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1 **Title:** Attractiveness of uninfested vegetables to the omnivorous predators
2 *Dicyphus bolivari* and *D. errans* (Hemiptera: Miridae) and their relative suitability
3 for oviposition

4
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10 11 12 **1. Introduction**

13 Augmentative biological control with parasitoids and predators has been
14 practiced for decades to control the main pests in greenhouse crops (Van
15 Lenteren and Woets, 1988). Biological control programmes initially applied in
16 the Mediterranean Basin in the 1980s and 1990s were based on the northern
17 European experience, and underwent a rapid expansion in the early 21st
18 century, especially the release of generalist predators (Albajes and Alomar,
19 1999). Several species of Miridae (Hemiptera: Heteroptera) have received
20 special attention for their capacity to control the key pests in various vegetable
21 crops (Castañé et al., 2004; Perdikis et al., 2008; Ingegno et al., 2013). These
22 mirids are polyphagous and are also characterized by their facultative omnivory
23 (Alomar and Albajes, 1996; Ingegno et al., 2011), that is, their capacity to feed
24 on both prey and plant resources (Coll and Guershon, 2002; Albajes and
25 Alomar, 2008). The ability of mirids to feed facultatively on plants may allow
26 them to survive on the crop when prey is scarce or absent, establish
27 themselves early in the season, and prevent pests from reaching damaging
28 densities (Albajes and Alomar, 2008), although their use may also lead to some
29 crop plant damage, (Castañé et al., 2011; Calvo et al., 2012b).

30
31 In the Mediterranean region, predatory bugs such as *Dicyphus bolivari* Wagner,
32 (recently *D. maroccanus* has been synonymized with *D. bolivari*, Sánchez and
33 Cassis, 2018), *Dicyphus errans* (Wolff), *Dicyphus cerastii* Wagner, *Macrolophus*
34 *costalis* Fieber, *Macrolophus pygmaeus* (Rambur) and *Nesidiocoris tenuis*
35 (Reuter) can be found on vegetable and ornamental crops but also on many
36 non-crop plants (Carvalho and Mexia, 2000; Gabarra et al., 2004; Arnó et al.,
37 2010; Perdikis et al., 2011; Aviron et al., 2016; Leman et al., 2018). However, in
38 Europe, only two mirid bugs are currently commercialized, *M. pygmaeus* (sold
39 under its former name, *M. caliginosus*) and *N. tenuis*, which both have
40 characteristics that limit their usefulness as biological control agents: the
41 establishment of *M. pygmaeus* on crop plants after release in the greenhouse is
42 too slow, so that, it takes too long to reproduce, spread in the greenhouse, and
43 start pest suppression (Trottin-Caudal et al., 2012), whereas *N. tenuis* can
44 injure the crop plant under certain conditions (Castañé et al., 2011). In order to

45 overcome these disadvantages, there is interest in researching other native
46 predators, including *D. bolivari* and *D. errans* (Ingegno et al., 2017, 2019). The
47 former species has been mainly studied in the northeastern Iberian Peninsula
48 under the name *D. tamaninii*. However, a recent revision of Mediterranean mirid
49 bugs (Sánchez and Cassis, 2018) identified the species collected in that part of
50 the Iberian Peninsula as *D. bolivari*, so results reported for *D. tamaninii* there
51 should be attributed to *D. bolivari*. *Dicyphus errans* has been mainly studied in
52 northern Italy, where it is common (Tavella et al., 1997; Ingegno et al., 2008,
53 2013).

