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RESEARCH ARTICLE

DETERMINATION OF THE DIVERSITY AND ABUNDANCE OF POLLINATORS (HYMENOPTERA, APIDAE) OF YELLOW PASSION FRUIT (*PASSIFLORA EDULIS* F. *FLAVICARPA*) IN SOUTHERN BRAZIL

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ABSTRACT

Aiming to verify the sufficiency of diversity and abundance of bees in two areas of passion fruit cultivation, one with agricultural pesticides (area 1) and the other, of organic planting (area 2), in southern Brazil, sampling collections were untaken monthly, from January 2016 to May 2016, using entomological nets on flowering feet and tagging of individuals with numbered tags. Individuals not visually identified were prepared for identification. The flowers that were open were marked, *per* month, and the fruiting rate was inspected after 15 days. A total of 276 individuals were collected in area 1, of the species *Xylocopa frontalis* (60%), *Bombusmorio* (36%), *Xylocopabrasilianorum* (2%), *Centris (Melacentris) dorsata* (2%) and *Centris (Trachina) similis (*36%). In area 2, 267 individuals were captured: *Xylocopa frontalis* (44%), *Xylocopabrasilianorum* (31%) and *Bombusmorio* (25%). There was seasonality of the pollinators. The daily activities of the pollinators were attuned to the opening hours of the flowers. The number of estimated pollinators reached the minimum amount required for pollination of the crop. The fruiting is moderate and correlated to the number of pollinators in one area. There is possibly a need for a larger number of individuals for a higher pollination rate.

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INTRODUCTION

Brazil is the world's largest producer of passion fruit, with a total planted area of 58 thousand hectares and approximately 800 thousand tons of fruit produced annually (IBGE, 2013). The largest producer in Brazil is the northeastern region with 45 thousand hectares planted, with southern Brazil producing 1820 hectares and the southern State of Santa Catarina 801 hectares (IBGE, 2013). In Brazil there are approximately 120 native species of passion fruit, which belong to the genus *Passiflora* (BERNACCI, 2003). However, practically all the national production is based on a single cultivated species, *Passiflora edulis* Sims (Passifloraceae), known as yellow passion fruit or passion fruit (MELO *et al.*, 2005). The yellow passion fruit occupies a prominent place in Brazilian fruit growing, since it offers a faster economic return in relation to other crops, as well as the opportunity of distributed income for most of the year (SILVA *et al.*, 2014). The fruits are destined to the market of fruits, pharmaceuticals, juices and cosmetics industries (MARTINEZ *et al.*, 2012). By adapting well to tropical and subtropical climates, this species can be grown in most of Brazil. It blooms and fructifies throughout the year in the northeast region where the luminosity exceeds 11 hours a day (LIMA, 1999). In the southern region, the plant does not flower in the coldest and driest months, equivalent to the months of June to September (MELO *et al.*, 2014). The species *Passiflora edulis* f. *flavicarpa* Deneger (Passifloraceae) has large, colorful, odoriferous flowers that produce abundant nectar (AKAMINE & GIROLAMI, 1957). The flowers are short-lived, open in the afternoon from 12 o'clock, close at 10 p.m. and do not open any more (SAZIMA & SAZIMA 1989).

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When fertilization does not occur, the flowers wither and fall (SIQUEIRA *et al*., 2009). *P. edulis* depends on cross-pollination, since its flowers have different degrees of self-incompatibility (BRUCKNER *et al.,* 1995). The pollination is carried out by large bees of the *genera Xylocopa, Centris, Epicharis, Eulaema* and *Bombus* (CAMILLO, 2003) because the smaller insects collect the nectar without touching the reproductive parts and pollinating (MELETTI *et al*., 2003). The most effective natural pollinator agents of passion fruit are the bees of the genus *Xylocopa*, popularly known as carpenter bees (HOFFMANN *et al.,* 2000). Due to their size and flower behavior during nectar collection (SAZIMA & SAZIMA, 1989), these bees manage to reach the *stigma* of the flower and deposit the pollen grains that were removed from the anther of another flower (CAMILLO, 2003). Carpenter bees are important for pollination of passion fruit, but the number of individuals present in the orchards is declining every day due to the destruction of nests, inadequate cultural practices, among other problems (FREITAS & ALVES, 2009), which are causing losses of culture productivity and making studies necessary to provide information on how to increase the presence of these species in areas of passion fruit cultivation (FREITAS & OLIVEIRA-FILHO, 2003). Besides, according to Roubik (1995), it is important to know the process of pollination of passion fruit, since the quality and size of the fruits depend on the quantity of pollinators and the effectiveness of the pollination. Klein *et al.* (2003) add that knowledge about this interaction is also of importance for sustainable development programs. The production of passion fruit in the municipality of Araquari, in the state of Santa Catarina (SC) in southern Brazil, has not presented results of adequate productivity in the last years and the possibility of performing manual pollination has been suggested which, however, greatly increases production costs. Faced with this situation, this study aimed to verify if the determination of the richness and abundance of the pollinators of the crops is a tool to understand the rate of natural fruiting and the yield of the cultivation.

