

Floral visitors of canola (*Brassica napus* L.) hybrids in Cerrado Mineiro region, Brazil

Visitantes florais em híbridos de canola (Brassica napus L.) na região do Cerrado Mineiro, Brasil

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ABSTRACT: The objective of this study was to verify floral visitors of canola in the Triângulo Mineiro region, Minas Gerais, Brazil. A completely randomized plot design with two hybrids and 10 replicates was used, totaling 20 plots. The survey of floral visitors was made during 10 days. Faunal analyses of the collected species were performed based on frequency, constancy, dominance, and diversity. A total of 2,676 individuals belonging to 13 species of bees of two families (Apidae and Halictidae) were collected. The diversity index found among hybrids was similar (1.28 in hybrid 61 and 1.50 in hybrid 433). The species *Apis mellifera* Linnaeus, 1758 (Hymenoptera: Apidae), *Paratrigona lineata* (Lepeletier, 1836) (Hymenoptera: Apidae), and *Trigona spinipes* (Fabricius, 1793) (Hymenoptera: Apidae) were the most abundant and constant in the crops during all the evaluated days for both hybrids. So, it is important that efforts be made to conserve natural areas close to crops in order to provide resources for the permanence of floral visitors in the area.

KEYWORDS: *Apis mellifera*; Apidae; faunistic index; Halictidae; native bees.

RESUMO: O objetivo deste estudo foi verificar os visitantes florais de canola na região do Triângulo Mineiro, Minas Gerais, Brasil. Utilizou-se um delineamento experimental de blocos inteiramente randomizados com dois híbridos e 10 amostras replicadas, totalizando 20 amostras. A pesquisa de visitantes florais foi feita durante 10 dias. As análises faunísticas das espécies coletadas foram realizadas com base na frequência, constância, domínio, riqueza e diversidade. Um total de 2.676 indivíduos pertencentes a 13 espécies de abelhas de duas famílias (Apidae e Halictidae) foram coletados. A riqueza das espécies encontradas entre os híbridos foi semelhante (10 espécies no híbrido 61 e 12 espécies no híbrido 433), bem como o índice de diversidade (1,28 no híbrido 61 e 1,50 no híbrido 433). A espécie *Apis mellifera* Linnaeus, 1758 (Hymenoptera: Apidae), *Paratrigona lineata* (Lepeletier, 1836) (Hymenoptera: Apidae) e *Trigona spinipes* (Fabricius, 1793) (Hymenoptera: Apidae) foram as mais abundantes e constantes nas culturas durante todos os dias avaliados para ambos os híbridos. Com isso, é importante que sejam feitos esforços para conservar as áreas naturais próximas às culturas, a fim de fornecer recursos para a permanência de visitantes florais na área.

PALAVRAS-CHAVE: *Apis mellifera*; Apidae; índices faunísticos; Halictidae; abelhas nativas.

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INTRODUCTION

Canola (*Brassica napus* L.) is a plant of the cruciferous family and is resultant of a genetic improvement of rapeseed (EMBRAPA, 2011). It is an autogamous plant, with an alogamy rate of more than 20%, nectariferous and polliniferous, and is frequently visited by pollinating insects (TOMM et al., 2009). These are attracted mainly by the nectar produced by the floral nectaries, two in each pair of long stamens and two in the inner part of the short stamens (MUSSURY; FERNANDES, 2000). Studies demonstrate that the presence of pollinating insects, especially *Apis mellifera* Linnaeus, 1758 (Hymenoptera: Apidae), through its foraging behavior in flowers, can significantly increase the yield indices of this crop (DELAPLANE; MAYER, 2000; SABBABI Et al., 2005; ABROL, 2007).

Bees are recognized as the main agents in the pollination process (KLEIN et al., 2006; OLLERTON et al., 2011), since even though varying in size, shape, and lifestyle, all bee species must visit a large number of flowers daily to suit their individual food needs, or of their offspring and the colonies (MICHENER, 2000). Visits to flowers made by other animals are occasional. The vast majority does not have flowers as their only source of food and the visits occur in isolated moments (FREITAS; PAXTON, 1998).

