Original Research Article

Ecological survey of pests and natural enemies in the sour passion fruit progenies

ABSTRACT

Aims: This experiment was to identify the major pests, natural enemies and verify the regarding the incidence of insect pests of progenies of *Passiflora edulis* to pests.
Study Design: Experimental design was completely randomized blocks with twenty-three progenies and three replicates with four plants per plot.
Place and Duration of Study: Experimental evaluations of the Federal University of Viçosa/Rio Paranaíba University Campus, Rio Paranaíba county, Minas Gerais, Brazil from May to September 2011.
Methodology: The population fluctuation of insects, for characterization of their occurrence and identification of progenies with respect to their degree of resistance.
Results: Among the monitored pests stood out, *A. vanillae vanillae*, *D. juno juno* e *Dasiops* sp. The correlation between the amount of *Dione juno juno* and the attacked leaf had a higher magnitude of occurrence in relation *Agraulis vanillae vanillae*.
Conclusion: It was found that there were no differences between the sour passion fruit progenies and resistance to pests, and to verify that ants are important predators of pests of sour passion fruit.

Keywords: Passiflora edulis Sims, pests, natural enemies.

1. INTRODUCTION

Brazil is the world's largest producer of sour passion fruit (*Passiflora edulis* Sims), presenting in recent years a growing increase in cultivated area, due to the demand for fruits in the fruit market in natura and by the juice industry. However, although the country stands out as the world's leading producer, the average yield per area is 13.5 $t\ ha^{-1}$ year.

The causes for this low production are the presence of diseases and insect pests throughout the crop cycle, making sour passion fruit cultivation unfeasible in some regions of the country. Among the limitations in crop management are losses caused by insects, especially those caused by caterpillars [1] and bedbugs, which are considered frequent and severe pests in the main producing regions.

However, other insects are important for culture, among them the fly the of flower, mites, borer sour passion fruit drill, kitties and aphids. Among the insects present in sour passion fruit some provide great benefits to the production, highlighting the mamangava *Xylocopa* sp. (Hymenoptera: Apidae), responsible for pollination [2] and important natural enemies in pest control.

Antunes et al. [3] report that the occurrence of natural enemies in the cropping system minimizes the need for man's intervention in the control of insect pests, highlighting that the use of biological agents for the control of insect pests has intensified in recent years in Brazil, with significant results in the management of phytophagous organisms.

Pests associated with sour passion fruit can cause economic damages, as they promote reduction in fruit production and, in extreme cases, cause the death of plants. In this way, sour passion fruit breeding programs aim to improve morphological, physiological and agronomic characteristics that promote greater productivity increase, fruit quality improvement and resistant or pest tolerant genotypes [4, 5, 6].

Comment [A1]: Which recently, was increased its' cultivation area,
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Comment [A9]: Antunes et al. [3]

However, the same genetic improvement directed to more productive genotypes and better quality of fruits, can produce plants more vulnerable to pest attack. But to determine this vulnerability requires a detailed and systematic survey of the pests causing losses and the environmental and regional conditions involved, aiming to obtain information that can subsidize possible interventions directed to local or regional control.

In the survey of the entomofauna associated to the fruits and seeds of plants of the genus *Enterolobium* of the family Leguminosae, Meiado et al. [7] verified that the fruits of *E. contortisiliquum* presented a high percentage of infestation (91%), meanwhile on the fruits of *E. timbouva* the percentage of infestation was from 5%. The survey allowed to determine the differentiated consumption of the plant species and the agents involved.

Comment [A10]: ??

The survey of the arthropod population in a potato agroecosystem (*Solanum tuberosum*), the most frequent phytophagous species were the *Epitrix* sp., e *Diabrotica speciosa*, in the second-season, followed by the spittle *Empoasca kraemeri*, in both periods of growth of the culture. The predatory species *Eriopis connexa* and *Geocoris* sp. were numerous in the traditional culture period [8]. This demonstrates that knowledge of pests and their occurring natural enemies associated with a particular crop and season of the year may guide control efforts for a more restricted group of pests.

Comment [A11]: Why mention potato crop ?????