MATERIALS AND METHODS

Study area

The study was carried out in two areas of passion fruit cultivation on *treillis,* one with the application of agricultural pesticides and the other, an organic planting, in the municipality of Araquari, SC (Figure 1, A). The municipality has a territorial area of 4026 km², with altitude of 9 meters above sea level, predominant mesothermic climate with hot summer (Cfa), average temperature of 21.1ºC and average annual rainfall of 1745 mm (CLIMATE-DATA.org). The predominant type of soil is Neosol aMa2 (quartzous marine sand) (CIRAM, 2002). The municipality is located in the hydrographic region of the northern lowland, partially inserted in the *Itapocu* river basin (STEINBACH *et al.,* 2013). The vegetation cover consists of mangroves, *restinga* (dunes) and lowland dense rain forest (KNIE, 2002). The crop area with pesticides (Figure 1, B) presented different types of vegetation in its neighborhood such as corn, cassava, eucalyptus and an isolated forest zone. It is located in the geographical coordinates 26º23'04.75 "S, 48º42'39.59" W. The size of the planted area was 2,667.6 m², with 353 feet of yellow passion fruit. In this area the following products were used: fungicides (Cercobin, Cerconil, Manzate, Dithane), bactericidal (Kasumin), insecticide (Decis) for caterpillars control, chemical fertilization (potassium chloride, ammonium sulfate or formulated NPK 13-13 -13-28 OR 5-20-10) and organic fertilization (chicken manure). It is in the present study called area 1. The organic crop area (Figure 1, C) was located within a preserved native forest area, located at the geographic coordinates 26º26'56.29 "S, 48º42'48.95" W. The size of the plantation was 3,094 m² with 433 feet. In this area only organic products such as turkey and chicken manure, ashes, mixtures as Bordeaux mixture, raw milk, horsetails, neem oil, bovine urine were used. It is in the present study called area 2. The localities are located at an approximate distance of 7,14 km one from the other, in a straight line.

Data collection

Sampling was carried out through three monthly collections from January 2016 to May 2016, during the flowering period of the plants, between 12:00 o´clock and 5 p.m. At each hour of sampling, the temperature and the relative humidity of the air were recorded with the use of a dry/ wet bulbthermos hygrometer. The methodology of bee sampling was based on Sakagami *et al.* (1967), consisting of the collection of bees on flowers, with the aid of an entomological net, traversing the study areas in a uniform way, throughout the period of flowering. Bees were labeled according to Yamamoto's methodology (2009): the individuals were accommodated in a modified syringe in order to position them for marking when a numbered label was attached to the mesothorax of the bees with permanent glue (Figure 2) and, after drying of the glue, the tagged individuals were released, in a recapture attempt procedure. Floral visitors that could be identified quickly and securely were only registered. The unidentified bees in the field were collected with the aid of entomological net, sacrificed in ethyl acetate, mounted on entomological pins, labeled, dried, identified by means of identification keys and also with comparison with specimens of the bee collection at the Bee Laboratory (LABEL) of UNIVILLE.

For the verification of the natural fruiting of the yellow passion fruit, at the beginning of the data collection period, the open flowers of the cultivation (flowers last only one day) were marked with colored plastic ribbons at each sampling day, tied to their peduncles, on the same days as the censuses were carried out (Figure 3). After 15 days, the area was inspected and the amount of flowers that had borne fruit was counted. Data were arranged in database and tabulated. Quantitative analyzes of the data were performed by calculating abundance and frequency, population estimate for open populations by the stochastic estimation of Jolly-Seber (JOLLY, 1965; SEBER, 1965) and Spearman correlation to verify the relation of fruiting to the number of individuals in the sample.

RESULTS

A total of 543 individuals were enrolled in the two study areas. In area 1, 276 individuals of five species were identified, among them, *Xylocopa (Neoxylocopa) frontalis* Olivier, 1789, *Xylocopa (Neoxylocopa) brasilianorum* (Linnaeus, 1767), *Bombus (Fervidobombus) morio* (Swederus, 1787), *Centris (Melacentris) dorsata* Lepeletier, 1841 and *Centris (Trachina) similis* (Fabricius, 1804). In area 2, 267 individuals of three species, *X. frontalis, X. brasilianorum* and*B. morio* (Table 1) were tagged. In contrast to the study by Benevides*et al.* (2009), the greatest diversity of pollinators was observed in the furthest area of the forest fragments. *Xylocopa frontalis* and *Bombusmorio* were the most abundant species in area 1, totaling 96% of the samplings.