The presence of bees in canola flowers promotes an increase not only in the quantity of seeds produced, but also in the quality of the oil, and consequently the market value of the crop (DURÁN et al., 2010; ALI et al., 2011; BOMMARCO et al., 2012; JAUKER et al., 2012; WITTER et al., 2014). The species *A. mellifera* is the best-known pollinator of canola flowers (ADEGAS; NOGUEIRA-COUTO, 1992; SMITH, 2002; KAMLER; JAŠ, 2003; SABBABI et al., 2005; MUNAWAR et al., 2009; DURÁN et al., 2010). However, studies performed in countries as Canada, Pakistan, Germany, and the United Kingdom observed other species of Apidae and other families as Andrenidae, Halictidae, and Megachilidae as important pollinators, such *Bombus hortorum* (Linnaeus, 1761), *Andrena* sp. Fabricius, 1775, *Halictus* sp. Latreille, 1804, and *Osmia rufa* (Linnaeus, 1758), respectively (MORANDIN et al., 2007; ALI et al., 2011; JAUKER et al., 2012; GARRATT et al., 2014).

The abundance of insects that pollinate canola flowers varies according to the region. These pollinators belong mainly to the orders Hymenoptera and Diptera (MORANDIN; WINSTON, 2005; SABBABI et al., 2005; ALI et al., 2011; BOMMARCO et al., 2012; JAUKER et al., 2012; WITTER et al., 2014; GARRATT et al., 2014). In canola fields in Rio Grande do Sul, native insects of several groups were registered, predominantly bees (Hymenoptera), flies (Diptera), and beetles (Coleoptera) (WITTER et al., 2014).

The concern with the conservation of the bees has increased considerably due to the decline of the pollinators

and, consequently, interfering in landscapes densely occupied by economic activities (KEVAN; VIANA, 2003). The factors that most contribute to the reduction of bee diversity are the habitat fragmentation, which originates from deforestation; the use of phytosanitary products in agricultural crops, and the introduction of species capable of competing with native bees, mainly for floral resources (KEARNS et al., 1998; KEVAN; VIANA, 2003).

Considering this decline in pollinator populations, the search for new bee species for pollination services in several regions of the world is increasing, since the introduction of exotic species has several restrictions (VELTHUIS; VAN DOORN, 2006). In Brazil, the efforts to use native pollinators are mainly directed to the bees *Centris* spp., *Xylocopa* spp., and many species of Meliponini. Solutions must be sought to maintain pollinators close to the rural properties, and to maintain landscapes that support pollinators and provide them a nesting site, food, and building materials for nests (WITTER; TIRELLI, 2014).

The high economic value attributed to the bees shows that pollination services in canola deserve further investigation due to the lack of knowledge about the pollination requirements of the hybrids available in Brazil. In addition, the benefit generated by the bees in canola crop can change due to local climatic conditions, which indicates the importance of understanding the possible factors that could affect the pollination process (CHAMBÓ et al., 2014).

In order to establish strategies for increasing the productivity of canola grains, it is necessary to know the regional fauna and its potential pollinators. Although there are studies in the southern region of Brazil, little is known about the diversity of these insects in regions of higher latitudes in the country, especially in the Cerrado of Minas Gerais. The objective of this study was to identify the main floral visitors of canola in the Triângulo Mineiro region located in a Cerrado area, in order to recognize their diversity.

MATERIAL AND METHODS

Study sites

The studies were conducted at the Experimental Farm of the Universidade Federal de Uberlândia, located at 19°05'48" S and 48°21'05" W, and at an altitude of approximately 800 m. The soil of the area is classified as dystrophic Red Latosol, A moderate, medium texture, tropical Cerrado sub-deciduous, and mild wavy relief type (EMBRAPA, 2006). The Aw climate, according to the Köppen classification, is marked by two well-defined seasons, one rainy and one dry (ROSA et al., 1991). The area contained 104 ha of preserved area, formed by complex vegetation

that includes restricted sense Cerrado, dense Cerrado, Vereda, and Gallery forest, besides 151.72 ha with fruit and pasture (NETO, 2008).