In the monitoring of the entomofauna associated with the varieties Incasoy-24, Incasoy-27, Cubasoy-23 and Doko in the provinces of Havana and Matanzas, the insects with the highest incidence belonged to the families Crisomelidae, Noctuidae, Thripidae and Pentatomidae. The major damages to the grains were caused by the bedbugs *Piezodonis guildinii*, *Jalysus reductus* e *Prachilorachius bilobulatus* in the Incasoy-27 variety. Temperature was the variable most related to infestation. The parasitoid *Trissoleus* sp. and the fungi *Beauveria bassiana* e *Aspergillus* spp. were efficient natural enemies, but not for decreased pest populations [9].

In view of the above the present work was developed with the purpose of identifying and estimating the population density of the main species of pest insects and natural enemies in sour passion fruit progenies, as well as the main injuries.

2. MATERIAL AND METHODS

This work was developed from May to September of 2011 in the experimental area of the Federal University of Viçosa / Rio Paranaíba Campus University in Rio Paranaíba county, Minas Gerais, Brazil. Geographically, the experimental area is latitude 19° 12' South and longitude 46° 07' West with an altitude of about 1100m and an annual mean temperature of 20.4° C.

In the evaluations the occurrence of insect pests and their natural enemies were observed, which were carried out in a competition experiment of sour passion fruit progenies aiming productivity and fruit quality. The planting spacing was 3.5 m between rows and 4.0 m between plants. The plants were driven in a vertical spalier with a height of 1.80 m in galvanized wire, individualizing each plant with the aid of pruning. Farming practices were usually recommended to culture. The plants were arranged in a randomized complete block design, with three replicates and four plants per plot.

The survey of pests and natural enemies were done in twenty-three sour passion fruit progenies, being five commercially used (BRS SC1, BRS GA1, BRS OV1, FB 200, FB 300) and the others are half sib from the sour passion fruit breeding program of the Federal University of Viçosa (Table 1).

The sour passion fruit plants were evaluated weekly to determine the density of defoliating caterpillars, with a direct count of *Agraulis vanillae vanillae* (Linnaeus, 1758) (AGR) and *Dione juno juno* (Cramer, 1779) (DIO) (Lepidoptera: Nymphalidae). The caterpillars found in the branches were quantified and removed from the plants in order to evidence the posture of adults in specific groups of progenies. The bugs *Diactor bilineatus* (Fabricius, 1803) (DIA) and *Holymenia clavigera* (Herbst, 1784) (HOL) (Hemiptera: Coreidae), present in the branches were also counted, as well as *Diabrotica* sp. (DSP) (Coleoptera: Chrysomelidae) and the floral bud fly *Dasiops* sp. (DAS) (Diptera: Lonchaeidae). In the evaluation of the floral bud fly, the attack was accounted for by the injured buttons, which were removed at each evaluation so that there was no influence on the following evaluations. Natural enemies when present were collected and quantified. The number of leaves attacked (AL) was determined by quantifying the number of leaves that showed signs of the attack caused by leaf defoliating caterpillars in a 2 m^2 area of the leaf canopy of plants on both sides of the espalier.

During the experimental period, the data of temperature (º C) (TEMP), precipitation (mm/day) and relative humidity (%) in Rio Paranaíba county, Minas Gerais, were obtained with the aid of the Main Climatological Station of the Federal University of Viçosa/Rio Paranaíba Campus University (Figure 1).

For statistical analysis the data were transformed $[(x + 0.5)^{1/2}]$ and submitted to analysis of variance (F test). In addition, the densities of the evaluated pests were submitted to the correlation analysis with natural enemies and climatic elements to evidence the effect of these factors on the attack on the sour passion fruit progenies. Based on the correlation analysis, the significant relationships were represented by seasonal variation curves during the experimental period.