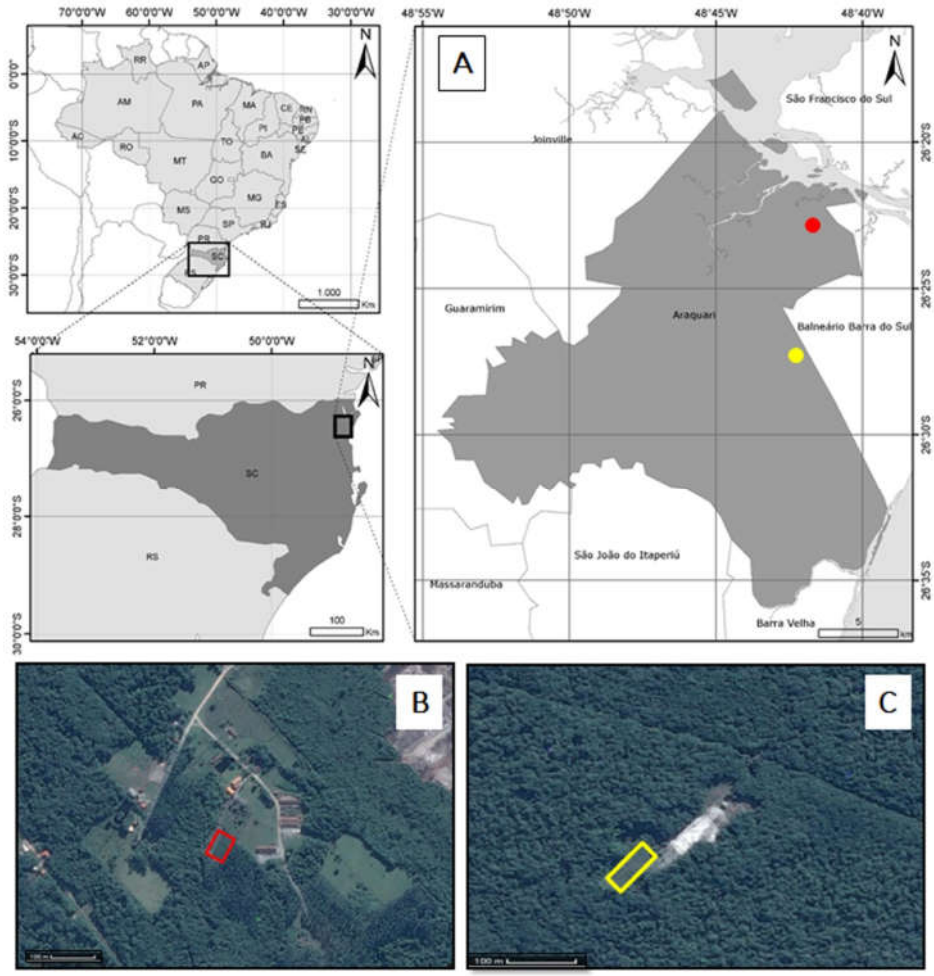

Figure 1. Study areas of *Passiflora edulis*(Passifloraceae) at the municipality of Araquari, SC. Legend: (A) Location of the municipality of Araquari, SC. (B) The two study areas in the municipality of Araquari (red point is crop with pesticides, yellow point is organic crop). (C) Location of the study areas. Source: Map Interativo de Santa Catarina (CIASC, 2013); Google Maps, 2015

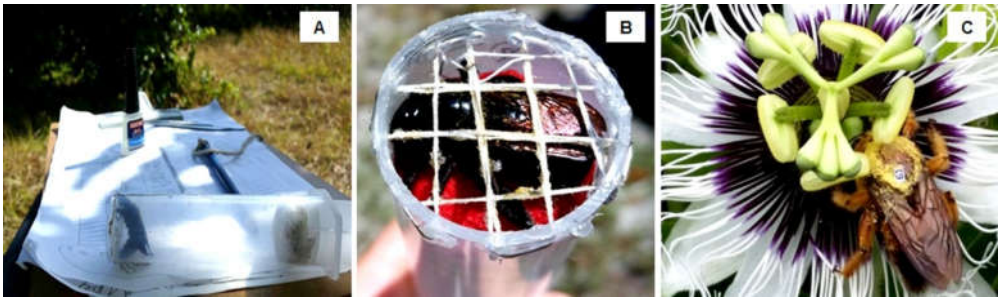

Figure 2. Procedures of marking of pollinating bees in the *Passiflora edulis* (Passifloraceae) crops at the municipality of Araquari, SC. Legend: (A, B) Syringe modified for marking the bees. (C) Free individual with marking. Source: personal archive

Figure 3. Procedure of marking the flowers of *Passiflora edulis* (Passifloraceae) at the municipality of Araquari, SC. Legend: (A) Flower marked with ribbon. (B) Result of a not pollinated flower. (C) Result of a pollinated flower. Source: personal archive

Table 1. Bee species (Apidae) sampled in the crops study areas of *Passiflora edulis* (Passifloraceae) in Araquari, SC