A completely randomized experimental design with two hybrids and 10 replications was used, totaling 20 plots. Each plot consisted of six planting lines with four meters in length, 0.20 m spacing between rows, and a density of 18 m⁻¹ seeds. The plots were separated by 0.5 m, totaling an experimental area of 121 m², so the flowers could form a compact area to cause attractiveness to the insects. The experiment was established on April 2, 2016, with both hybrids flowering after 55 days and presenting senescence after 97 days.

The hybrids used in this experiment were Hyola 61 and Hyola 433. The hybrid Hyola 61 has polygenic resistance to *Phoma lingam* Tode ex. Shaw. Desm., known as blackleg, and excellent performance both under water deficiency and severe cold. This hybrid has medium cycle characteristics of 123 to 155 days from emergence to maturation and presents great stability of yield when cultivated under varied conditions. Hyola 433 is a short-cycle hybrid suitable for highly fertile soils (TOMM et al., 2009).

To control insect pests, mainly aphids of the species *Lipaphis pseudobrassicae* Davis, 1914 (Hemiptera: Aphididae), and *Myzus persicae* Sulzer, 1776 (Hemiptera: Aphididae), two applications of Decis 25 EC[®] were performed, on June 4 and 15, and one application of Acephate Nortox[®] on June 26, prior to the beginning of the evaluations.

The experiment was conducted without an irrigation system. The irrigation was performed manually, with a volume of 20 mm per plot, once a week, until the complete establishment of the plants. The management of weeds was done by manual weeding throughout the conduction of the experiment.

Sampling visitors

The survey of floral visitors was carried out in May and June of 2016, periods in which the averages of temperature and relative humidity of the air were 21.4°C and 74.8% respectively, according to National Meteorological Institute (INMET).

The samples were collected during 10 days of evaluation, and the insects sighted in the plots were collected to posterior identification. The evaluations were performed on 2 plots per day, one for each hybrid. After 10 days all plots were observed (since there were 10 replications per hybrid).

The same plot of each hybrid was evaluated along the day, to make it possible the comparison of the data on insect visitors in different times, so each plot was evaluated seven times in at the same day. Each observation lasted 20 min per plot adopting intervals of 20 min to start the next hour of evaluation, so in 1 hour two plots were evaluated, one for each hybrid. The evaluations occurred starting at 7:00 a.m. until 10:00 a.m. and from 1:00 p.m. to 3:00 p.m.

The collections were performed in different days, so the presence of insects could vary, however both hybrids were evaluated at the same day to become possible a comparison between them.

The specimens were collected with entomological net and stored in 100 mL plastic bottles with a screw cap. The collected species were recorded and only released after the daily evaluations. This procedure was adopted mainly for *A. mellifera*. The individuals not identified in the field were sacrificed with ethyl acetate and individualized for later identification in the laboratory by a specialist. Afterwards, the bees were kept in entomological drawers (TAURA; LAROCA, 2001) at Universidade de Uberlândia.

Faunistic indexes

Faunal analyses of the collected species were performed based on frequency, constancy, dominance, and diversity indexes.

Constancy, frequency, and dominance were calculated using the equations proposed by SILVEIRA-NETO et al. (1976). Frequency represents the participation of individuals of a species in relation to the total of individuals collected and was obtained by the formula $F = (n / N) \times 100$, where F = frequency percentage; n = number of individuals of the species; N = total number of individuals obtained in each collection.

Constancy was obtained by the occurrence of the species in the collections by the formula $C = (p / N) \times 100$, where C = percentage of constancy, p = number of samples containing the species, N = total number of samples.

The species were then classified into categories according to the BODENHEIMER classification (1955) in: constant species (W) — present in more than 50% of the collections; accessory species (Y) — present in 25 – 50% collections; accidental species (Z) — present in less than 25% of the collections.