3. RESULTS AND DISCUSSION

It was verified for the different characteristics evaluated that there were no significant differences (P = 0.05) for the twenty-three sour passion fruit progenies (Table 2). The results demonstrate that the occurrence of different species of defoliating caterpillars and progeny attack were similar, inferring that because they were not selected in the improvement for this objective, or by reduced genetic variability for this characteristic, are similar in terms of attack intensity and occurrence of quantitative insect pests and natural enemies. The ants *Dorymyrmex* sp. and *Camponotus* sp. (ANT) were the species found in the evaluated area. For some characteristics, there are high values of environmental variation, demonstrated by the coefficient of variation, assuming an interference of the environment in the behavior of the insects.

Comment [A12]: What kind of ant …to consider it pest to plant…. Mentioned order and family

The incorporation of resistance to insect pests in genetic materials is a methodology recommended by the ease of use and cost however, one must have prior knowledge of the main pests that affect the crop. Srinivas et al. [10] describe that genetic improvement of crops for tolerance to biotic and abiotic factors is a major focus of breeding programs worldwide, because it is considered that the incorporation of insect resistance is considered the most effective and environmentally safe control method.

Angelini and Boiça Júnior [4] working with ten sour passion fruit genotypes to evaluate the food preference of *D. juno juno* caterpillars. The results found by the authors for caterpillars aged ten days in relation to dry mass consumption in the test with a chance of choice showed no significant difference. Although, the genotypes *Passiflora edulis* and *Passiflora alata* considered patterns of susceptibility and resistance, respectively, were present. The gregarious feeding of herbivorous insects assists in the exploration of its host plant. Denno and Benrey [11] working with the size variation of groups of caterpillars *Chlosyne janais* (Drury, 1782) (Lepidoptera: Nymphalidae), found twice as fast growth in grouping with thirty individuals compared to those groups smaller than ten individuals. According to Karban and Agrawal [12] this effect may occur in gregarious groups due to the fact that the aggregation of herbivorous insects acts as a drain for the host plant or by hindrance of induced defenses compared to smaller groups of herbivores. Therefore, the generalized attack on the progenies, most prominently for the gregarious caterpillar *D. juno juno*, and as a consequence, the indiscriminate presence of *A. vanillae vanillae.*

Based on the correlation coefficient analysis, no significant differences were observed in the majority of the variables evaluated in the different sour passion fruit progenies. However, we can verify that there was a significant correlation between some variables, positive for AGR x AL (0.245), AGR x RH (0.111), DIO x AL (0.468), DIA x VES (0.175), DAS x VES (0.132), DAS x RH (0.471), CAN x BRA (0.091), ARA x ANT (0.170), ARA x TEMP (0.086), AL x RH (0.301), ANT x TEMP (0.218), VES x TEMP (0.109), and negative for AGR x ANT (-0.101), DIO x ANT (-0.142), DAS x ANT (-0.247), DIA x VES (-0.175), ARA x RH (-0.089), AL x ANT (-0.159), AL x TEMP (-0.125), ANT x RH (-0.306) (Table 3).

Considering the results obtained, the interaction between the *A. vanillae vanillae* attack and the number of attacked leaves (AGR x AL = 0.245), although presenting low magnitude, demonstrates that the attack of this insect-plague damages the plants, due to the reduction of the photosynthetically active leaf area affecting fruit production and maintenance. Similarly, one notices interaction between the *D. juno juno* attack and the number of attacked leaves (DIO x AL = 0.468) was observed. However, this pest species, for the conditions of our work, promoted greater injury in the leaf area of the plants, confirmed by the value of the magnitude of the interaction, due to the habit of forming aggregates with a large number of caterpillars.

Correlations with relative humidity showed positive and elevated values, providing increases in the number of insects, as verified for the amount of *A. vanillae vanillae*, *D. juno juno*, *Diabrotica* sp. and *Dasiops* sp. However, the amount of ants decreases with increases in relative humidity (ANT x UR = - 0.306) indicating that insects of this family are sensitive to high humidity.