54 Research has focused not only on assessing the potential for
55 augmentative releases, but also on identifying the factors that enhance natural
56 crop colonization (Gabarra et al., 2004; Aviron et al., 2016) and on early
57 attraction of the predator into the greenhouse when crop plants have not yet
58 been infested by pests in order to keep pest numbers below economic
59 thresholds throughout the season (Perdikis and Lykouressis, 1996; Messelink et
60 al., 2015). Early predator establishment on the crop plant for conservation
61 biological control relies on the crop plants attract naturally occurring predators
62 from a certain distance to lay eggs into them (Gabarra et al., 2004). If predators
63 are not attracted to crop plants from a distance, colonization may occur too late
64 to provide efficient biological control. In this case, early inoculation of crop
65 seedlings in the nursery has been shown to be feasible and is routinely done for
66 commercial bugs such as *N. tenuis* and *M. pygmaeus* (Calvo et al., 2012a;
67 Backer et al., 2014). This technique has been tested with *D. bolivari* and *D.*
68 *errans* on tomato and yielded good establishment and distribution of the
69 predators on the plants and no plant damage on seedlings was observed
70 (Madeira et al., 2018).

71 There is little information available about plant colonization processes or
72 the cues that mirid predators use to locate host plants from a distance (Ingegno
73 et al., 2016). Studies on olfactory orientation of omnivorous mirid bugs have
74 aimed to identify volatiles released by infested plants and their attractiveness to
75 predators. Most of these have been done with a few commercial species (e.g.
76 Ingegno et al., 2011; Lins et al., 2014; Pérez-Hedo and Urbaneja, 2015; Naselli
77 et al., 2017; Rim et al., 2017), but few have examined the response of native
78 species such as *D. bolivari* or *D. errans* to crop plants (e.g. Ingegno et al., 2013,
79 2017). Previous studies have shown that *M. pygmaeus* and *N. tenuis* respond
80 to volatiles from infested plants, but have not addressed whether mirids are also
81 attracted by host plants that are not yet infested, a feature that would enhance
82 crop colonization early in the season.

83 The first aim of this study was to determine whether *D. bolivari* or *D.*
84 *errans* are attracted by uninfested crop plants (tomato, pepper, cucumber), a
85 feature that would facilitate early greenhouse colonization before insect pest
86 establishment. To this end, responses of adult predators to plants was studied
87 in a Y-tube olfactometer. The second aim was to test whether the predators are
88 willing to lay eggs on uninfested seedlings and if they expressed oviposition

89 preferences among crop plants. To this end, predator adults were allowed to
90 choose between pairs of uninfested seedlings for oviposition.

91

92 **2. Material and methods**

93

94 *2.1. Plants and insects*

95 Experimental plants of tomato (*Solanum lycopersicum* L., cv. Roma VF), sweet
96 pepper (*Capsicum annuum* L., cv. Estrella), cucumber (*Cucumis sativus* L., cv.
97 Negrito) and marigold (*Calendula officinalis* L. cv. Fitó, Doble variada) were
98 grown in a climate-controlled room (25 ± 2 °C and 16:8 h L:D photoperiod). The
99 seeds were sown in peat substrate (Klasmann-Deilmann®, Geeste, Germany)
100 in pots (Ø 5.5 cm, height 10 cm) with no pesticide or fertilization application, and
101 they were watered as needed. Low nitrogen peat substrate was used to avoid
102 plant nitrogen contents to interfere with the selection of host plant species as
103 seen by Vankosky and VanLaerhove (2017).

104 The herbivore *Bemisia tabaci* Gennadius (Hemiptera: Aleyrodidae) and
105 the predators *D. bolivari* and *D. errans* were reared under controlled conditions
106 (25 ± 2 °C and 16:8 h L:D photoperiod) at the Universitat de Lleida (Catalonia,
107 NE Iberian Peninsula). Laboratory colonies of insects were started from
108 specimens collected on local plants (*B. tabaci*), from individuals provided by the
109 laboratory of Entomology of the Catalan Agricultural Research Institute IRTA-
110 Cabrils (Catalonia) and initially collected in that area on various local plants (*D.*
111 *bolivari*), and from individuals reared at the Università di Torino (*D. errans*) on
112 several crop and non-crop plants.

