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Prey preference, interaction with selected natural enemies, and alternative nutritional sources of the mirid bug *Dicyphus tamaninii* Wagner

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Abstract: The present study aimed to investigate the prey preference of the omnivorous bug *Dicyphus tamaninii* Wagner (Heteroptera: Miridae) among 5 different prey species, and its interaction with 3 different natural enemies commonly used in greenhouses. Moreover, the survival duration of the predator was studied in response to different nutritional sources. In multi-choice trials all developmental stages of the predator tested, namely N_3, N_5, and adult female, showed a clear preference for *Aphis gossypii* Glover over other prey species offered. Nonetheless, a considerable number of *Tetranychus urticae* Koch, *Frankliniella occidentalis* (Pergande), and *Trialeurodes vaporariorum* (Westwood) were also consumed. *Myzus persicae* (Sulzer) was the least preferred by all the predatory stages tested. In a separate experiment, *D. tamaninii* was able to complete its development from N_1 to adult stage in an average of 21 days, with 20% mortality, when offered only *T. urticae* as prey.As testing all of the potential interactions with other beneficial arthropods is not practical, the present study focused on 3 natural enemies most likely to be disrupted by a possible release of *D. tamaninii* in a greenhouse; these were *Amblyseius cucumeris* Oudenmans, *Phytoseiulus persimilis* Athias-Henrriot, and *Aphidius colemani* Viereck (*A. gossypii* mummies), in the presence of unparasitized *A. gossypii* nymphs. The results show that *D. tamaninii* mostly attacked unparasitized *A. gossypii* first. Moreover, an average of only 3.8 *A. cucumeris*, 2.6 *P. persimilis*, and 0.2 *A. colemani* individuals day^{-1} female^{-1} were attacked. Furthermore, the results show that *D. tamaninii* females were able to survive for 41.2, 14.5, 9.8, and 3.8 days when offered only *A. gossypii*, honey emulsion, cucumber plant, or no food, respectively.

Key words: *Aphis gossypii,* biological control, *Dicyphus tamaninii*, natural enemies, prey preference

Introduction

In nature, as well as under the conditions of managed agro-ecosystems, several pests and natural enemies usually exist together in the same habitat. Before considering a certain predator for a biological control program it is important to investigate its affinity toward the target prey. As such, more attention should be direct towards such an eventual prey preference.

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The omnivorous bug *Dicyphus tamaninii* Wagner (Heteroptera: Miridae) is a promising natural enemy that has been investigated as a predator of the cotton aphid *Aphis gossypii* Glover (Homoptera: Aphididae) in Germany, Spain, and other Mediterranean countries (Alvarado et al. 1997; Saleh and Sengonca 2000, 2001a, 2001b), the western flower thrips *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae) in Spain and Germany (Castane et al. 1997; Zegula and Sengonca 2000), and the greenhouse whitefly *Trialeurodes vaporariorum* Westwood (Homoptera: Aleyrodidae) (Gabarra et al. 1988). Furthermore, it was reported that *D. tamaninii* was able to feed on plant material (Alomar and Albajes 1996; Sengonca et al. 2002).

Taking into account the polyphagous nature of the predator, studying its prey preference and interaction with other natural enemies that commonly exist in greenhouses, and its potential to serve as prey for the predatory bug is warranted. Such information would be of great value in biological control programs that use *D. tamaninii* along with other predators or parasites used to control a variety of arthropod plant pests. Thus, the present study aimed to investigate the prey preference of *D. tamaninii* females among 5 different prey species, and its interaction with 3 different natural enemies. Moreover, the survival duration of *D. tamaninii* was studied in response to different nutritional sources.