Pollinators				Abundance	
Tribe	Genus	Subgenus	Species	Area 1	Area 2
Xylocopini	*Xylocopa*	*(Neoxylocopa)*	*frontalis*	165	118
Xylocopini	*Xylocopa*	*(Neoxylocopa)*	*brasilianorum*	5	82
Bombini	*Bombus*	*(Fervidobombus)*	*morio*	100	67
Centridini	*Centris*	*(Trachina)*	*similis*	1	0
Centridini	*Centris*	*(Melacentris)*	*dorsata*	5	0
Total				276	267

Table 2. Populational estimate of effective pollinators of *Passiflora edulis* (Passifloraceae) in area 1 in the municipality of Araquari, SC

		Xylocopa frontalis		*Bombusmorio*	
Months	Steps	Marked individuals	Estimated size of the population in number of individuals	Marked individuals	Estimated size of the population in number of individuals
January	1	0		0	0
	2	8	8	0	0
	3	16	17	0	0
February	4	45	55	0	0
	5	12	39	0	0
	6	5	18	0	0
March	7	13	57	27	48
	8	2	9	10	18
	9	6	14	22	27
April	10	5	11	32	44
	11	7		2	

Table 3. Populational estimate of effective pollinators of *Passiflora edulis* (Passifloraceae) in area 2 in the municipality of Araquari, SC

		Xylocopa frontalis		*Xylocopabrasilianorum*		*Bombusmorio*	
Months	Steps	Marked individuals	Estimated size of the population in number of individuals	Marked individuals	Estimated size of the population in number of individuals	Marked individuals	Estimated size of the population in number of individuals
January	1	0	0	0	0	0	0
	2	23	39	0	0	0	0
	3	12	18	0	0	0	0
February	4	23	68	1	1	0	0
	5	10	67	17	32	4	4
	6	7	29	8	19	8	14
March	7	21	49	12	20	2	4
	8	24	56	6	8	4	5
	9	18	31	10	14	12	15
April	10	14	23	10	17	18	30
	11	9					

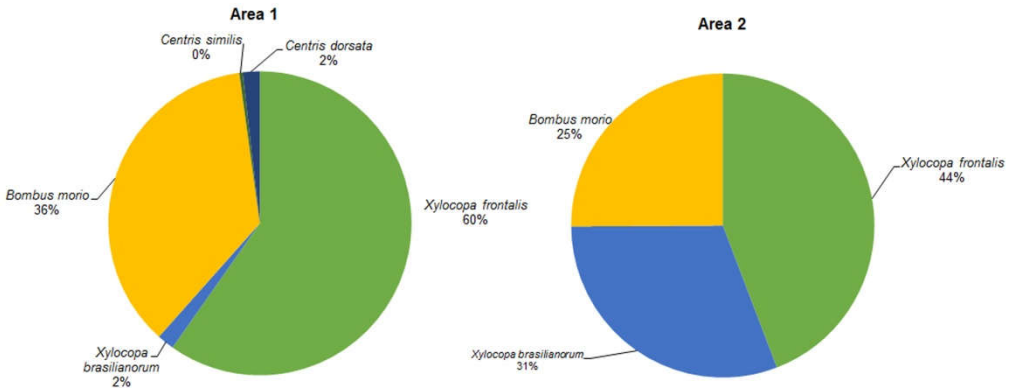

Figure 4. Relative frequency of sampled individuals *per* species *per* crop of *Passiflora edulis* (Passifloraceae) in the municipality of Araquari, SC

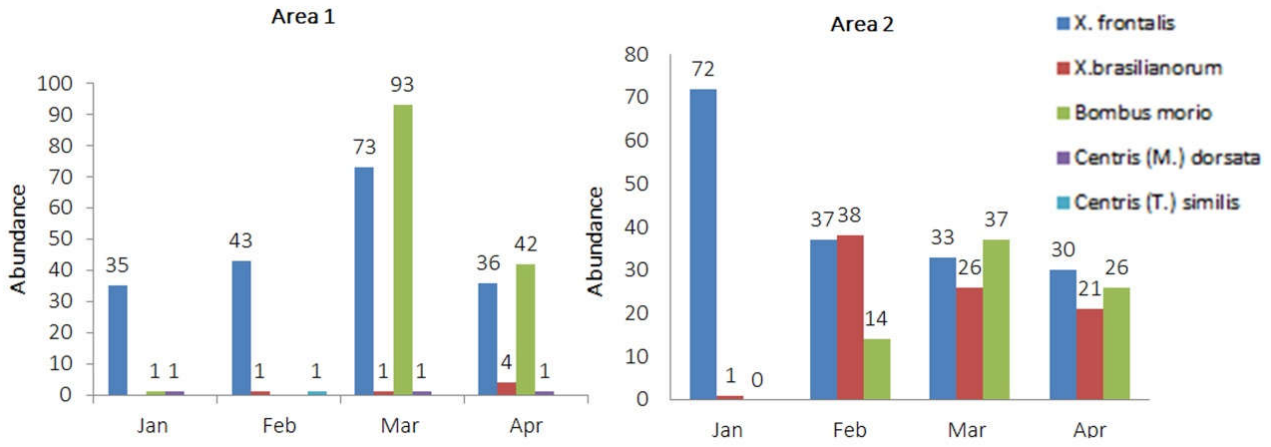

Figure 5. Abundance of pollinators *per* sampling month at the crop of *Passiflora edulis* (Passifloraceae) in the municipality of Araquari, SC