113 The *B. tabaci* colony was reared on cabbage (*Brassica oleracea* L., cv.
114 acephale) plants in a climate-controlled room. Every two to three weeks, new
115 host plants were supplied as needed.

116 The mirid colonies were reared in our laboratory in 2-L glass jars for at
117 least 5 generations before trials, fed *ad libitum* with frozen eggs of *Ephesia*
118 *kuehniella* Zeller (Lepidoptera: Pyralidae) (BIOCARE GmbH, Germany) as prey,
119 and provided with water by means of a wet cotton and also French green bean
120 pods (*Phaseolus vulgaris* L.) and or tomato stems as egg-laying substrates.
121 Twice a week, the mirid colonies were provided with food, and the water and
122 egg-laying substrates were replaced. The substrates with mirid eggs were
123 placed in new rearing jars.

124

125 *2.2. Y-tube olfactometer bioassay*

126 The Y-tube olfactometer consisted of a Y-shaped glass tube of 3.8 cm inner
127 diameter, 18 cm long for each arm tube and 20 cm long for the main tube. The
128 two arms were connected via a plastic tube to two identical glass bottles (2.8 L),
129 in which volatile sources had been placed. The glass bottles were kept behind a
130 panel to prevent the insects from visually detecting the plants.

131 The bottles were connected to an air pump (Kn LAB Laboport, type
132 N86KN-18) that produced a unidirectional humidified airflow regulated at 250

133 mL/min from the bottles to the base of the main tube of the olfactometer. The
134 airflow passed through a water filter (Analytical Research Systems, model VCS-
135 HADS-2AFM2C) before it entered the bottles. The bioassays were conducted in
136 a dark room (25 ± 2 °C) with the Y-tube illuminated by a 28- to 35-W cool white
137 fluorescent tube positioned 57 cm above the arms, providing a light intensity of
138 2643 lux. The Y-tube was positioned vertically, as in another study with
139 *Dicyphus* species (Ingegno et al., 2013).

140 The olfactory bioassays were conducted between 12:00 and 16:00 h.
141 Males and females of *D. bolivari* and *D. errans* were used. Except for the
142 bioassay with mated females, newly moulted adults were separated by sex (<24
143 h) and used when they were between 6 and 14 days old. Before the bioassay,
144 each individual was transferred to a transparent vial (\varnothing 1 cm, height 10 cm) and
145 starved for 3 to 4 h. Insects were individually introduced at the downwind end of
146 the entry main arm and observed until they walked at least 5 cm up one of the
147 side arms or until five minutes had elapsed. Insects not choosing a side arm
148 within five minutes were considered as having made no choice and were not
149 counted in the data analysis. Each insect was tested only once and then
150 discarded. To minimize any spatial effect on choices, the volatile source bottles
151 were switched between the right and left side arms after five individuals had
152 been tested. After each use, the olfactometer setup was cleaned with neutral
153 soap, washed with acetone (99%) and placed in the oven at 60° C for at least 2
154 hours.

155 The plants used for this trial had the following characteristics: Tomato (5-
156 7 fully developed leaves, \pm 27 cm); sweet pepper (8 fully developed leaves, \pm
157 25 cm); cucumber (4-5 fully developed leaves, \pm 23 cm); marigold (10-12 fully
158 developed leaves, \pm 18 cm).

159

160 The following bioassays were conducted for both *Dicyphus* species:

161

- 162 i. Response to volatiles emitted by uninfested plants vs. clean air.
 - 163 a. Tomato vs. clean air; (species and sex, $n \geq 300$);
 - 164 b. Sweet pepper vs. clean air; (species and sex, $n \geq 200$);
 - 165 c. Cucumber vs. clean air (species and sex, $n \geq 200$).
- 166 ii. Response to volatiles emitted by uninfested tomato vs. clean air by mated
167 females and unmated females (species, $n \geq 200$). After the experiment, 20%
168 of females assumed to be mated were kept to confirm the status; more than
169 60% were mated.
- 170 iii. Response to volatiles emitted by uninfested tomato vs. uninfested marigold
171 plant (species and sex, $n \geq 200$).
- 172 iv. Response to volatiles emitted by uninfested tomato vs. tomato previously
173 infested by *Dicyphus* species (species and sex, $n \geq 150$). Three six-day-old
174 couples of the respective *Dicyphus* species were released in a transparent
175 insect-rearing tent (BugDorm®-2120, 60x60x60) with three tomato plants.