Materials and methods

Prey preference with a mixed population of different prey species

A multi-choice experiment was set up in order to assess the preference of *D. tamaninii* N_3 and N_5 instars, and adult females for 5 different prey species–*A. gossypii* (1-2 days old), *Myzus persicae* (Sulzer) (1-2 days old), *F. occidentalis* (L_1-L_2), *T. vaporariorum* (N_2-N_3), and *Tetranychus urticae* Koch (adults). The experiments were launched with freshly hatched N_3 and N_5 instars, and 1-week-old females of the predatory bug. For each predator, 10 individuals of each prey species were simultaneously offered on 4.5-cm cucumber leaf discs placed in 5.5-cm rounded plastic cages lined with a 0.5-cm-thick agar gel layer. The cages with the prey and predators were incubated at 25 ± 1 °C, with relative humidity of 60 ± 10% and an artificial photoperiod of 16:8 h (L:D). The number of killed prey of each species was determined daily by deducting the number of living individuals from the original number at the beginning of the experiment. The predators were transferred daily to new cages containing fresh prey from the 5 species. The experiments were conducted throughout the developmental period of the predatory nymphs and for 3 days with the adult females. In order to reduce possible adaptation of the predator to a certain prey species, all the tested *D. tamaninii* individuals were fed a mixed population of the 5 prey species during the entire time, from their emergence until the beginning of the experiments. Ten replicates were conducted with each predatory stage tested.

Development on *T. urticae* as prey

The red spider mite *T. urticae* was selected for use in this experiment, as it is one of the most common and significant pests that exist in vegetable greenhouses in which *D. tamaninii* would be utilized as a biological control agent. A 1-choice laboratory experiment was set up in which 15 freshly hatched *D. tamaninii* nymphs were placed individually on cucumber leaf discs in plastic cages and an excess number of *T. urticae* in different developmental stages were offered daily as prey. *T. urticae* individuals used in the experiment were obtained from a colony established on bean plants in which some leaves, heavily infested with the mite, were taken from the stock culture and the mites were brushed out of them using a mite-brushing machine. The mites collected by the machine were then gently transferred into the cages with a camel hair brush for *D. tamaninii* to prey on. The experiment was conducted at 25 ± 1 °C, with relative humidity 60 ± 10% and an artificial photoperiod of 16:8 h (L:D). *D. tamaninii* molting and mortality were observed twice daily.

Interaction with selected beneficial arthropods

The predatory behaviour of adult *D. tamaninii* females was studied when *Amblyseius cucumeris* Oudenmans, *Phytoseiulus persimilis* Athias-Henriot, and *Aphidius colemani* Viereck (*A. gossypii* mummies), in the presence of unparasitized 3- to 5-

day-old *A. gossypii* nymphs, were simultaneously present in the experimental arena, which consisted of a 4.5-cm cucumber leaf disc placed upside-down in a 5.5-cm plastic cage, lined with a 0.5-cm-thick agar gel layer. Mated 1-week-old adult *D. tamaninii* females were placed individually in the arena for 24 h, after which time the number of killed individuals was recorded. The adult predatory females used in the experiments were provided only water for a period of 24 h before release. Replicates in which *A. colemani* adults emerged from the mummies during the experiment were not considered. Ten *D. tamaninii* females were tested and the experiment was repeated for 3 days. Experiments were conducted under the same climatic conditions mentioned above.

Alternative nutritional sources

One-week-old *D. tamaninii* adult females, previously fed *A. gossypii*, were divided into 4 groups of 15 individuals each. The individuals within each group were placed in Plexiglas cages and offered only 1 of 4 diets, which were a mixed population of *A. gossypii*, 10% honey emulsion, a cucumber plant, or no food. The cages were checked daily for mortality. Food was added or replaced whenever needed.

Statistical analysis

The results of the experiments on the prey preference of *D. tamaninii* and its interaction with different natural enemies were statistically analyzed using one-way analysis of variance, whereas the t-test was utilized for the statistical analysis of the results on the development of *D. tamaninii* males and females when fed *T. urticae* as prey. For statistical comparison of several means, one-way or multifactor analysis of variance was conducted. Significant differences were determined utilizing Duncan's multiple range test at $P < 0.05$ (Renner 1981). When comparing only 2 means the t-test was conducted.