A species is considered dominant when it has a frequency higher than 1/S, where S is the total number of species in the community. The diversity index was measured by the index α , based on MARGALEF (1972), which is the ratio between the number of species (S) and the number of individuals in a community (N).

Data analysis

The Anderson-Darling normality test (AD) was applied with a significance of 5%, so an AD with value of $p > 0.05$ has normal distribution. The Levene test was applied to homoscedasticity, considering 5% reference to significance. The normal distribution with the “Z” test was applied for two independent means and the two-proportion test, adopting alpha rejection level of 0.05 and the critical value of “Z” of alpha 1.96. The analyses were done in program R.

RESULTS

Sampling visitors

In relation to the insect sampling in the two canola hybrids, 2,676 individuals belonging to 13 bee species of two families (Apidae and Halictidae) were collected. The number of individuals collected in the H61 hybrid was lower than H433, but there was no significant difference among the dominant species, except for *Paratrigona lineata* (Lepelletier, 1836) (Hymenoptera: Apidae), found more frequently in H433 (39.58%) than in H61 (35.20%). This difference could be caused mainly because H433, characterized by being a fast-cycle hybrid, had a higher number of flowering plants and, consequently, a greater number of flowers and floral resources available to the insects compared to H61, which is an intermediate cycle hybrid (Table 1).

The species *Tetragona clavipes* (Fabricius, 1804) (Hymenoptera: Apidae), *Exomalopsis fulvofasciata* (Smith, 1879) (Hymenoptera: Apidae), and *Augochloropsis* sp. 3 (Hymenoptera: Halictidae) were not found in H61, and *Augochloropsis* sp. 1 were not found in H433. The diversity indexes between hybrids were similar (1.28 in H61 and 1.50 in H433). Values between 1.5 and 3.5 (Table 1) are considered normal according to MARGALEF (1972). Values below 1.5 could be a result of the predominance of some taxonomic groups to the detriment of the majority, while values over 5.0 denote levels above normal (BEGON et al., 1996).

The subfamily Halictinae, a group of generalist pollinators (EICKWORT, 1969), presented 5 species for both hybrids. However, the constancy of the species sampled was considered accidental (Z), occurring in less than 25% of the collections in both hybrids, except for *Augochlora* sp. 2, a species considered accessory (Y) according to the classification of BODENHEIMER (1955), with a collection frequency between 25 and 50% (Table 1).

The subfamily Apinae, characterized as being a species of social bee and with a structure to transport pollen (corbicula), was the most representative with 95.98% (n = 1,099) and 96.8% (n = 1,482) of the total collections in hybrids H61 e H433, respectively. *Apis mellifera*, *P. lineata*, and *Trigona spinipes* (Fabricius, 1793) (Hymenoptera: Apidae) were the most constant and dominant species in relation to the others (Table 1).

Six species of the subfamily Halictinae were collected all belonging to the Augochlorini tribe (Table 1). Among the bees of the Augochlorini tribe, it was obtained two species belonging to the genus *Augochlora* and four to the genus *Augochloropsis*, bees of metallic color, often in shades of green. This group of bees is considered very diverse, with a large number of species in Brazil. In the present study, species of the genus *Augochlora* and *Augochloropsis* were considered accidental species in canola flowers, with a frequency of less than 0.5%, except for *Augochlora* sp. 2 which was considered an accessory species in both evaluated hybrids (Table 1).

Table 1. Faunistic analysis of the collected floral visitors in Hyola 61 and Hyola 433 hybrids, Uberlândia, Minas Gerais, 2016.