176 The plants were infested for five days, and after infestation the plants with
177 *Dicyphus* eggs were used in the bioassay.
178 v. Response to volatiles emitted by uninfested tomato vs. marigold plant
179 infested by *B. tabaci* (species and sex, $n \geq 150$). About fifty adults of *B. tabaci*
180 were released in a transparent methacrylate cylinder (\varnothing 20 cm, height 35 cm)
181 with one marigold plant. Plants were infested for ten days, and after
182 infestation the plants with *B. tabaci* eggs and nymphs were used in the
183 bioassay.

184

185 2.3. Oviposition choice bioassay

186

187 To test *D. bolivari* and *D. errans*, for oviposition preferences among host plants,
188 we provided bugs with free-flight, pairwise choices of the four plants tested in
189 olfactometer bioassays. We only used uninfested plants, and plant size was
190 similar to that of the plants used in the olfactometer experiments. For each
191 pairwise choice test, ten combinations of two plants, including pairs of the same
192 plant, were exposed for five days to three pairs of a *Dicyphus* species. The
193 insects were six- to nine-day-old adults when tested to ensure that they were
194 ready to oviposit (Madeira et al., 2018). Each of the ten combinations was
195 replicated six times. These bioassays were conducted inside transparent insect-
196 rearing tents (60x60x60 cm, Insect Rearing BugDorm®-2120F, from BugDorm
197 Store) under controlled conditions (25 ± 2 °C and 16:8 h L:D daylength).

198 After exposure to the predators for five days, all plants were isolated in a
199 laboratory chamber (25 ± 2 °C and 16:8 h L:D daylength). Oviposition
200 preference was assessed by counting the number of nymphs that emerged from
201 each plant from 6 to 15 days after predator removal; it was assumed that
202 eclosion rates would be similar across host plants. Each replicate was
203 terminated after three consecutive days with no nymph emergence.

204

205 2.4. Data analysis

206

207 In the olfactometer bioassays, the dependent variable 'response' (proportion of
208 responses to one source) was analysed using generalized linear modelling
209 (GLM) based on a binomial distribution with a logit link function. The
210 explanatory variables used in the models were 'species' (*D. bolivari* vs. *D.*
211 *errans*) and 'sex' (female vs. male) as factors and their two-way interactions.
212 One of the models also included the explanatory variable 'mating status (Mated
213 vs. Unmated). After these analyses, at each olfactometer bioassay, responses
214 were analysed using a Chi-squared test

215 In the oviposition preference bioassays, the dependent variable
216 'offspring' (number of nymphs) was analysed using GLM based on a Poisson
217 distribution with a log link function, and the model included the explanatory
218 variables 'combination' (10 combinations of two plants) and 'species' (*D. bolivari*
219 vs. *D. errans* as factors and their two-way interactions). The total number of

220 offspring on each individual plant within each combination was analyzed using a
221 Chi-squared test. Statistical analyses were performed using R software version
222 3.5.3 (R Development Core Team 2019).

