

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.

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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.

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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.

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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.

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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].

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

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

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

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

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

81 2. MATERIAL AND METHODS

82
83 This work was developed from May to September of 2011 in the experimental area of
84 the Federal University of Viçosa / Rio Paranaíba Campus University in Rio Paranaíba county,
85 Minas Gerais, Brazil. Geographically, the experimental area is latitude 19° 12' South and
86 longitude 46° 07' West with an altitude of about 1100m and an annual mean temperature of
87 20.4° C.

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

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

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

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110 leaves that showed signs of the attack caused by leaf defoliating caterpillars in a 2 m² area of
111 the leaf canopy of plants on both sides of the espalier.

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

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

122

123 3. RESULTS AND DISCUSSION

124

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

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

141 Angelini and Boiça Júnior [4] working with ten sour passion fruit genotypes to
142 evaluate the food preference of *D. juno juno* caterpillars. The results found by the authors for
143 caterpillars aged ten days in relation to dry mass consumption in the test with a chance of
144 choice showed no significant difference. Although, the genotypes *Passiflora edulis* and
145 *Passiflora alata* considered patterns of susceptibility and resistance, respectively, were present.
146 The gregarious feeding of herbivorous insects assists in the exploration of its host plant. Denno
147 and Benrey [11] working with the size variation of groups of caterpillars *Chlosyne janais* (Drury,
148 1782) (Lepidoptera: Nymphalidae), found twice as fast growth in grouping with thirty individuals
149 compared to those groups smaller than ten individuals. According to Karban and Agrawal [12]
150 this effect may occur in gregarious groups due to the fact that the aggregation of herbivorous
151 insects acts as a drain for the host plant or by hindrance of induced defenses compared to
152 smaller groups of herbivores. Therefore, the generalized attack on the progenies, most
153 prominently for the gregarious caterpillar *D. juno juno*, and as a consequence, the indiscriminate
154 presence of *A. vanillae vanillae*.

155 Based on the correlation coefficient analysis, no significant differences were observed
156 in the majority of the variables evaluated in the different sour passion fruit progenies. However,
157 we can verify that there was a significant correlation between some variables, positive for AGR
158 x AL (0.245), AGR x RH (0.111), DIO x AL (0.468), DIA x VES (0.175), DAS x VES (0.132),
159 DAS x RH (0.471), CAN x BRA (0.091), ARA x ANT (0.170), ARA x TEMP (0.086), AL x RH
160 (0.301), ANT x TEMP (0.218), VES x TEMP (0.109), and negative for AGR x ANT (-0.101), DIO
161 x ANT (-0.142), DAS x ANT (-0.247), DIA x VES (-0.175), ARA x RH (-0.089), AL x ANT (-
162 0.159), AL x TEMP (-0.125), ANT x RH (-0.306) (Table 3).

163 Considering the results obtained, the interaction between the *A. vanillae vanillae*
164 attack and the number of attacked leaves (AGR x AL = 0.245), although presenting low
165 magnitude, demonstrates that the attack of this insect-plague damages the plants, due to the
166 reduction of the photosynthetically active leaf area affecting fruit production and maintenance.
167 Similarly, one notices interaction between the *D. juno juno* attack and the number of attacked

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168 leaves (DIO x AL = 0.468) was observed. However, this pest species, for the conditions of our
169 work, promoted greater injury in the leaf area of the plants, confirmed by the value of the
170 magnitude of the interaction, due to the habit of forming aggregates with a large number of
171 caterpillars.

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

177 The correlations between Formicidae (ANT) and passionflower pests, in which the
178 caterpillars (AGR and DIO) and floral bud fly (DAS) and bed bug (DSP) stand out, present
179 negative values, demonstrating that the occurrence of ants in sour passion fruit plants promotes
180 the reduction of the number of pests. This fact is confirmed by the interaction ANT x AL (-
181 0.159), demonstrating that the occurrence of individuals in this family promotes a reduction in
182 the number of leaves attacked by pest insects. Rossi and Fowler [13] working with fauna
183 evaluation of predatory ants on sugarcane crops observed that these same ant species
184 (*Dorymyrmex* sp. and *Camponotus* sp.) act in the biological control of *Diatraea saccharalis*
185 (Fabr.) (Lepidoptera: Pyralidae) preying their eggs and the early larval stages. Leal et al. [14]
186 showed that the visits of ants to foliar and bracteal nectaries in *Passiflora coccinea* almost
187 doubled the amount of seeds produced, compared to flowers from which the ants were
188 artificially excluded. The results suggest a protective role of ants against herbivores, improving
189 the reproductive success of the plant.

