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Article

Prey stages preference of different stages of *Typhlodromus bagdasarjani* (Acari: Phytoseiidae) to *Tetranychus urticae* (Acari: Tetranychidae) on rose

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Abstract

Tetranychus urticae Koch is one of the most injurious tetranychid mites on greenhouse roses. *Typhlodromus bagdasarjani* Wainstein & Arutunjan is a generalist indigenous phytoseiid mite with a wide distribution in Iran and frequently reported from plants infested by tetranychids. In this research, the preference of protonymph, deutonymph and adult of *T. bagdasarjani* on different stages of *T. urticae* was studied under laboratory conditions (25 ± 1°C, 75 ± 5% RH and 16L: 8D h. of photoperiod). The experiment was carried out on rose leaf square (blarodje variety). The preference index for each predator stage was calculated with Manly's β index. Comparison of the mean preference index for protonymph ($F = 135.61$; $df = 3, 84$; $P < 0.0001$), deutonymph ($F = 264.71$; $df = 3, 83$; $P < 0.0001$) and female ($F = 173.52$; $df = 4, 119$; $P < 0.0001$) of the predator showed that all stages significantly preferred *T. urticae* eggs followed by prey larvae and protonymphs. Due to the our results can be suggested that *T. urticae* eggs are more profitable prey stage for *T. bagdasarjani* than other stages with regard to both nutritional benefit and handling time.

Key words: Prey, predator, *Rosa hybrida* L. cv. blarodje, Rosaceae

Introduction

The rose (*Rosa* spp.) ranks among the top three cut flowers in worldwide retail cut flowers sales (Mercurio 2007). Due to the importance of aesthetic quality, ornamental crops generally have an extremely low economic threshold level and even very small damage symptoms on leaves or flowers are regarded as a reduction in quality (Field & Hoy 1984; van de Vrie 1985; Landeros *et al*. 2004). *Tetranychus urticae* Koch is the major pest of greenhouse roses (Field & Hoy 1984; van de Vrie 1985; Landeros *et al*. 2004; Mercurio 2007).

Several species of natural enemies have been reported on spider mites. Predacious mites from the family Phytoseiidae are important natural enemies that some of them such as *Phytoseiulus persimilis* Athias-Henriot and *Neoseiulus californicus* (McGregor) play an important role in suppressing mite populations in greenhouses (Sabelis 1985; McMurtry & Croft 1997; Mercurio 2007; Kasap 2010; Elings *et al*. 2011). However, *Typhlodromus bagdasarjani* Wainstein & Arutunjan is a generalist indigenous phytoseiid mite with a wide distribution in the Middle East, especially in orchards of

Iran and frequently reported from plants infested by tetranychid and eriophyid mites as well as insect pests such as thrips and whiteflies (Daneshvar 1993; Kamali *et al*. 2001; Shirdel *et al*. 2004; Faraji *et al*. 2007; Ganjisaffar *et al*. 2011a, b; Farazmand *et al*. 2013). This species is a beneficial biocontrol agent of *T. urticae* (Shirdel *et al*. 2004; Ganjisaffar *et al*. 2011a, b; Farazmand *et al*. 2013). An important characteristic of *T. bagdasarjani* is well adaptation to warm climates that could be more efficient in controlling *T. urticae* in warm areas than the currently available natural enemies such as *P. persimilis* (Skirvin & Fenlon 2003; Ganjisaffar *et al*. 2011a, b). Furthermore, it could be used in greenhouses and outdoors, when temperature is above 20°C, particularly in the summer months (Ganjisaffar *et al*. 2011a, b). According to McMurtry and Croft (1997), *T. bagdasarjani* considered as a generalist predator (Type III) that can reproduce after feeding on pollen. Various plant exudates as well as honeydew may serve as survival foods or important food supplements which may increase the reproduction potential in the presence of prey. These characteristics are advantages of generalist predators in comparison to the specialists such as *P. persimilis* and there is increasing evidence that generalist predators can suppress spider mites at low population densities (McMurtry & Croft 1997; Field & Hoy 1984; Badii *et al*. 2004).

Tendencies for feeding on particular food types and prey species are well known for several phytoseiid species (Blackwood *et al*. 2001, 2004; Badii *et al*. 2004; Furuichi *et al*. 2005; Kasap 2010; Xiao & Fadamiro 2010; Xu & Enkegaard 2010). However, preferences for different prey stages have not been investigated completely (Blackwood *et al*. 2001). This is the first study on prey stage preference of *T. bagdasarjani* on *T. urticae* as prey on rose. Information on the prey stage preference of a predator is valuable for evaluation of its control efficiency of pests that have several active and non-active stages (Xu & Enkegaard 2010).