Results

Prey preference with a mixed population of different prey species

In all stages of *D. tamaninii* tested there was a general tendency to prefer *A. gossypii* as prey (Figure 1); an average of 1.4-6.5, 2.0-8.0, and 7.3-7.5 aphids

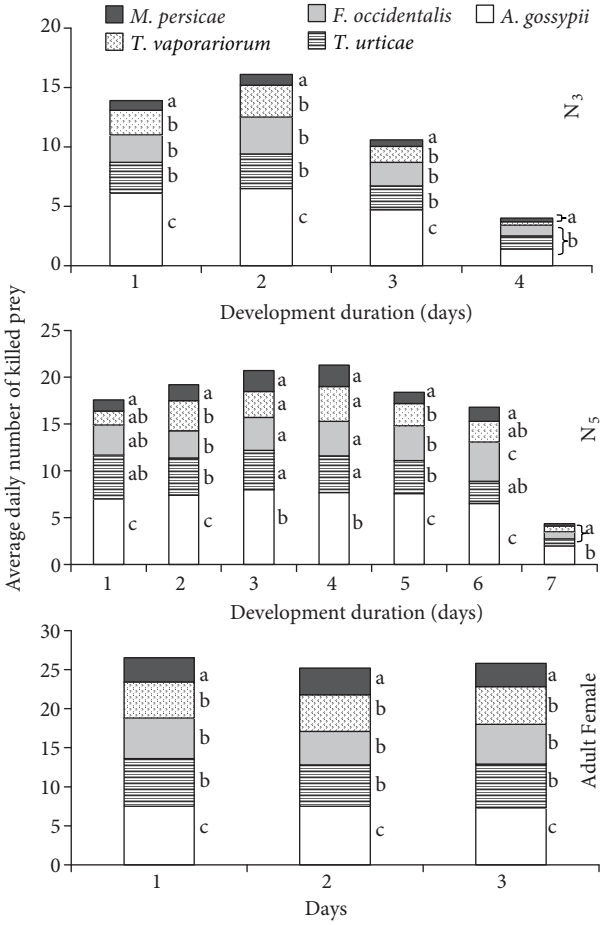

Figure 1. Prey consumption by N_3, N_5, and females of *Dicyphus tamaninii* with a mixed population of 5 different prey species. Different letters within the same column indicate a significant difference using Duncan's multiple range test.

day^{-1} were consumed by N_3, N_5, and adult females, respectively. Among the other 4 prey species offered, *M. persicae* was the least preferred by all predatory stages tested; an average of 0.3-0.9 individuals were consumed by N_3, 0.3-2.3 by N_5, and 3.0-3.4 by adult females. No clear tendency in the prey preference of *D. tamaninii* was observed between *T. urticae*, *F. occidentalis*, and *T. vaporariorum*. The prey preference toward *A. gossypii* was more pronounced in both nymphal stages of the predator than in the adult female. Furthermore, average daily prey consumption of all prey species increased along with development to the adult stage; average consumption was 16.1 prey by N_3, 21.3 prey by N_5, and 26.5 prey by adult females.

Development on *T. urticae* as prey

The results of the experiments conducted on the development of *D. tamaninii* offered only *T. urticae* as prey show that the predatory bug was able to feed successfully on *T. urticae* and develop from N_1 to the adult stage within an average of 21.2 days for females and 20.8 days for males (Table 1). There was no significant difference in development time between males and females: among the 5 nymphal instars, N_5 was longest, lasting for 6.8 in females and 6.4 days in males. Table 2 shows the average percentage of mortality in *D. tamaninii* during development on *T. urticae*; only 16 out of 20 N_1 individuals reached the adult stage, i.e. 20% mortality. The highest mortality occurred in the first 2 nymphal instars.