The correlations between Formicidae (ANT) and passionflower pests, in which the caterpillars (AGR and DIO) and floral bud fly (DAS) and bed bug (DSP) stand out, present negative values, demonstrating that the occurrence of ants in sour passion fruit plants promotes the reduction of the number of pests. This fact is confirmed by the interaction ANT x AL (-0.159), demonstrating that the occurrence of individuals in this family promotes a reduction in the number of leaves attacked by pest insects. Rossi and Fowler [13] working with fauna evaluation of predatory ants on sugarcane crops observed that these same ant species (*Dorymyrmex* sp. and *Camponotus* sp.) act in the biological control of *Diatraea saccharalis* (Fabr.) (Lepidoptera: Pyralidae) preying their eggs and the early larval stages. Leal et al. [14] showed that the visits of ants to foliar and bracteal nectaries in *Passiflora coccinea* almost doubled the amount of seeds produced, compared to flowers from which the ants were artificially excluded. The results suggest a protective role of ants against herbivores, improving the reproductive success of the plant.

In a complementary way, the interaction ANT x ARA (0.170) is verified, demonstrating that the occurrence of these associated arthropods makes it possible to confirm them as natural enemies of sour passion fruit pests. Ants and spiders are among the main predators of invertebrate herbivores, and can, therefore significantly reduce the injuries caused to host plants [15,16]. The results of this work evidenced and corroborate the importance of these predators as being important natural enemies of pests in fruit trees.

Xião et al. [17] working with the citrus crop, verified the contribution of predation in the mortality of *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae). The results found by these authors demonstrated that the predation, mainly by ants, acting in the early stages of this plague, was the largest single cause of mortality, more than 30% of all deaths by natural enemies, and 60% of all predator deaths.

The population of spiders present in the branches of sour passion fruit showed no significant correlation with the evaluated pest densities, although Brown et al. [18] report that the occurrence of spiders in apple orchards, peach trees and cherry trees in the United States is linked to the predation of the main pests of these *crops.*

Observing the abundance of *A. vanillae vanillae* during the evaluation months, it was verified that the incidence peaks of the pest occurred in the months of May to mid July, while *D. juno juno* presents high incidence peaks during the months of May to mid August (Figura 2) in the studied region. The population peak observed in the winter months corroborates the results reported by Lima & Veiga [19] in Pernambuco, Brazil.

Boiça Júnior et al. [20] observed that the total number of *D. juno juno* caterpillars showed a higher peak of occurrence in the months of July and December in the Jaboticabal, São Paulo, assuming that the control of these should be done in these months.

Among the insects that attack the sour passion fruit, *D. juno juno* is characterized as one of the main pests, causing defoliation, which causes the reduction of the growth and production of sour passion fruit; being that successive attacks of this pest can cause the death of the plants [21].

The number of leaves attacked has a high incidence in the period from May to mid August (Figure 2), and this result is due to the attack of *D. juno juno* and *A. vanillae vanillae,* which in a similar way present high occurrence in this period. Associated with this description, there was a higher occurrence of individuals of the family Vespidae (*Polybia platycephala* and *Mischocyttarus rotundicollis*) in periods of high occurrence of pests. According to Moura et al. [22] representatives of this family are predators of *D. juno juno*. Prezoto et al. [23] studied the prey of the social wasp *P. platycephala*, revealing its potential for biological pest control programs. Among the captured prey were insect orders Diptera (33.4%), Lepidoptera (28.6%), Hemiptera (12.0%), Hymenoptera (9.4%) and Coleoptera (7.2%), with estimated capture of 4,380 prey per year for a single colony.

The increase in temperature also favored the increase of individuals of the Vespidae family (VES x TEMP = 0.109). Climatic conditions affect the foraging rate of predatory wasps. the activity rhythm foraging activity in *P. platycephala sylvestris* reveals a more intense activity during the hot and humid season of the year (13.94 to 21.15 worker outputs per hour) than in the cold and dry season (2.00 a 2.47 outputs per hour) [24].

Another pest that presents high incidence during the period of May to June is the the fly the of flower (Figura 2). The occurrence of such a pest in the period described can be evidenced by the presence of floral buds in the sour passion fruit that is common at this time and by the absence of precipitations, fact that influences the development of the pest, as it jeopardizes its displacement in the crops.