Materials and Methods

Plant source: The rose plants (*Rosa hybrida* cv. 'blarodje' (Rosaceae)) used in this study were grown in beds under commercial conditions (Cocopeat: Perlit; 60: 40 %) in greenhouse. The roses were pruned and planted in large plastic pots (top 25 cm in diameter, 40 cm in depth and bottom 20 cm in diameter) at 25±2°C, 65±10% RH and 16L: 8D hours photoperiod.

Prey source: *Tetranychus urticae* were reared on bean leaves in Acarology laboratory at the Department of Plant Protection, Faculty of Agriculture, University of Tehran in Karaj, Iran. Mites were transferred to the detached rose leaves resting upside down on a water layer on cotton wool in transparent plastic containers (20×10×4 cm). When over-population was observed, some of the older leaves were cut into small pieces and placed on fresh rose leaves to allow the mites move onto new ones and maintain the *T. urticae* colony on rose leaves. Water was added to the rearing unit to keep the leaves fresh and prevent mites from escaping. These containers were maintained in a controlled rearing room at 24±2°C, 60±5% RH and 16L: 8D h. of photoperiod, for three months (about 8 generations) before the beginning of experiments.

Predator source: *Thyphlodromus bagdasarjani* was collected from black mulberry trees on the campus of Tarbiat Modares University, Tehran, Iran. The predator rearing unit included a piece of green hard plastic on a water-saturated sponge in a plastic container (26×16×7 cm). The borders of sponge were surrounded with moistened tissue papers to ensure a constant water supply to the phytoeiids and to prevent them from

escaping (Overmeer 1985; Walzer & Scahusberger 1999). Every two days, *T. urticae*-infested rose leaves were added to each rearing unit. Every three days, some maize pollen was offered as supplementary food. This culture was started three months (about 8 generations) before the beginning of experiments. Predator colony was maintained at 25±1°C, 75±5% RH and 16L: 8D h. of photoperiod in a growth chamber.

Experimental units: The experimental units consisted of leaf squares (3×3 cm) cut from fresh rose leaves placed upside down on a water-saturated sponge (4×4×1 cm) in a 6 cm diameter Petri dish. Wet tissue paper strips (0.5 cm in width) were placed around the leaf margin to prevent the mites from escaping and provide a 3×3 cm arena on leaf for experimental unit. Newly emerged protonymphs and deutonymphs and 3-day old mated females of the predator were used for experiment. Predators not starved before beginning of experiment.

The immature predators were offered an equal number of newly laid eggs, and newly emerged immature stages of *T. urticae* to prevent entering prey stages to quiescent phase or molting to the next stage during the test. Preliminary experiments indicated that immature predators rarely fed on *T. urticae* adult females, so this prey stage was ignored. To provide prey eggs, *T. urticae* adult females were placed in each experimental unit for 24 h. to lay eggs. Then the females were carefully removed as not to disturb their web and eggs were decreased to required density. Equal numbers of other prey stages (Table 1) were added into these units. Prey stages for adult predators were newly laid eggs and newly emerged larvae, protonymphs, deutonymphs and females. Each predator was allowed to feed on the prey stages for a total of 24 h. At the end of this period, the number of each prey stage consumed was recorded. Each treatment had 25 replicates. As a Control, arenas were maintained with the same densities of prey stages without predator for determining the natural mortality. Experimental units were held at 25±1°C, 75±5% RH and 16L: 8D h. of photoperiod in a growth chamber.

Statistical analysis: Prey stage preferences were quantified with the index β (Manly *et al.* 1972):

$$\beta_j = \frac{ln(r_j/n_j)}{\sum_{j=1}^{5} ln\,(r_j/n_j)}, j = 1, 2, 3, 4, 5$$

where β_j is Manly's Beta for each prey stage j, r_j is the number of individuals in prey stage j consumed by the predator after 24 hours, and n_j is the number of individuals in prey stage j available to the predator. This index assigns preference values from 0 to 1. The larger amount of this index for each prey stage, the more preferred the stage.

It is appropriate to use it where prey stages are offered simultaneously and are not replenished throughout the test (Manly *et al*. 1972; Blackwood *et al*. 2001, 2004). The β-value was calculated for each replicate and averaged to determine the mean β-value for each treatment. Differences between treatments were analyzed by Tukey range test (HSD) at 95% confidence level in SAS software (GLM procedure).