223

224

225 **3. Results**

226 *3.1. Experiments in the olfactometer*

227 In the olfactometer experiments, we tested a total of 1538 adults of *D. bolivari* or
228 *D. errans*, of which 1153 individuals selected an odour source in five minutes,
229 therefore representing a 75% success rate. GLM-binomial distribution analyses
230 were performed to determine whether the predator species, sex, and female
231 mating status significantly influenced insect choice; then, significant factors
232 were analysed by χ^2 tests. Only sex for uninfested tomato vs. uninfested
233 calendula resulted significant ($\chi^2=5.35$; $df=1$, $P=0.02$)(Fig. 1). Neither of the two
234 predators was attracted by uninfested host plants; that is, when tomato
235 ($\chi^2=1.15$; $df=1$, $P=0.28$), pepper ($\chi^2=1.60$; $df=1$, $P=0.21$), or cucumber ($\chi^2=0.10$;
236 $df=1$, $P=0.75$), were each tested against clean air in the Y-form olfactometer, no
237 significant differences between the two choices were found (Fig. 1). Female
238 mating status did not alter this result ($\chi^2=0.01$; $df=1$, $P=0.92$); 48 vs. 49% of
239 (mated vs. unmated) females preferred the tomato plants to clean plants.

240 In contrast, tomato was preferred by females when it was tested against
241 calendula ($\chi^2=26.04$; $df=1$, $P<0.001$). When the calendula was infested by
242 whiteflies there was preference for uninfested tomato ($\chi^2=2.10$; $df=1$, $P=0.15$).
243 Tomato plants bearing eggs of the predator became more attractive to the
244 predator than tomato plants that had not been infested by the predator ($\chi^2=6.53$;
245 $df=1$, $P=0.01$).

246

247 *3.2. Dual-plant choice experiments for oviposition preference*

248 Predator preference for host plants for oviposition was measured by the number
249 of nymphs eclosing from eggs laid during five days of predator-plant interaction.
250 There was a significant interaction between species and plant combination
251 factors ($\chi^2= 43.64$, $df = 9$, $P < 0.001$); for this reason, each predator species
252 was analysed separately. For both species, the number of nymphs per tent was
253 significantly different according to the plant combination contained in the tent
254 (Fig. 2), being lower in cages with only cucumber or pepper plants or their
255 combination than in cages with at least one tomato or calendula plant (Fig. 2).
256 When predator preference for host plants to lay eggs on was examined
257 according to the total number of nymphs produced on each individual plant,
258 tomato and calendula were preferred to pepper or cucumber by the two
259 predators (Fig. 3). Predator preference when tomato and calendula were
260 combined in the same cage varied with the predator species; *D. bolivari*
261 preferred calendula to tomato for ovipositing, whereas *D. errans* preferred
262 tomato (Fig. 3).

263

264

265 4. Discussion

266 None of the three crop plants tested in the Y-tube olfactometer (tomato,
267 sweet pepper and cucumber) were themselves more attractive to the bug
268 species than clean air. This would indicate that uninfested plants do not emit
269 volatiles that attract these predatory mirid bugs independent of other factors.
270 Similar results were recorded for *N. tenuis* on tomato (Lins et al., 2014).
271 However, a preference for uninfested crop plants over clean air has also been
272 found with Y-tube olfactometry for *M. pygmaeus* (Ingegno et al., 2011; Lins et
273 al., 2014) and *N. tenuis* (Naselli et al., 2017; Rim et al., 2015) on tomato and
274 eggplant (*Solanum melongena* L.). Similar results were found for three
275 neotropical predatory mirids on tomato (Silva et al., 2018), by Abbas et al.
276 (2014) on tomato and *D. maroccanus* (today synonymized to *D. bolivari*
277 according to Sánchez and Cassis, 2018), and by Pérez-Hedo and Urbaneja
278 (2015) on sweet pepper for *N. tenuis*, *M. pygmaeus*, and *D. maroccanus*. Other
279 authors have emphasized the importance of plant genotypes in explaining
280 variability of results regarding the attractiveness of uninfested plants to natural
281 enemies (Rapusas et al., 1996).