The incidence of ants individuals in the sour passion fruit progenies has had the highest peak occurring from August, when temperature increases. The highest densities of natural enemies recorded in the evaluations were predatory ants (Figure 2). This may have contributed negatively to the presence of other agents of natural control of passionflower pests, among which we can mention predatory parasitoids, wasps and beetles. he abundance of predatory ant *Solenopsis invicta* Buren (Hymenoptera: Formicidae) had a negative influence on 16 taxa of herbivores in cotton, but also showed a negative correlation with density 22 and 14 taxa of natural enemies present in cotton and soybean, respectively [25]. Although in our work we did not show the aggressiveness of ant species found in the progenies when compared to the very aggressive *S. invicta* species.

The occurrence of pest insects is related to locality and specific climatic conditions, so pest surveys and natural enemies can guide breeding programs aiming at insect pests of more widespread occurrence in the country and / or regional.

4. CONCLUSION

Based on the information, among the monitored pests stood out, *A. vanillae vanillae*, *D. juno juno* e *Dasiops* sp. Among the natural enemies monitored stood out the ants (*Dorymyrmex* sp. and *Camponotus* sp.) and predators wasps (*P. platycephala* and *M. rotundicollis*). No differences were observed in relation to the insect pests and natural enemies in the twenty-three sour passion fruit progenies evaluated. The ants are important predators of passionflower pests, but due to their high density can impact the general biological control that occurs in the crops. The correlation between the *D. juno juno* population and the number of leaves attacked presented greater magnitude of occurrence regarding *A. vanillae vanillae*.

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Table 1. Identification (ID) and ancestry of the sour passion fruit progenies evaluated. Rio Paranaíba county, Minas Gerais, Brazil in 2011

ID	Ancestry
1	UFVMAR 29
2	UFVMAR 41
3	UFVMAR 42
4	UFVMAR 9
5	UVFMAR37

6	UFVMAR 26
7	UFVMAR 2
8	UFVMAR 13-1
9	UFVMAR 13-2
10	UFVMAR 19
11	UFVMAR 115
12	UFVMAR 133
13	UFVMAR 257
14	UFVMARG 258
15	UFVMAR 259
16	UFVMAR 392
17	UFVMAR 3117
18	UFVMAR 3118
19	BRS GA1
20	BRS OV1
21	BRS SC1
22	FB-200
23	FB-300

Table 2. F test by ANOVA and its probability for the different variables evaluated in the sour passion fruit progenies. Rio Paranaíba county, Minas Gerais, Brazil in 2011

Variation Factors	GL[1]	F	P	F	P	F	P	F	P
		A. vanillae vanillae		Araneae		Cantharidae		*Diabrotica* sp.	
Blocks	2	1.33	0.27	11.76	0.001	0.72	0.40	3.93	0.03
Treatments	22	0.89	>0;40	1.48	0.13	0.78	>0.40	0.80	>0.40
Residue	44								
Coefficient of variation (%)		62.5		25.8		4.9		15.9	
		Dasiops sp.		*Diactor bilineatus*		*Dione juno juno*		Attacked leaves	
Blocks	2	1.06	0.35	0.14	0.40	5.22	0.007	0.88	0.40
Treatments	22	0.81	>0.40	1.57	0.10	0.70	>0.40	0.69	>0.40
Residue	44								
Coefficient of variation (%)		35.8		3.6		52.3		19.9	
		Ants		*Holymenia clavigera*		Braconidae		Vespidae	
Blocks	2	1.79	0.18	1.00	0.40	0.98	0.40	3.35	0.04
Treatments	22	1.41	0.16	0.91	>0.40	0.79	>0.40	0.65	>0.40
Residue	44								
Coefficient of variation (%)		29.6		2.9		5.5		64.8	

[1] Degree of freedom.