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

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

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

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

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

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

217 The number of leaves attacked has a high incidence in the period from May to mid
218 August (Figure 2), and this result is due to the attack of *D. juno juno* and *A. vanillae vanillae*,
219 which in a similar way present high occurrence in this period. Associated with this description,
220 there was a higher occurrence of individuals of the family Vespidae (*Polybia platycephala* and
221 *Mischocyttarus rotundicollis*) in periods of high occurrence of pests. According to Moura et al.
222 [22] representatives of this family are predators of *D. juno juno*. Prezoto et al. [23] studied the
223 prey of the social wasp *P. platycephala*, revealing its potential for biological pest control
224 programs. Among the captured prey were insect orders Diptera (33.4%), Lepidoptera (28.6%),

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225 Hemiptera (12.0%), Hymenoptera (9.4%) and Coleoptera (7.2%), with estimated capture of
226 4,380 prey per year for a single colony.

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

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

237 The incidence of ants individuals in the sour passion fruit progenies has had the
238 highest peak occurring from August, when temperature increases. The highest densities of
239 natural enemies recorded in the evaluations were predatory ants (Figure 2). This may have
240 contributed negatively to the presence of other agents of natural control of passionflower pests,
241 among which we can mention predatory parasitoids, wasps and beetles. he abundance of
242 predatory ant *Solenopsis invicta* Buren (Hymenoptera: Formicidae) had a negative influence on
243 16 taxa of herbivores in cotton, but also showed a negative correlation with density 22 and 14
244 taxa of natural enemies present in cotton and soybean, respectively [25]. Although in our work
245 we did not show the aggressiveness of ant species found in the progenies when compared to
246 the very aggressive *S. invicta* species.

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

251 4. CONCLUSION

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

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368 **25.**

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

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

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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

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372

UNDER PEER REVIEW

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

Variation Factors	GL ¹	F	P	F	P	F	P	F	P
		<i>A. vanillae vanillae</i>		Araneae		Cantharidae		<i>Diabrotica</i> 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	62.5		25.8		4.9		15.9	
Coefficient of variation (%)		<i>Dasiops</i> sp.		<i>Diactor bilineatus</i>		<i>Dione juno juno</i>		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	35.8		3.6		52.3		19.9	
Coefficient of variation (%)		Ants		<i>Holymenia clavigera</i>		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	29.6		2.9		5.5		64.8	
Coefficient of variation (%)									

¹ Degree of freedom.

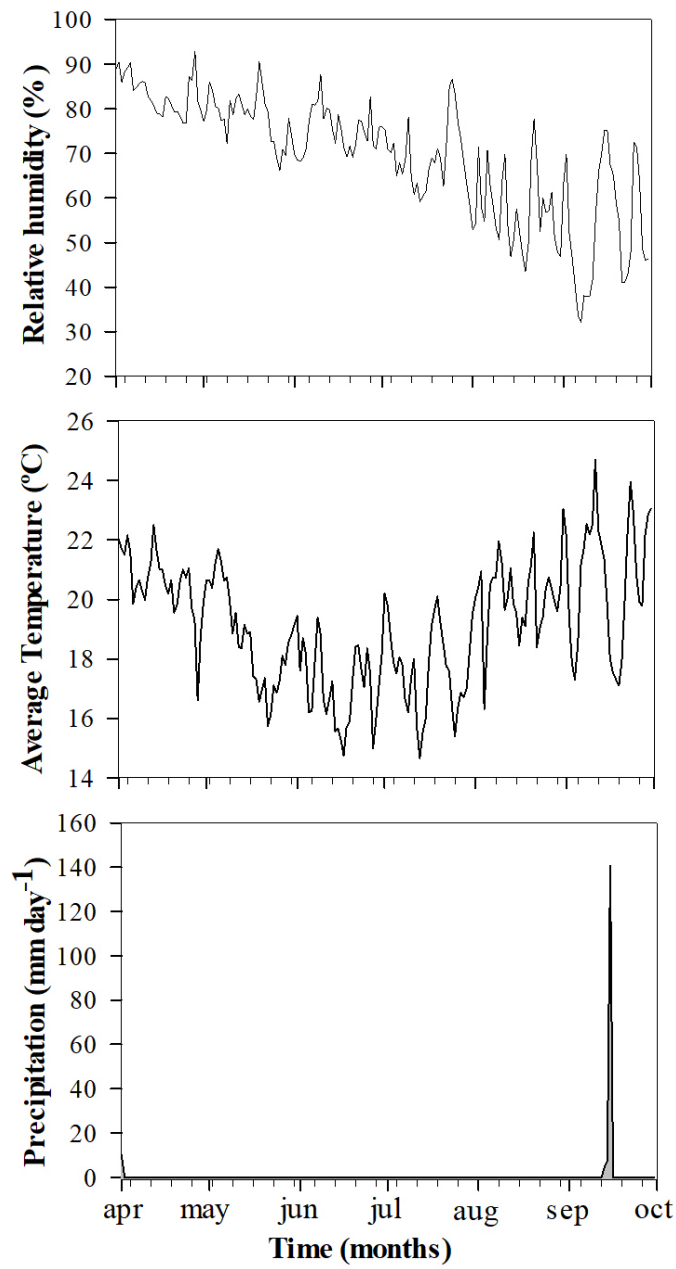
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387 **Table 3. Correlation values between the variables evaluated in the sour passion fruit progenies. Rio Paranaíba county, Minas Gerais, Brazil in**
 388 **2011**