282 The lack of response of *D. bolivari* and *D. errans* to uninfested crop
283 plants could hamper the early colonization of greenhouse crops by these
284 naturally occurring predators. Only when the herbivores enter greenhouses and
285 start feeding on the plants will they become attractive to natural enemies, as
286 many authors have also shown (e.g. Reddy, 2012). As shown in the present
287 work, if the predator is allowed to oviposit on the seedlings in the nursery, plants
288 become attractive to the predator and this may also cause the predator to
289 recognize volatiles emitted by the plant and move close to it. Moayeri et al.
290 (2007) also reported that plants previously exposed to omnivore predator
291 females for feeding became attractive to conspecific males, but the authors
292 inferred that this behavior improved mate finding by males, rather than plant
293 colonization for feeding and reproduction, an explanation also invoked by
294 Ingegno et al. (2016) in their electroantennography (EAG) studies with two
295 *Macrolophus* species. Thus gender and sexual behaviour may have an effect
296 on the plant preferences of omnivorous predators, independent of the role of
297 plant volatiles in host plant discovery. Our results suggest that the gender of
298 predators did not influence plant selection except when uninfested tomato
299 plants were tested against uninfested calendula, in which case the females of
300 both species were more discriminating in the olfactometer.

301 Several studies have been devoted to determining which non-agricultural
302 plants present in habitats surrounding or close to greenhouses can serve as
303 refuges for predatory mirid bugs, from which they could disperse to colonize
304 greenhouse crops (Tavella and Goula, 2001; Gabarra et al., 2004; Alomar et al.,
305 2006; Ingegno et al., 2016, Balzan, 2017). Among these, *Calendula* spp. have
306 received particular attention with regard to *M. pygmaeus* and *D. bolivari* (Alomar
307 et al., 2006; Lambion, 2011; Ardanuy et al., 2019). Surprisingly, *D. bolivari* and

308 *D. errans* preferred the odour of tomato to calendula, even when calendula
309 infested by whiteflies was tested against uninfested tomato, which was not
310 preferred over clean air. In contrast with that found for other omnivorous mirids,
311 it seems that *Dicyphus* species are not attracted by uninfested plants indicating
312 that no olfactory cues can be expected from greenhouse crops early in the
313 season to favour early entrance of predators into greenhouses. For this reason,
314 transplantation of young plants with predator eggs into the greenhouse can
315 enhance early crop colonisation (Madeira et al., 2018). This has been also
316 tested for other omnivorous predators like *M. pygmaeus* (Lenfant et al., 2000) or
317 *N. tenuis* (Calvo et al., 2012b; Perdikis et al., 2015).

318 Although none of the four plants alone were attractive in the olfactometer,
319 they still received oviposition in the enclosures, probably because other short-
320 distance cues allowed them to recognize the plants as a suitable source of food
321 and potentially, prey. Plant selection by omnivorous predators for phytophagy,
322 oviposition, or sources of prey is probably a more complicated process than for
323 predators which are strictly carnivorous (Coll and Guershon, 2002). The
324 process can likely be influenced by both the plant and the presence/absence of
325 prey, as seen in another *Dicyphus* species (Sanchez et al., 2004). Plant quality
326 features like nitrogen content have been found to affect oviposition preference
327 (Groenteman et al., 2006; Vankosky and VanLaerhoven, 2017). Other authors
328 have implicated plant stickiness and hairiness as influencing *D. hesperus*
329 female oviposition decisions (Sanchez et al., 2004), and differences in these
330 plant traits could explain our results which showed tomato and marigold were
331 preferred over pepper for oviposition. Host plant selection by omnivore females
332 can be a combination of different cues that remain unidentified and more work
333 is warranted to better understand this important issue (Vankosky and
334 VanLaerhoven, 2017).