Table 3. Correlation values between the variables evaluated in the sour passion fruit progenies. Rio Paranaíba county, Minas Gerais, Brazil in 2011

Variables[1]	HOL	AL	CAN	ARA	ANT	BRA	VES	RH	TEMP
AGR		0.245**	-0.011 ^{ns}	-0.019 ^{ns}	-0.101*	-0.016 ^{ns}	0.001 ^{ns}	0.111**	-0.065 ^{ns}
DIO		0.468**	-0.043 ^{ns}	-0.010 ^{ns}	-0.142**	-0.041 ^{ns}	0.082*	0.295**	0.032 ^{ns}
DSP		0.063 ^{ns}	0.021 ^{ns}	0.043 ^{ns}	-0.142**	0.027 ^{ns}	0.238**	0.271**	0.065 ^{ns}
DAS			0.003 ^{ns}	-0.051 ^{ns}	-0.247**	-0.043 ^{ns}	0.132**	0.471**	0.037 ^{ns}
DIA	-0.006 ^{ns}		-0.008 ^{ns}	0.002 ^{ns}	-0.028 ^{ns}	-0.010 ^{ns}	0.175**	-0.002 ^{ns}	-0.002 ^{ns}
CAN	-0.007 ^{ns}			-0.011 ^{ns}	-0.045 ^{ns}	0.091*	0.035 ^{ns}	0.067 ^{ns}	0.013 ^{ns}
ARA	-0.012 ^{ns}				0.170**	-0.005 ^{ns}	-0.034 ^{ns}	-0.089*	0.086*
AL					-0.159**	-0.022 ^{ns}	-0.038 ^{ns}	0.301**	-0.125**
ANT	0.001 ^{ns}					-0.006 ^{ns}	-0.031 ^{ns}	-0.306**	0.218**
HOL						-0.008 ^{ns}	0.035 ^{ns}	-0.042 ^{ns}	-0.009 ^{ns}
BRA							0.021 ^{ns}	0.027 ^{ns}	0.032 ^{ns}
VES								-0.016 ^{ns}	0.109**

* Significant correlation coefficient at the 5% level by Test t. ** Significant correlation coefficient at the 1% level. ^{ns} Non-significant correlation coefficient.
[1] Variables: *Agraulis vanillae vanillae* (AGR), Araneae (ARA), Braconidae (BRA), Cantharidae (CAN), *Dasiops* sp. (DAS), *Diabrotica* sp. (DSP), *Diactor bilineatus* (DIA), *Dione juno juno* (DIO), Attacked leaves (AL), Formicidae (ANT), *Holymenia clavigera* (HOL), Average temperature (TEMP), Relative humidity (RH) and Vespidae (VES).