Family	Subfamily	Tribe	Species	Hyola 61				Hyola 433			
				N	F (%)	C (%)	D	N	F (%)	C (%)	D
Apidae	Apinae	Apini	<i>Apis mellifera</i>	464	40.52	W	D	581	37.95	W	D
			Meliponini	<i>Paratrigona lineata</i>	403	35.20	W	D	606	39.58	W
			<i>Trigona spinipes</i>	232	20.26	W	D	293	19.14	W	D
			<i>Tetragona clavipes</i>	0	0.00	-	-	2	0.13	Z	N
	Xylocopinae	Exomalopsini	<i>Exomalopsis analis</i>	14	1.22	Y	N	16	1.05	Y	N
			<i>Exomalopsis fulvofasciata</i>	0	0.00	-	-	1	0.07	Z	N
			<i>Exomalopsis auropilosa</i>	4	0.35	Z	N	4	0.26	Z	N
Halictidae	Halictinae	Augochlorini	<i>Augochlora</i> sp. 1	5	0.44	Z	N	3	0.20	Z	N
			<i>Augochlora</i> sp. 2	18	1.57	Y	N	21	1.37	Y	N
			<i>Augochloropsis</i> sp. 1	1	0.09	Z	N	0	0.00	-	-
			<i>Augochloropsis</i> sp. 2	1	0.09	Z	N	1	0.07	Z	N
			<i>Augochloropsis</i> sp. 3	0	0.00	-	-	1	0.07	Z	N
			<i>Augochloropsis</i> sp. 4	3	0.26	Z	N	2	0.13	Z	N
TOTAL				1,145	100			1,531	100		
S				10				12			
ID				1.28				1.50			
1/S				10.00				8.33			

N: number of captured individuals; F: frequency (%); S: number of species; ID: diversity index; C: constancy (W: constant, Y: accessory, Z: accidental); D: Dominance (D: Dominant, N: Non-dominant).

Frequency of floral visitors per day and per hour

The species *A. mellifera*, *P. lineata*, and *T. spinipes* were predominantly the most abundant and frequent species in the canola crop during the 10 days of evaluation. In H61, *A. mellifera* presented the largest number of individuals collected ($n = 464$), being more frequent in six days of evaluation (Table 2). For H433, *P. lineata* and *A. mellifera* were the most frequent during the days and presented the largest number of individuals collected, $n = 606$ and $n = 581$, respectively, with no significant difference between them. The species *T. spinipes*

presented similar frequency in the two hybrids (H61 = 20.26% and H433 = 19.14%). The other species presented frequencies lower than 6.9% per day and represented 4.45% of the collections in H61 and 3.32% in H433 (Table 2).

In both hybrids, forage activity was observed at 7:00 am, but with a reduced number of individuals. The activity began to intensify and increase from 8:00 am, culminating in a peak (maximum foraging activity) around 9:00 am (H61: $n = 280$; H433: $n = 337$), with a slight decrease at 10:00 am. During the morning period, *A. mellifera* was the most abundant species in the crop, with a frequency higher than 50.3% at all times (Table 3 and Fig. 1). In the afternoon period,

Table 2. Total floral visitors collected in the flowers of canola (*Brassica napus*) in 10 days of evaluation, Uberlândia, Minas Gerais, 2016.

Day	Hybrid Hyola 61								Hybrid Hyola 433							
	<i>A. mellifera</i>		<i>P. lineata</i>		<i>T. spinipes</i>		Other species		<i>A. mellifera</i>		<i>P. lineata</i>		<i>T. spinipes</i>		Other species	
	N	F (%)	N	F (%)	N	F (%)	N	F (%)	N	F (%)	N	F (%)	N	F (%)	N	F (%)
1	50	51.02	19	19.39	22	22.45	7	7.14	73	57.94	19	15.08	26	20.63	8	6.35
2	65	56.03	24	20.69	19	16.38	8	6.90	74	51.39	46	31.94	17	11.81	7	4.86
3	61	50.41	32	26.45	23	19.01	5	4.13	59	40.14	43	29.25	42	28.57	3	2.04
4	48	32.21	63	42.28	33	22.15	5	3.36	69	38.33	74	41.11	31	11.67	6	3.33
5	38	41.76	16	17.58	34	37.36	3	3.30	65	44.83	29	20.00	45	31.03	6	4.14
6	31	27.68	40	35.71	37	33.04	4	3.57	48	28.92	68	40.96	42	25.30	8	4.82
7	22	20.95	59	56.19	17	16.19	7	6.67	36	19.35	103	55.38	39	20.97	8	4.30
8	43	34.96	39	31.71	33	26.83	8	6.50	62	33.88	79	43.17	35	19.13	7	3.83
9	52	54.74	35	36.84	6	6.32	2	2.11	50	39.37	65	51.18	8	6.30	4	3.15
10	54	38.57	76	54.29	8	5.71	2	1.43	45	33.09	80	58.82	8	5.88	3	2.21
Total	464 a		403 b		232 c		51 d		581 a		606 a		293 b		60 c	