335 The two predators achieved very different fecundities on the four plants
336 tested. This means that pre-plant inoculation of the four plants tested is feasible,
337 but the numbers of adults to be released in the nursery, and their duration of
338 exposure to the seedlings, will vary among crops. Three pairs of predators
339 produced anywhere from three to 17 nymphs per plant in five days. This density
340 of predators per seedling would probably be too high in seasons with low pest
341 pressure, but more suitable under high pest pressure. Initial release rates
342 recommended for *M. pygmaeus* and *N. tenuis* in greenhouse tomatoes range
343 from 0.5 to 1.6 adults per plant (Arnó et al., 2009), values not dissimilar from the
344 number of nymphs per plant achieved in this work.

345 Marigold plants did not seem to be a good companion plant for
346 inoculation of *D. bolivari* in seedlings, whereas marigold might be inoculated
347 with *D. errans* in the nursery and then moved to the greenhouse as a banker
348 plant. Although predatory bugs have been tested for preferences among odor
349 sources (e.g. Ingegno et al., 2011; Silva et al., 2018), it remains unknown how
350 well these experiments reflect actual behavior in the field (Ballhorn and Kautz,
351 2013). In this study, we found that orientation to volatile cues does not always

352 reflect oviposition free choice under short-distance cues, as *D. bolivari* showed
353 contradictory results for tomato and calendula between the olfactometer and
354 oviposition assays.

355 In conclusion, some results indicate the need to inoculate *D. bolivari* or
356 *D. errans* in nursery plants, because uninfested plants do not have the capacity
357 to attract either of the predators from a distance. In addition to making the
358 plants more attractive to the predators when they have been transplanted in the
359 greenhouse, inoculation of young plants with predator eggs allows predator
360 populations to become established on the crop early in the season.
361 Diversification of the nursery by inoculating several crops with predators could
362 potentially increase oviposition on those crops less attractive to them, although
363 this effect merits further investigation.

364

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372

373

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547 Figure captions

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549 Fig. 1. Percentage of responses (mean \pm SE) of *D. bolivari* and *D. errans* adults
550 in a Y-tube olfactometer to the odours of clean air vs. uninfested tomato, clean
551 air vs. uninfested pepper, clean air vs. uninfested cucumber, females:
552 uninfested tomato vs. uninfested calendula, males: uninfested tomato vs.
553 uninfested calendula, uninfested tomato vs. infested calendula (with *B. tabaci*)
554 and uninfested tomato vs. tomato previously visited (by the predator). * $P <$
555 0.05 ; ** $P \leq 0.01$.

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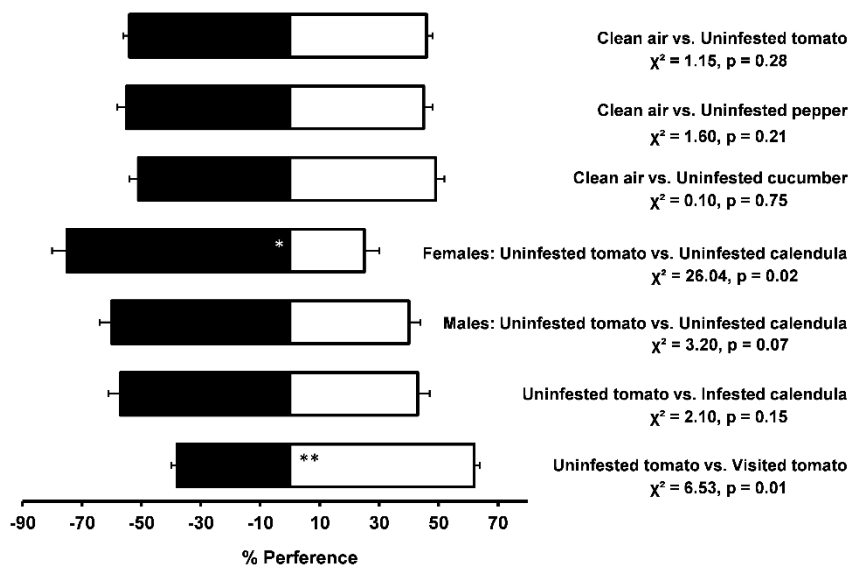
557 Fig. 2. Mean number + SE of nymphs per tent produced by three predator
558 couples of two predatory species left for 5 days in a tent with a combination of
559 two plants, as shown on the X axis. Means followed by different letters are
560 significantly different ($P < 0.05$).