Interaction with selected beneficial arthropods

Results show that all arthropod species confined in the experimental arena were attacked by *D. tamaninii*. As seen in Figure 2, 1 *D. tamaninii* female consumed an average of 8.8 *A. gossypii*, which was significantly more than all other species tested. Although the predatory bug consumed an average of 3.8 more *A. cucumeris* individuals than *P. persimilis* individuals (an average of 2.6 individuals were killed) statistical analysis shows that the difference was not significant. The least preferred prey was *A. gossypii* mummies containing the parasitoid *A. colemani*, of which only an average of 0.2 individuals were attacked.

Furthermore, 2-h observation under a binocular microscope showed that more than 70% of the consumed *A. gossypii* were attacked within this period after launching the experiment. During the first 2 h almost no predatory mites or *A. gossypii* mummies were attacked by *D. tamaninii*. The interaction between the 2 predatory mites was also observed and intraguild predation between both species did not occur.

Alternative nutritional sources

Figure 3 shows the results of the experiments conducted in order to determine the mean lifespan of 1-week-old *D. tamaninii* females fed with different

Table 1. Mean nymphal developmental time of *Dicyphus tamaninii* with *Tetranychus urticae* as prey.

Sex	Repl.	Nymphal development time (days)					Total
		N_1	N_2	N_3	N_4	N_5	
Female	6	3.2	3.3	3.3	4.5	6.8	21.2 ± 0.6
Male	10	3.3	3.3	3.6	4.2	6.4	20.8 ± 0.5

Table 2. Mean percentage mortality of *Dicyphus tamaninii* nymphs fed on *Tetranychus urticae.*

Nymphal stage	Mean percentage mortality
N1	10
N2	0
N3	0
N4	5
N5	5
Total	20

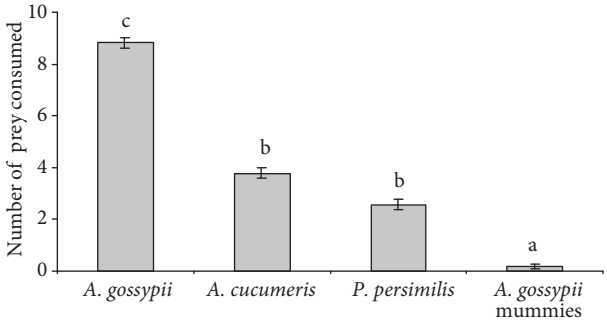

Figure 2. Mean daily numbers of killed aphids, predatory mites, or mummies containing *Aphidius clemani* larvae by *Dicyphus tamaninii*. Columns with different letters are significantly different using Duncan's multiple range test.

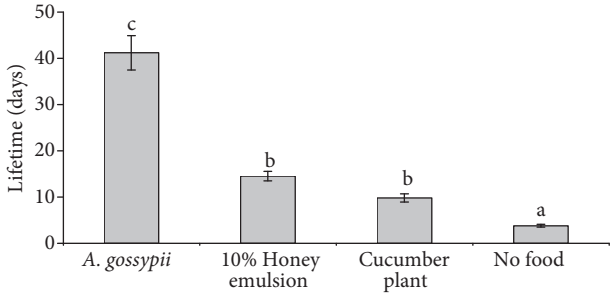

Figure 3. Mean lifetime *Dicyphus tamaninii* females fed on different nutritional sources. Columns with different letters are significantly different using Duncan's multiple range test.

nutritional sources at 25 ± 1 °C. When *A. gossypii* was offered as prey the predatory females lived a mean 41.2 days, whereas those fed only 10% honey emulsion lived for significantly fewer days (mean: 14.5 days). The lifespan was also shortened to 9.8 days when the females were fed only a cucumber plant. *D. tamaninii* females without food survived for a mean 3.8 days, which was the shortest lifespan.