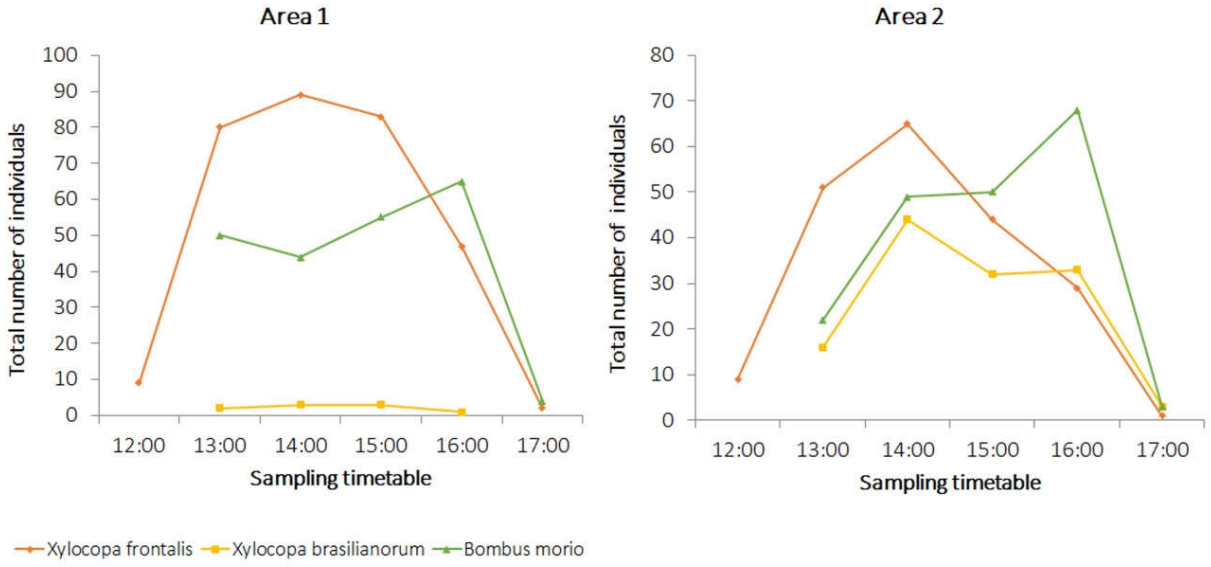

Figure 6. Distribution of the observation of the bee pollinating species *per* sampling time at the crop of *Passiflora edulis* (Passifloraceae) in the municipality of Araquari, SC

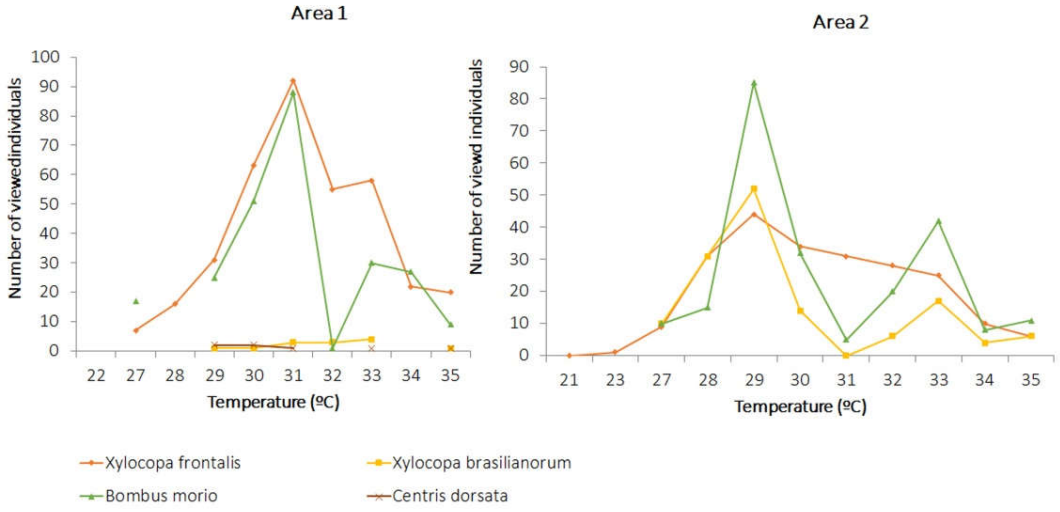

Figure 7. Distribution of pollinating bee species *per* temperature at the crop of *Passiflora edulis* (Passifloraceae) in the municipality of Araquari, SC