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**

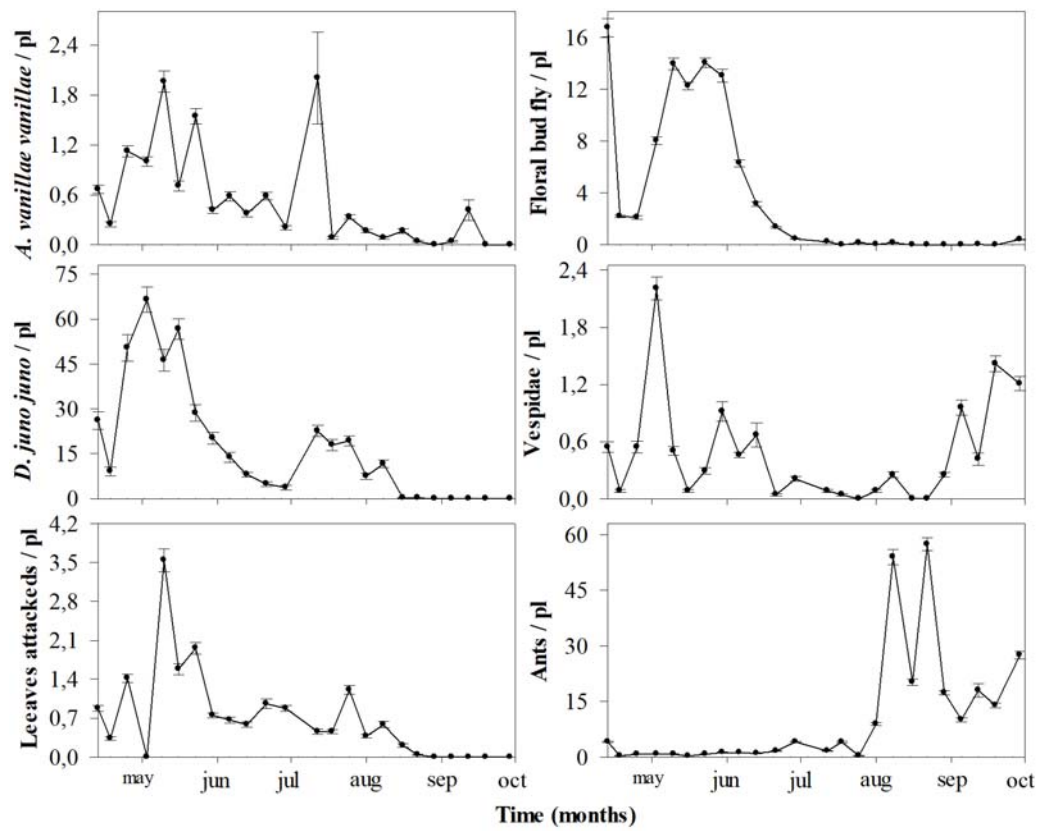
389 * Significant correlation coefficient at the 5% level by Test t. ** Significant correlation coefficient at the 1% level. ^{ns} Non-significant correlation coefficient.

390 ¹ Variables: *Agraulis vanillae vanillae* (AGR), Araneae (ARA), Braconidae (BRA), Cantharidae (CAN), *Dasiops* sp. (DAS), *Diabrotica* sp. (DSP), *Diactor*
 391 *bilineatus* (DIA), *Dione juno juno* (DIO), Attacked leaves (AL), Formicidae (ANT), *Holymeria clavigera* (HOL), Average temperature (TEMP), Relative
 392 humidity (RH) and Vespidae (VES).



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



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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