plant species with flowers visits recorded by *Xylocopa* (*Neoxylocopa*) *ordinaria* bees, in Catimbau National Park (published data* and records in the PLEBEIA-UFPE Database), Brazilian semi-arid region.