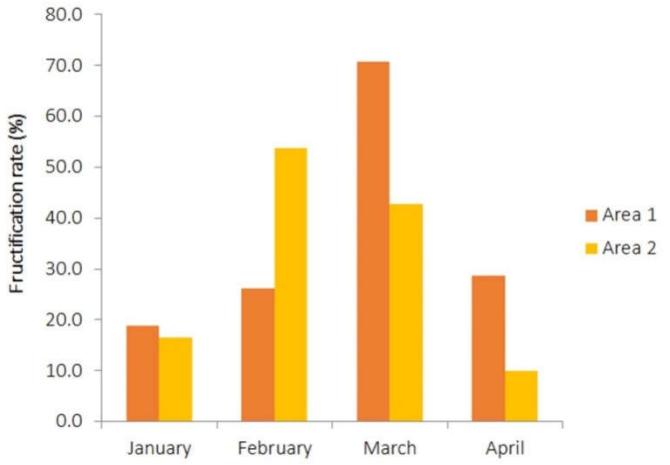

Figure 8. Fructification rate of the two crop areas of *Passiflora edulis* (Passifloraceae) in the municipality of Araquari, SC

species *Bombusmorio* had greater abundance in the two study areas. And, from that same month, all species declined. It was verified that there was a synchronization between the daily activities of the pollinators with the opening hours of the flowers, which began at 1 p.m. (Figure 6). The flowers of *P. edulis* open from 1 p.m. on.

While the activity of the genus *Xylocopa* decreased, that of the *Bombusmorio* increased, that is, this last species raised its activity from 3 p.m. on. In the days of surveys, the mean temperature and relative humidity were, in area 1, 30.9ºC and 70.7%, and in area 2, 30.5ºC and 64.2%. Pollinators were more abundant at temperatures between 30ºC and 31ºC for area 1 and 29ºC at 30ºC in area 2, and in both areas, a second abundance moment occurred at 33ºC (Figure 7). At the end of April and during May, there was a drop in temperature values, which approached 20ºC. During this period, there was low abundance of pollinators (less than 10 individuals) in each of

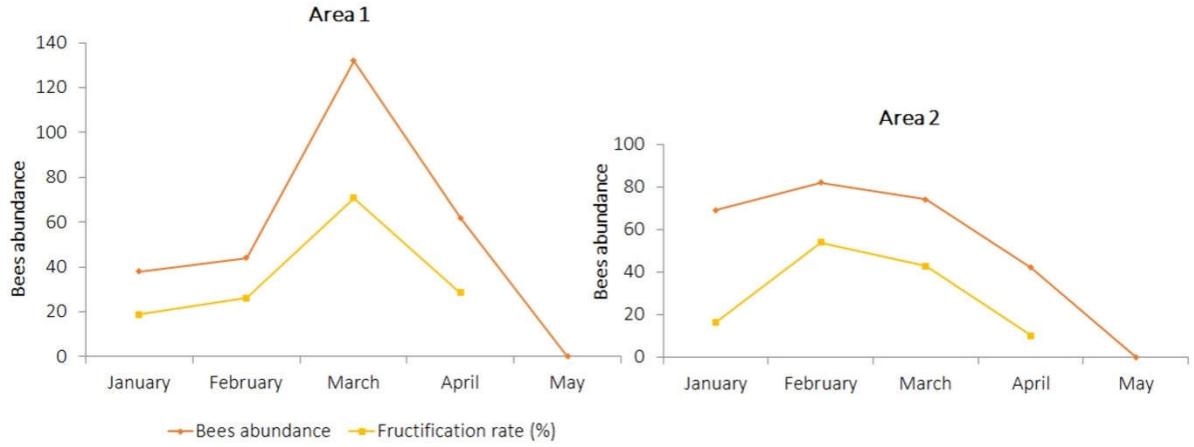

Figure 9. Comparison of the fruiting rate with the quantity of pollinating bees in the two crop areas of *Passiflora edulis* (Passifloraceae) in the municipality of Araquari, SC

In area 2, the most abundant species were *Xylocopa frontalis* and *Xylocopabrasilianorum*, representing 74.9% of the samplings (Figure 4). In both area 1 and 2, the pollinator species that stood out was *X. frontalis*, with 60% and 44% frequency, respectively. The species *X. brasilianorum* had a greater abundance in area 2, with 82 individuals, representing 31% of the individuals collected, differently from area 1 with 2%. Another species that was highlighted in both areas was *Bombusmorio*, with 36% in area 1 and 25% in area 2. Only in area 1 the genus *Centris* was found, with six individuals in total. In January, in area 1, only *X. frontalis* species was present in the crop, with 35 individuals. In February, an individual of *X. brasilianorum* appeared. In March, the forage activity of *Bombusmorio* (93 individuals) began. The number of individuals was reduced in April, with the following abundant species: *Bombusmorio* (42), *X. frontalis* (36), *X. brasilianorum* (4) and *Centris (Trachina) similis* (1) (Figure 5). In area 2, there was a greater abundance of *X. frontalis* species in the month of January (72 individuals) and only one individual of *X. brasilianorum*. From February on, the species *Bombusmorio* appeared and the abundance of *X. brasilianorum* began to increase. In the months of March and April, the abundance of the three present pollinators was similar, dropping however at each collection: *X. frontalis* (33 and 30 respectively), *X. brasilianorum* (26 and 21) and *Bombusmorio* (37 and 26) (Figure 5). It was verified that, in March, the the two areas. Fruiting had an average of 36.1% in area 1 and 30.8% in area 2 (Figure 8). Area 1 had the highest fructification in March (70.7%), while in area 2, the months with the highest fructification were February (53.8%) and March (42.7%). In both areas, the months of January and April presented lower fruiting (18.8% and 28.6 in area 1 and 16.5% and 10% in area 2) (Figure 8). At the end of April, the temperature began to decrease gradually, consequently the amount of flowers decreased and thus there was no verification of fruiting in the month of May, due to the absence of flowers in the previous month.