Discussion

The results of the experiments on the prey preference of *D. tamaninii* show that the predator was able to attack and feed on all 5 prey species offered. All developmental stages of the predator tested–N_3, N_5, and adult females–showed a clear preference for *A. gossypii*, as compared to the other prey species offered; however, considerable numbers of *T. urticae*, *F. occidentalis*, and *T. vaporariorum* were also consumed. Despite the preference for the cotton aphid, these 3 important pests will also be accepted by *D. tamaninii* as prey, an important fact to be considered when utilizing the predator in biological control programs. Several researchers reported that *D. tamaninii* preys on *F. occidentalis* (Gabarra et al. 1995; Riudavets and Castane 1998), *T. vaporariorum* (Gabarra et al. 1988; Castane et al. 1997), and *A. gossypii* (Alvarado et al. 1997; Saleh and Sengonca 2000, 2001a, 2001b); however, there are no reports of the predation of *T. urticae* by *D. tamaninii*.

As the red spider mite is an important pest that occurs frequently on cucumber and many other crops in open fields and in greenhouses, it would very useful to know if *D. tamaninii* can successfully complete development to the adult stage when offered only *T. urticae* as prey in the absence of *A. gossypii* or other possible prey. The results of the present study show that the spider mite was a suitable prey for *D. tamaninii*, which achieved full development in about 21 days with mortality of 20%. Saleh and Sengonca (2001a) studied the life table of *D. tamaninii* fed young *A. gossypii* and reported a nymphal development period of about 22 days and mortality of 20%, which is consistent with the results obtained with *T. urticae* in the present study.

As *D. tamaninii* is a polyphagous predator, it is possible that predation on other natural enemies might disrupt biological control and precipitate crop losses. As testing all potential interactions is not practical, the present study focused on 3 natural enemies most likely to be disrupted by a possible release of *D. tamaninii* in a greenhouse–*A. cucumeris*, *P. persimilis*, and *A. colemani* inside *A. gossypii* mummies, in the presence of unparasitized *A. gossypii* nymphs. Results show that *D. tamaninii* mostly attacked unparasitized *A. gossypii* first. Moreover, relatively low numbers of other beneficial arthropods were attacked by *D. tamaninii*. These results indicate that this predator is unlikely to cause considerable disruption to the natural enemies tested; however, this needs to be confirmed in a greenhouse. Gillespie and McGregor (2000) studied the interaction of the closely related predatory mirid bug *Dicyphus hesperus* Knight with *Encarsia formosa* (Gahan) and *P. persimilis* on tomato under greenhouse conditions, concluding that the effect of all natural enemies was additive and that these predators can therefore be used in combination within the framework of a biological control program.

The ability of a natural enemy to feed and survive on alternative nutritional sources, such as plant material, may be an advantage in stabilizing its population dynamics (Lalonde et al. 1999). It was observed in the present study that the predatory bug was also able to feed on the cucumber leaf discs used in the experiments. This has sparked interest in setting up an experiment in order to investigate how long *D. tamaninii* can survive when certain nutritional sources are exclusively offered to the predator. Results show that *D. tamaninii* was able to feed and survive for considerable periods of time

when fed honey emulsion or cucumber plant. Such plant feeding habits of *D. tamaninii*, especially when prey offered was limited, were confirmed by Saleh and Sengonca (2002), and Alomar and Albajes (1996) on cucumber and tomato, respectively; they added that no significant damage to either of the crops was observed.

Based on the results of the present study, it can be concluded that although *D. tamaninii* showed a clear preference for *A. gossypii*, it also accepted the 4 other pest species offered. Moreover, if released simultaneously with *A. cucmeris*, *P. persimilis*, and *A. colemani,* the predatory bug is not likely to disrupt their effectiveness in a biological control program; however, this needs to be confirmed in greenhouse trials. Furthermore, *D. tamaninii* was able to survive for considerable periods when offered only honey emulsion or a cucumber plant.

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