Results

When all stages of *T. urticae* were simultaneously presented, *T. bagdasarjani* fed on all stages but the mean consumption rates of predator stages differed between the prey stages (Table 1). Comparing the mean preference index (β) for protonymph ($F = 135.61$; $df = 3, 84$; $P < 0.0001$), deutonymph ($F = 264.71$; $df = 3, 83$; $P < 0.0001$) and female (F

= 173.52; df = 4, 119; P < 0.0001) of *T. bagdasarjani* showed that all stages of predator preferred eggs to other prey stages, significantly (Table 2).

Table 1. Mean consumption of *Typhlodromus bagdasarjani* stages when offered different stages of *Tetranychus urticae*, simultaneously.

Predator stages	Prey stages	n	No. eaten (mean ± SE)	max.	min.
Protonymph	Egg	6	4.12 ± 0.14	5	3
	Larva	6	1.72 ± 0.09	2	1
	Protonymph	6	1.40 ± 0.10	2	1
	Deutonymph	6	0.40 ± 0.10	1	0
Deutonymph	Egg	7	5.20 ± 0.13	6	4
	Larva	7	2.68 ± 0.15	4	2
	Protonymph	7	1.76 ± 0.10	3	1
	Deutonymph	7	0.36 ± 0.05	1	0
Female	Egg	11	7.32 ± 0.25	10	6
	Larva	11	5.48 ± 0.22	7	3
	Protonymph	11	5.40 ± 0.24	7	3
	Deutonymph	11	2.32 ± 0.15	4	1
	Female	11	1.08 ± 0.14	2	0

The predator protonymph and deutonymph preferred prey eggs, followed by prey larvae and protonymphs. Predator protonymph had no significant preference between prey larvae and protonymphs whereas predator deutonymph showed a significant preference (Table 2). The predator immature stages showed the least preference to prey deutonymph. The female predator preferred prey eggs, followed by prey larvae and protonymphs with no significant difference. This stage of predator had the least preference to prey adult (Table 2). There was no mortality in Control.

Table 2. Mean β-value for each prey-stage when *Typhlodromus bagdasarjani* offered different stages of *Tetranychus urticae*, simultaneously.

Predator stages	Prey stages	β mean ± SE	β max.	β min.
Protonymph	Egg	0.634 ± 0.020 a	0.831	0.411
	Larva	0.187 ± 0.014 b	0.316	0.078
	Protonymph	0.144 ± 0.011 b	0.270	0.071
	Deutonymph	0.035 ± 0.009 c	0.125	0
Deutonymph	Egg	0.625 ± 0.011 a	0.743	0.514
	Larva	0.220 ± 0.012 b	0.376	0.121
	Protonymph	0.130 ± 0.008 c	0.221	0.068
	Deutonymph	0.025 ± 0.007 d	0.103	0
Female	Egg	0.396 ± 0.020 a	0.631	0.244
	Larva	0.244 ± 0.013 b	0.371	0.126
	Protonymph	0.240 ± 0.013 b	0.351	0.113
	Deutonymph	0.083 ± 0.006 c	0.150	0.025
	Female	0.036 ± 0.005 d	0.082	0

* β values followed by the same letter in each predator stage are not significantly different at $P< 0.05$ level (GLM Procedure, HSD)

Discussion

The aim of this study was to determine the prey stage preference of protonymph, deutonymph and female *T. bagdasarjani* at constant densities of different stages of *T. urticae* on rose. The prey stage preference of a predator has been found to correlate with prey suitability in terms of impact on predator fitness and can affect predator-prey dynamic in presence or absence of preferred prey (Xiao & Fadamiro 2010; Xu & Enkegaard 2010).

Phytoseiid predators select prey species or prey stage according to its profitability. This profitability may be because of its larger effective food mass, higher composition of nutrients or other chemical compounds and less energy or time for digesting nutritive compounds and attacking and catching the prey (Sabelis 1985).

Our results confirm that all stages of *T. bagdasarjani* prefer *T. urticae* eggs to other stages and consumed more prey eggs significantly. In this regard, the results of Blackwood *et al*. (2001, 2004) showed that specialist predator females prefer *T. urticae* eggs versus larvae, while generalist predators prefer larvae or have no prefer to eggs probably due to not having effective mouthparts to pierce the *T. urticae* eggs chorion as do easily mouthparts of most specialist predators. Also, Kasap (2010) indicated that *Kampimodromus aberrans* (Oudemans) females as a generalist predator, consumed mostly larvae in presence of different stages of *T. urticae*.