N: number of captured individuals; F: frequency (%). *Apis mellifera*, *Paratrigona lineata*, *Trigona spinipes*.

*Lowercase letters distinguish significant differences between the totals of individuals collected for each species for each hybrid. The binomial test was used with significance of 0.95.

Table 3. Number of floral visitors collected per hour in canola flowers, *Brassica napus*, Uberlândia, Minas Gerais, 2016.

Time	Hybrid Hyola 61 (Number of individuals)				Hybrid Hyola 433 (Number of individuals)			
	<i>Apis mellifera</i>	<i>Paratrigona lineata</i>	<i>Trigona spinipes</i>	Other species	<i>Apis mellifera</i>	<i>Paratrigona lineata</i>	<i>Trigona spinipes</i>	Other species
07h00	5 a	1 b	2 ab	0 c	19 a	1 b	5 b	0 c
08h00	82 a	19 b	33 c	4 d	79 a	14 b	57 c	7 b
09h00	167 a	34 b	79 c	9 d	199 a	41 b	97 c	9 d
10h00	124 a	49 b	66 b	16 c	161 a	77 b	74 b	16 c
13h00	45 a	124 b	30 a	8 c	52 a	203 b	25 c	10 d
14h00	20 a	101 b	16 a	10 c	38 a	161 b	21 c	14 c
15h00	21 a	75 b	6 c	4 c	33 a	109 b	14 c	4 d

*Totals followed by the same letter in the lines do not differ from each other by the binomial test (significance of 0.95) for the number of individuals collected per species in each hour.

the total number of individuals continued to decrease until 3:00 p.m. (H61: n = 102; H433: n = 156). In this period, *P. lineata* was the most abundant species, with a frequency above 59.9% between 1:00 p.m. and 3:00 p.m., the last collection time (Table 3 and Fig. 1).

DISCUSSION

The three species of *Exomalopsis* found in canola fields (*E. analis*, *E. fulvofasciata*, and *E. auropilosa*) occur in most parts of the Brazilian territory (SANTOS et al., 2014), even in open areas, with little forest cover (GLAGLIANONE; CAMPOS, 2015). They are considered small bees, up to 8 mm in length (MICHENER, 2000). In the present work, it was verified that *E. analis* was considered an accessory species (Y) in both hybrids, being present in 70% of the days of collection (Table 1). This indicates that these bees can survive in agricultural fields, and their nests may be constructed in the ground in the middle of the plantation or in marginal areas. Therefore, conserving the soil in these areas and avoiding the overuse of plant protection products are important measures to maintain the populations of these bees (GLAGLIANONE; CAMPOS, 2015).

After detecting the effective pollinating bees in a crop, one should consider how to increase the frequency of visits of these species, aiming to elevate the productivity through the presence of bees. The knowledge of the species biology is also necessary in order to improve the techniques that favor the presence of bees in the crops (SANTOS et al., 2014). One of the main aspects of the species to be observed is the nesting habit, which could influence their management in the areas (GARÓFALO et al., 2012).