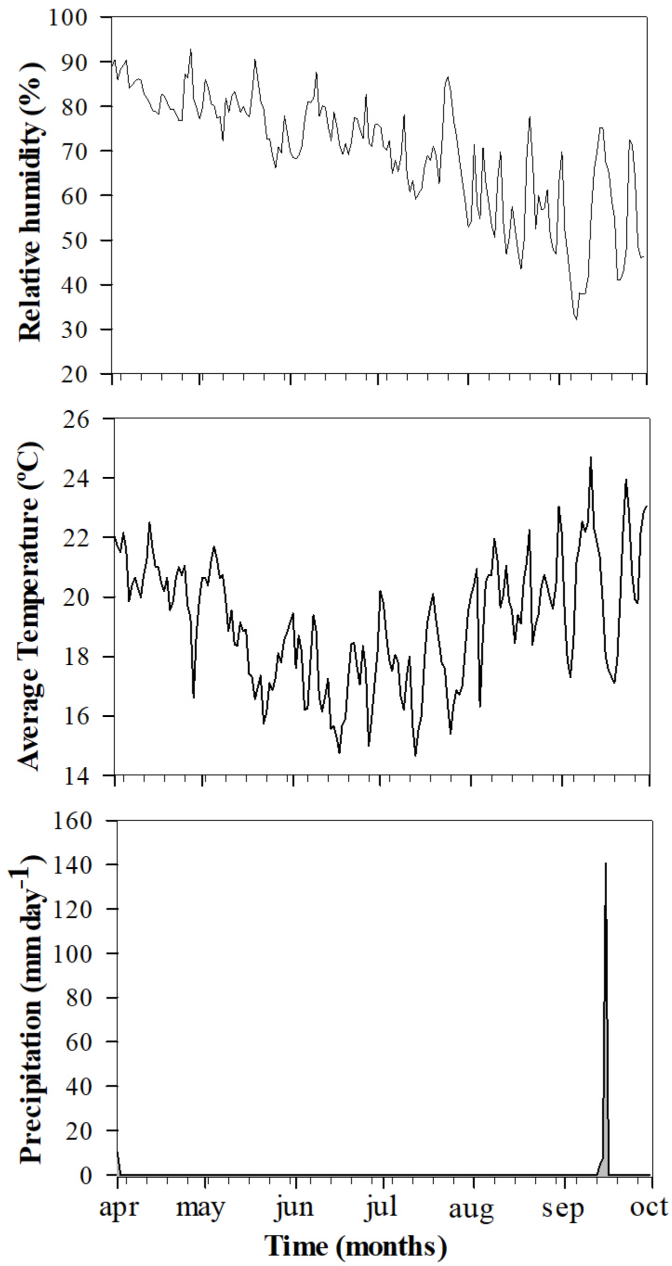

Fig. 1. Variation of climatic relative humidity (%), mean air temperature (ºC) and total rainfall (mm/day). Rio Paranaíba county, Minas Gerais, Brazil in 2011

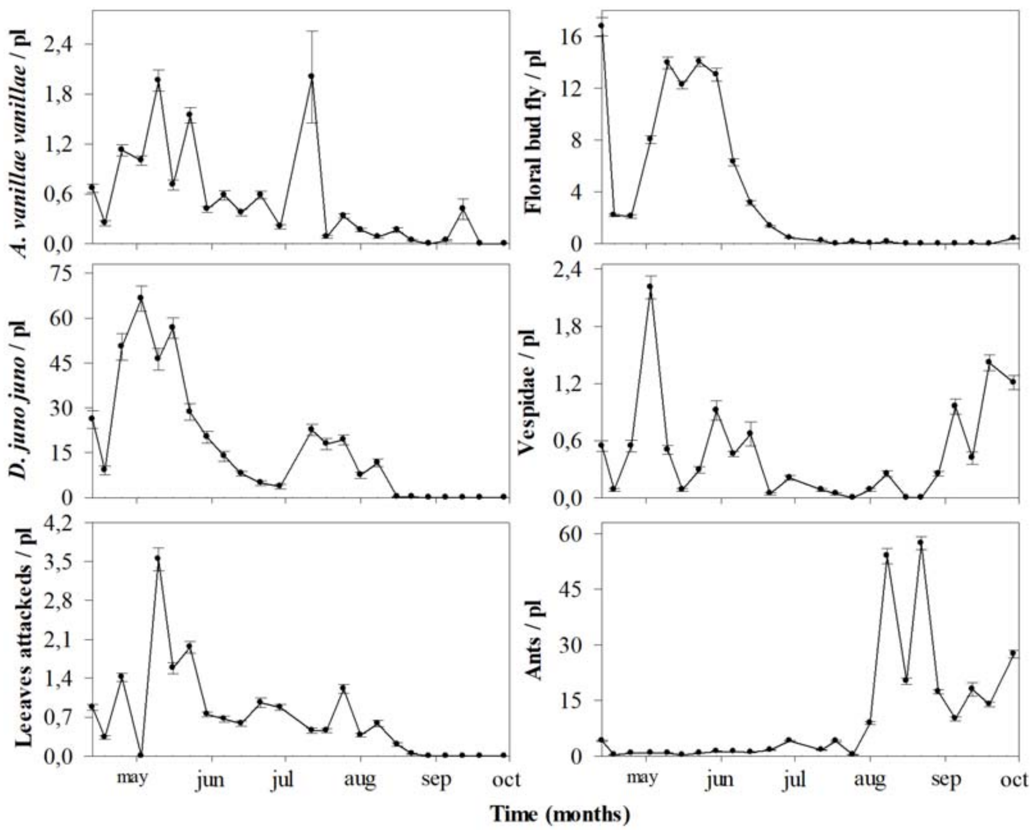

Fig. 2. Abundance (mean ± standard error) pests, natural enemies and injuries in the sour passion fruit progenies. Rio Paranaíba county, Minas Gerais, Brazil in 2011