On the other hands, other previous studies on generalist phytoseiid species which were fed on *T. urticae* have shown the same results as our results, whereas these researches were only on female predators. For example,the *Euseius hibisci* (Chant) females (as a generalist predator) consumed mostly eggs in presence of all *T. urticae* stages (Badii *et al.* 2004), whereas this predator preferred larva over other prey stages (Blackwood *et al*. 2001, 2004). Also, the females of *Neoseiulus womersleyi* Schicha (generalist predator) showed preference to eggs versus females of *T. urticae* (Furuichi *et al*. 2005). Therefore, Blackwood *et al*. (2001, 2004) results cannot be extended for all generalist predators especially when all stages of prey are present.

Eggs are more accessible than active stages of prey for predator because they are immobile and unable to defense or escape. Consequently, the handling time for eggs is less than other prey stages. Moreover, food quality of eggs may be higher than of other prey stages (Sabelis 1985; Badii *et al.* 2004; Furuichi *et al*. 2005).

Based on the results obtained here, it can be concluded that *T. urticae* eggs are more profitable than other stages to *T. bagdasarjani* regarding both nutritional benefit and handling time that reflect the individual fitness of predator females. Results showed that *T. bagdasarjani* nymphs had less preference to *T. urticae* deutonymphs and predator females had less preference to prey adults regarding ability of these prey stages to escape and defense. Sabelis (1985) stated that time required to preyi on larger prey species or prey stages are more than others. Xu and Enkegaard (2010) suggested that *Amblyseius swirskii* Athias-Henriot prefer *T. urticae* protonymphs to deutonymphs due to their smaller body size and less activity and defense.

Finally, it should be noted that *T. urticae* produce complicated web on host plant in natural conditions but it does not have enough time for webbing in laboratory conditions. This could influence the obtained results in natural conditions such as greenhouses.

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ترجیح شکارگری مراحل نموی کنه شکارگر *Typhlodromus bagdasarjani* (Acari: Phytoseiidae) نسبت به مراحل نموی کنه *Tetranychus urticae* (Acari: Tetranychidae) روی رز

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چکیده

کنهٔ تارتن Koch *Tetranychus urticae* از خسارت‌زاترین گونه‌های خانوادهٔ Tetranychidae در گلخانه‌های رز است. کنهٔ شکارگر Wainstein & Arutunjan *Typhlodromus bagdasarjani* از شکارگرهای عمومی خانوادهٔ Phytoseiidae با پراکندگی گسترده در ایران است و به فراوانی از گیاهان آلوده به کنه‌های تارتن تترانیکید گزارش شده است. برای ارزیابی کارایی هر شکارگر، عوامل مهمی مانند ترجیح شکارگری آن نسبت به مراحل نموی شکار بررسی می‌شود. در این پژوهش ترجیح شکارگری مراحل نموی *T. bagdasarjani* نسبت به مراحل مختلف نموی *T. urticae* در شرایط آزمایشگاهی (دمای ۱±۲۵ درجه سلسیوس، رطوبت نسبی ۵±۷۵ درصد، دوره نوری ۸:۱۶ ساعت (روشنایی: تاریکی)) و روی دیسک‌های برگی رز (رقم بلاروج) بررسی شد. ترجیح در هر مرحلهٔ نموی شکارگر با استفاده از شاخص β منلی محاسبه شد. مقایسهٔ میانگین شاخص ترجیح برای هر یک از مراحل نموی پوره‌های سن یکم (F= ۱۳۵/۶۱؛ df= ۳،۸۴؛ P<۰/۰۰۰۱) و سن دوم (F= ۲۶۴/۷۱؛ df= ۳،۸۳؛ P<۰/۰۰۰۱) و مادهٔ بالغ (F= ۱۷۳/۵۲؛ df= ۴،۱۱۹؛ P<۰/۰۰۰۱) نشان داد که همهٔ مراحل نموی شکارگر به‌طورمعنی‌داری تخم *T. urticae* را نسبت به سایر مراحل نموی آن ترجیح می‌دهند. پس از تخم *T. urticae*، لارو و پوره سن یکم آن مورد ترجیح مراحل رشدی شکارگر است. با توجه به نتایج می‌توان چنین بیان کرد که تخم *T. urticae* نسبت به سایر مراحل نموی آن از نظر سودمندی غذایی و زمان دست‌یابی برای *T. bagdasarjani* مناسب‌ترند.

واژگان کلیدی: شکار، شکارگر، *Rosa hybrida* L. cv. blarodje، Rosaceae.

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