For most species that nest in the soil, such as *E. analis* and *P. lineata*, management techniques are still scarce (IMPERATRIZ-FONSECA et al., 2006). However, *A. mellifera*, besides its wide distribution, is recognized for being a versatile

species and of easy handling (KLEIN et al., 2006). Studies with the objective of investigating their influence on canola production have already been conducted in several parts of the world. In Canada, SABBABI et al. (2005) found a 46% increase in productivity with an introduction of three colonies of *A. mellifera* per hectare.

In Rio Grande do Sul, studies with Hyola 432 hybrid showed that *A. mellifera* can increase yield up to 70% (ROSA et al., 2011), proving to be an efficient pollinator of this crop. However, as an exotic species, it can change the structure of interactions between native bees and plants in the natural community (SANTOS et al., 2012; SILVEIRA et al., 2006).

Considering the use of native bee species as potential pollinators of canola is not only beneficial for crop productivity, but also helps to promote the conservation of native pollinator populations (BLOCHTEIN et al., 2015).

The management of native bees should be conducted with caution, as they are in an accelerated disappearance process (LOPES et al., 2005). It is necessary to perform responsible management in which there is a balance between the commercial interests and the conservation of the native bees (DEL SARTO et al., 2005), preventing the aggravation of this situation.

The species *A. mellifera* is the main species used for the pollination of agricultural crops in the world and was reported as the main pollinator of canola in previous studies (ADEGAS; NOGUEIRA-COUTO, 1992; SMITH, 2002; KAMLER; JAŠ, 2003; MUNAWAR et al., 2009). In the state of Rio Grande do Sul, Brazil, most pollination of canola flowers is carried out by this insect, since this is the most abundant species among flowers (ROSA et al., 2011; WITTER et al., 2014; HALINSKI et al., 2015). In this study, this species was dominant and constant in both hybrids, but presented a higher frequency in H61 (40.52%). In H433, the species had the second highest frequency among species (37.95%), with *P. lineata* being the most frequent in the crop (39.58%) (Table 1).

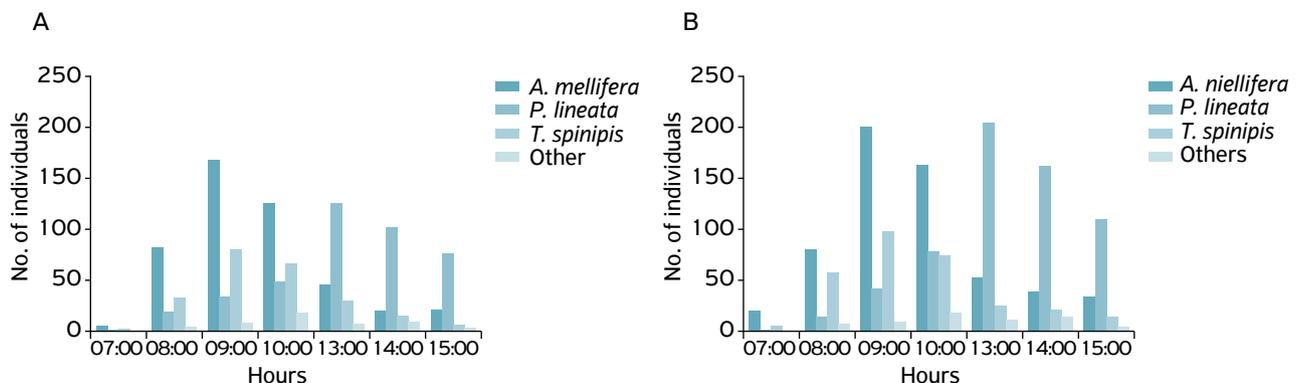


Figure 1. Floral visitors collected considering the evaluation time (from 7:00 a.m. to 3:00 p.m.) in canola, *Brassica napus*, Uberlândia, Minas Gerais, 2016. Hybrids (A) Hyola 61 and (B) Hyola 433.

Paratrigona lineata is a stingless bee species and therefore has management advantages over other species, such as being easily domesticated, having highly populated and perennial nests, utilizing worker recruitment strategies, and continuous foraging (HEARD, 1999). The species presented abundance close to *A. mellifera*. Besides that, it remained for longer periods in the flowers than the other species.