Considering the data obtained by the Jolly-Seber method in area 1, the estimated population size of the *X. frontalis* species ranged from 8 to 57 individuals and the estimated population size of the *Bombusmorio* species ranged from 18 to 48 individuals. Both species had greater abundance in the month of March. It was not possible to estimate the population for the species *X. brasilianorum* and *Centrisdorsata*, due to the low number of samplings (Table 2). In area 2, the estimated population size for *X. frontalis* species varied from 18 to 68 individuals, for *X. brasilianorum* from 1 to 32 individuals and for *Bombusmorio*, from 4 to 30 individuals (Table 3). According to Kavati (1998), to efficiently pollinate an orchard of 1.0 ha.of yellow passion fruit, it is estimated the need of 350 to 1000 pollinator individuals, depending on the species. Based

on this, it is estimated, for the areas of the present study, the need for 93 to 266 individuals for area 1 and from 105 to 309 individuals for area 2, in order to promote an efficient pollination throughout the crop. Summing the maximum estimates of all species, 105 individuals were obtained for area 1 and 130 individuals for area 2. Thus, the number of estimated pollinators reached the minimum amount required for pollination of the crop, requiring a greater number of individuals for a higher pollination rate, since the obtained fruiting was at moderate levels. It was verified in the present study that there was a positive correlation (Spearman) between the number of bees and the fruiting rate, with 0.99 for area 1 and 0.85 for area 2 (Figure 9), that is, the attractiveness of passion fruit cultivation to bumblebees and carpenter bees tends to increase with an increase in the number of flowers opening each day in the crop. There was significance only for area 1 ($p < 0.01$).

DISCUSSION

The pollinators of the genus *Xylocopa* found in this study are indicated by others as the main pollinators of the species *Passiflora edulis*, in works done in the states of Rio de Janeiro and Minas Gerais, Brazil (SILVA *et al.* 1999; HOFFMANN 2000; MELO *et al.* 2014) and this is attributed to the high fidelity of the interactions of the genus *Xylocopa* with this botanic species, being *X. frontalis* one of its main pollinators because of its large size and abundance in crops (MARCHI & ALVES-DOS-SANTOS, 2013). It has been noted that *X. frontalis* occurs in the areas of yellow passion fruit cultivation, regardless of the distance of the forest fragments (YAMAMOTO, 2009), since it inhabits different environments such as forests, anthropic environments and agricultural areas (BENEVIDES *et al.,* 2009). This species is often abundant and has a wide geographical distribution in the world (MARCHI & ALVES-DOS-SANTOS, 2013). The small number of individuals of the species *X. brasilianorum* verified in area 1, suggests that this species may be sensitive to pesticides or affected by the conservation status of the areas surrounding the crop. In the State of Rio Grande do Sul, *Xylocopabrasilianorum,* occurred exclusively in the rain forest but, in addition to these kinds of areas, there are records of its occurrence in anthropic areas of the city of São Paulo (MARCHI & ALVES-DOS-SANTOS, 2013). In Paraná, females of *X. brasilianorum* were found nesting between December and February and, during this period, they performed few flights (MELO *et al.,* 2005), which could justify the absence of this species in January.

The results found for *B. morio* are different from those of the neighbor state of Paraná, where the species was infrequent throughout the flowering period (MELO *et al.,* 2014) as these authors verified that the species was more representative from March on, but on sweet passion fruit (species *P. alata*).

Speaking of *Centris* species, according to Benevides*et al.* (2006), the bees of the Centridini tribes are present only in the orchards close to forest fragments, suggesting the greater dependence of these groups on natural habitats, as they require floral resources such as oils, as well as specific nesting substrates (CAMARGO *et al*., 1975). However, Gaglianone *et al.* (2010) observed that the richness of Centridini species in a forest area was smaller than in cultivation area, that is, the opposite of what would be expected, suggesting that one should consider that the density of flowers in a cultivation area may result in greater attractiveness to these bees than the isolated flowers in the forest fragments.