561

562 Fig. 3. Total number of *D. bolivari* and *D. errans* nymphs that emerged per plant
563 when different combinations of two plants were offered to predators within tents
564 for oviposition for 5 days. In each plant comparison and predator species, chi
565 squared and significance are shown. * $P < 0.05$; *** $P < 0.001$.

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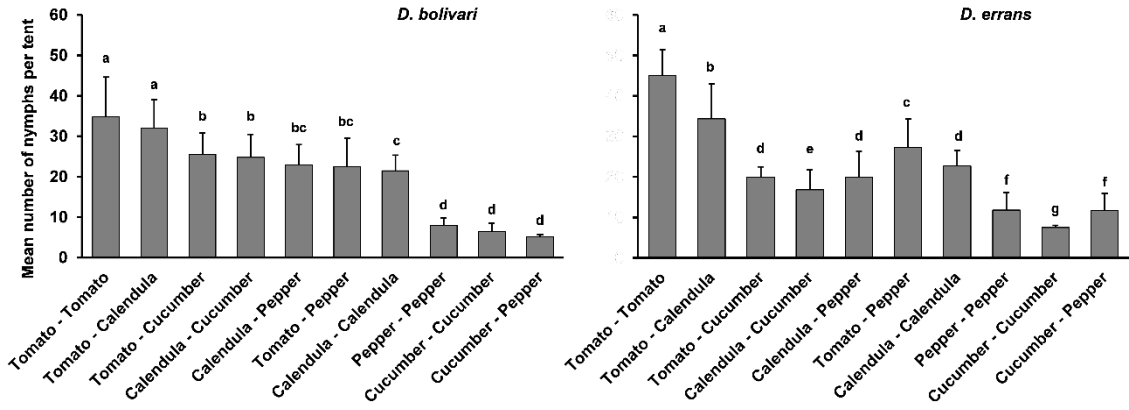


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569 Fig. 1

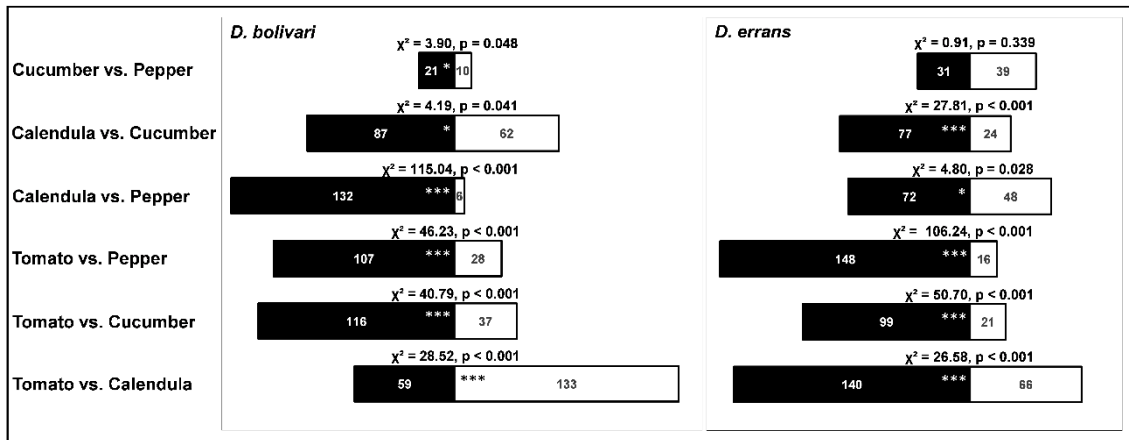
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Fig. 2



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Fig. 3