Trigona spinipes, an abundant species in the Brazilian Cerrado (SANTOS et al., 2004), was the third most frequent and dominant species in the crop (Table 1). According to ALMEIDA; LAROCA (1988), this species has some characteristics that favor its abundance in several habitats, such as the aggressive forager bees, nests constructed in places of difficult access, generalist collecting habits, and populous colonies. However, it is considered a pest in several crops because of the damages caused during the collection of plant tissue used in the construction of the nests (FADINI; SANTA-CECÍLIA, 2000; VIEIRA et al., 2007). Despite being observed collecting plant tissue in vegetative parts of the canola, this species was present in floral buds, but not observed perforating these structures.

In general, the high frequencies found for *A. mellifera* and *T. spinipes* were already expected, since both are the most abundant species in the Brazilian Cerrado (CARVALHO; BEGO, 1995). These species of bees are characterized by presenting very populous colonies containing 5,000 to 180,000 individuals (MARTINS, 1994). Thus, they present high recruitment potential for foraging, contributing with a high number of bees visiting the flowers (BOREHAM; ROUBIK, 1987). However, *P. lineata*, which was present with low frequencies and was not considered an effective pollinator in previous studies implanted in the Cerrado region with different crops, such as tomato, *Lycopersicon esculentum* (SANTOS et al., 2014) and cotton, *Gossypium hirsutum* L. r. *latifolium* (PIRES et al., 2006), was present with high frequency.

Canola flowers secrete large amounts of nectar that is very attractive to *A. mellifera* and other pollinating insects (DELAPLANE; MAYER, 2000). In this study, floral visitors showed a similar pollen and nectar collection behavior, preferentially collecting nectar in the morning and pollen in the afternoon, except for *T. spinipes*, which collected only plant fibers from the stem in the afternoon (Table 3). The preference for collecting nectar in the morning may be related to the greater availability of this resource after the opening of the flowers at that time.

The physical characteristics and physiological limitations of floral visitors can generate patterns of visitation influenced by other factors such as luminosity and temperature (RAMALHO et al., 1991). *Apis mellifera* was the main species collected at 7:00 a.m., with lower temperatures.

This result may have occurred due to the ability to maintain high body temperature, which guarantees them access to the flowers very early, as well as promoting a great advantage in the competition for floral resources in relation to native bees (PIRANI; CORTOPASSI-LAURINO, 1993). In the earlier sampling times, the frequencies of the native species were relatively low.

In addition to the physiological constraints, these patterns of visitation can also be shaped by competition. *Apis mellifera*, besides being abundant, presents a greater competitive capacity in the exploration of resources (WILMS et al., 1996), and can influence the visitation of other species. *Paratrigona lineata*, being a small species in relation to the others and not very aggressive with the other species, did not influence the visitation of other bees.

In the present study, there was a low temporal overlap of niches between the two main species visiting the crop, with *A. mellifera* being more abundant in the morning (H61: n = 378, H433: n = 458) and *P. lineata* in the afternoon (H61: n = 300; H433: n = 473). However, *T. spinipes* competed with *A. mellifera* because it collected floral resources in the morning, presenting similar frequency peaks at similar times, and displaying some aggressiveness in relation to resource exploration (Table 3 and Fig. 1).

The alternating temporal habits between *A. mellifera* and *P. lineata* can be considered advantageous, since in both periods (morning and afternoon) the flowers were densely attended by insects, presenting high rates of daily. In addition, the crop was also considered attractive to local insects, as floral resources were offered to be explored for much of the day.

CONCLUSION

The main species visiting canola crops in Cerrado Mineiro were *A. mellifera*, *P. lineata*, and *T. spinipes*, in both evaluated hybrids. *Apis mellifera* and *T. spinipes* were found more frequently in the morning and *P. lineata* in the afternoon. The evaluated hybrids differed mainly in relation to the number of individuals collected, with H433 being considered more attractive than H61 during the evaluated period.

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