With regard to the abundance of pollinators, some authors also verified that the pollinator species declined from March on: Marchi (2008) observed that in June and July *X. frontalis* no longer performed external activity, Yamamoto (2009) noticed that the greatest richness of pollinating species occurred in February and March and Melo*et al.* (2014) observed that this occurred from November to February, decreasing in March and April.

The rate of visitation by females of *X. frontalis* occurs more frequently between 1 p.m. and 2 p.m., falling gradually afterwards during the anthesis period (MARCHI 2008, MELO *et al.,* 2014). The most frequent visiting time of *Xylocopa frontalis* seems to be favorable to pollination of yellow passion fruit because natural pollination, when it occurs between 2:30 p.m. and 4:30 p.m., is more likely to be efficient, even with only one visit, since it is the period in which the *stilettos* are already curved and the *stigmata* are easy to touch by large visitors (MARCHI, 2008). The opening hours of the flowers and the hours of activity of the bees are very important to know as this determines the period in which the phytosanitary treatments should be performed. Thus, in the cultivation of yellow passion fruit, treatments should be carried out in the morning or at night, never in the afternoon, since pollinators perform forage activities in the afternoon period (RUGGIERO, 1987; CAMILO, 2003).

About the abiotic factors registered, according to Baird (1986), heat loss by convection could restrict flight at lower temperatures. In fact, Pereira (2003) observed in the municipality of RibeirãoPreto, state of São Paulo, that temperature influenced the activity start time of the species *X. frontalis*, which only flew when the temperature exceeded 20° C, what could justify, in the present study, the absence of pollinators during May. In a study carried out in the State of São Paulo, according to Marchi (2008), the maximum temperature had a lower influence than the minimum temperature, probably due to the ability of thermoregulation that is a biological characteristic of large bees.

The rate of fruiting found was higher than that found in the state of Minas Gerais, where the average natural fruiting was 25% (YAMAMOTO, 2009). According to Ruggiero (1987), fruiting rates of passion fruit, under natural conditions, to be considered good, should be between 40 and 50%. Thus, in the present case, pollination of the crop was somewhat below a good yield. Melo*et al.* (2014) state that, when the natural fruiting rate is below 30 to 40%, it is necessary to induce management to increase and maintain bee populations, monitoring the activity of the bees to prevent deterioration of local conditions that could compromise the pollination services. In other studies, similar variations in minimum and maximum fruiting rates were found: 8% to 80% in the state of Paraná (MELO *et al.,* 2014) and 11.8% to 52.3% in the state of Bahia (SIQUEIRA *et al.,* 2009).

The no verification of fruiting in the month of May, due to the absence of flowers in the previous month, is similar to that reported for the state of Paraná in April 2005, when there was a drop in temperature and a marked fall in bee activity, as well as a concomitant decrease in flower production (MELO *et al.,* 2014). According to the same authors, in the month of May, individuals of the species *Xylocopa frontalis* leave their nests

in search of a new nest or for copulation and not for foraging activity, possibly because there is still no need to provide food to the offspring, and thus the individuals of this species are practically absent in the crop. The production of *P. edulis*, besides being confined to certain times of the year, has flowering and fruiting affected by changes in temperature, photoperiod and solar radiation (VASCONCELLOS & DUARTE FILHO, 2000). Cases of low fruiting may also be related to pollinator scarcity or rainfall in the late afternoon (AKAMINE & GIROLAMI, 1959).

According to Melo*et al.* (2014), only *X. frontalis* leads to fruit formation with a single visit because other visitors of medium to large body size (such as *Xylocopabrasilianorum* and *Bombusmorio*), although potential pollinators, do not lead to fruit formation with a single visit possibly because they do not leave a sufficient quantity of pollen grains to trigger the fruiting, which implies in the need of more visits to the flower for fertilization.

The attractiveness of passion fruit cultivation to bumblebees and carpenter bees tends to increase with an increase in the number of flowers opening each day in the crop (MELO *et al.,* 2014). According to Yamamoto (2009), the number of fruits formed increases as the number of visits of the species of *Xylocopa* increases, because a greater number of pollinators in action increases the amount of pollen deposited in the stigma of the flowers, improving the quality and quantity of fruits and seeds produced. This characteristic is important for a crop whose pollination is essential for fruit production. Follow-up of the fruiting for more than one year may add elements to the correlation between number of bees and the fruiting rate.

Data showed, finally, in both areas, the presence of effective pollinators of passion fruit, but in discrete abundance values. The population estimate of pollinators showed that the number of effective pollinators is in the minimum amount needed to effectively pollinate the crop, possibly explaining the moderate fruit yield. In order to increase the amount of pollinators, it is suggested to maintain these pollinators by increasing nesting resources for them. The determination of the richness and abundance of the pollinators in the studied crops may be considered an indicative of the rate of natural fruiting and the yield of the cultivation. Follow-up of the fruiting for more than one year may add elements to the correlation between number of bees and the fruiting rate.

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