

Article

Predation preference of *Neoseiulus californicus* and *Typhlodromus bagdasarjani* on heterospecific phytoseiid and *Scolothrips longicornis* in presence and absence of *Tetranychus urticae*

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Abstract

Predation preference of *Neoseiulus californicus* (McGregor) and *Typhlodromus bagdasarjani* Wainstein & Arutunjan on *Scolothrips longicornis* Priesner and heterospecific phytoseiid was determined on cucumber leaf discs in presence and absence of *Tetranychus urticae* Koch. The experiments were conducted under laboratory conditions at 25°C, 65% RH and a photoperiod of 16h light: 8h dark. The first and second instar of the thrips and larval stages of the phytoseiids were selected as intraguild preys. In the first experiment, the first or second instar larvae of the thrips and heterospecific larval phytoseiid (regarded as predator species) were offered to an adult female of phytoseiid. The females of *N. californicus* and *T. bagdasarjani* significantly preferred to prey upon the first instar larvae of the thrips (1.82 and 1.41 larvae per day, respectively) compared with phytoseiids (0.78 and 0.53 larva per day, respectively). Consumption of the two mentioned phytoseiid species on second instar larvae of the thrips (0.96 and 0.60 larva per day, respectively) and the phytoseiid (0.91 and 0.62 larva per day, respectively) were not significantly different. The females of both phytoseiid species were able to oviposit continuously when fed on the thrips and phytoseiid preys. In the second experiment, when *T. urticae*, the phytoseiid and thrips were offered simultaneously, both phytoseiid species could prey upon all three species but *T. urticae* was significantly consumed more (5.52 *T. urticae* per day by *N. californicus* and 4.46 *T. urticae* per day by *T. bagdasarjani*). Since these two predators belong to the type III phytoseiids, it seems that both species were able to survive in absence of *T. urticae* and tend to prey more on first instar larvae of the thrips compared with the heterospecific phytoseiid.

Key words: *Neoseiulus californicus*, *Typhlodromus bagdasarjani*, *Scolothrips longicornis*, predation preference, heterospecific phytoseiid

Introduction

Neoseiulus californicus (McGregor), *Typhlodromus bagdasarjani* Wainstein & Arutunjan and *Scolothrips longicornis* Priesner are efficient control agents of spider mites (Tetranychidae) in high temperatures (Ahn *et al.* 2010; Ganjisaffar *et al.* 2011;

Pakyari *et al.* 2011). *Neoseiulus californicus* (McGregor) feeds on spider mites, tarsonemid mites, small arthropods, pollen (Castagnoli *et al.* 1999) and *Thrips tabaci* (Rahmani *et al.* 2009). *T. bagdasarjani* feeds on spider mites, eriophyoides, tydeids, thrips and whiteflies (Daneshvar 1993), while *S. longicornis* is a specialized predator of spider mites (Kishimoto 2008).

In a series of studies, we investigated whether combined release of these three predator species could be resulted better biological control of *T. urticae* in a greenhouse compared with release of the species alone. In a biological control program, several predators may increase control capacity of a prey (Onzo *et al.* 2004). In contrast, predation interference may occur among several predators and predation rate of a prey decreases (Rosenheim 2001). In a time period when *T. urticae* is rare like in early and late cropping season, some phytoseiid mites feed on insects and also attack each other and persist (Hatherly *et al.* 2005).

The biology, reproduction and population growth parameters of *N. californicus* on *Frankliniella occidentalis* (Pergande) (Walzer *et al.* 2004) and *Thrips tabaci* Lindeman (Rahmani *et al.* 2009) have been studied. Van der Hoeven and Van Rijn (1990) showed that *N. californicus* can prey only on the first instar larvae of the western flower thrips *F. occidentalis*. Several studies have been conducted on predation preferences of phytoseiid mites on con- and heterospecific phytoseiids. In a study, Hatherly *et al.* (2005) showed that *N. californicus* and *Typhlodromips montdorensis* (Schicha) can feed on larval stages of each other. The females of *Typhlodromus pyri* Scheuten and *Kampimodromus aberrans* (Oudemans) consumed more larvae and protonymphs of the other species than their own (Schausberger 1999). MacRae and Croft (1993) have shown that *T. pyri* females have higher consumption rate on heterospecific phytoseiids than conspecific ones.

No study exists on predation preference of a phytoseiid species on heterospecific phytoseiid and thrips. It was the objective of the present study to test the hypothesis that in a time period of lack of spider mites, the polyphagous phytoseiids *N. californicus* and *T. bagdasarjani* are able to discriminate between phytoseiid and thrips, and they prefer to prey upon thrips when given the choice. Since interspecific predation occur in periods of food scarcity, it was questioned phytoseiids prefer which one, phytoseiid or thrips.

Materials and methods

Phytoseiid sources and rearing

The colony of *N. californicus* was provided by Koppert Biological Systems (Spical®; Berkel en Rodenrijs, The Netherlands) in 2009. *Typhlodromus bagdasarjani* was originally collected on blackberry trees in the Faculty of Agriculture campus, Tarbiat Modares University (Tehran), Iran in 2010. Both predator species were reared in arenas consisting a plastic sheet on top of water-saturated foam placed inside a plexiglas box (23×14×9 cm) partially filled with water. The edges of the plastic sheet were covered with moist tissue papers to prevent predators' escaping (Walzer & Schausberger 1999). The cucumber leaves with *T. urticae* were added to the arenas three times a week. To obtain the same-aged female predators for the experiments, the newly laid eggs were collected daily and transferred to the new arenas (each consisting a piece of cucumber leaf inside a 10-cm diameter Petri dish) bearing adequate *T. urticae*. Upon appearance of adult females of the predatory mites, they mated with males within 24 h. These females were isolated and starved for 6h before using in the experiments.

Thrips source and rearing

Scolothrips longicornis was originally collected on soybean field at the Faculty of Agriculture campus, Tarbiat Modares University (Tehran), Iran in 2010. This predator was reared on cucumber leaf discs infested by *T. urticae*. Each leaf disc was placed on a water-saturated cotton layer in a plastic Petri dish (6 cm diameter × 1 cm height). The leaf disc was placed in a container (6.5 cm diameter × 9 cm height) with a lid. A 20 mm diameter hole was created in the lid of each container, which was covered with a fine mesh to allow ventilation. In order to keep the leaves fresh, water was added daily to the containers.

Prey culture

Tetranychus urticae was originally collected from a strawberry greenhouse in Varamin, vicinity of Tehran, Iran in 2009 and reared on cucumber plants (*Cucumis sativum* cv. Pis) at $25\pm 5^{\circ}\text{C}$ and $65\pm 10\%$ RH and under natural light duration in a greenhouse.

Experimental procedure

In order to determine the predation preference of both phytoseiid species when were kept with the predatory thrips and heterospecific phytoseiid, two types of experiments were carried out as follows:

1. In the first experiment, predation rate of both phytoseiid species on the first or second instar larvae of *S. longicornis* and heterospecific phytoseiid larvae was determined in the absence of *T. urticae*. The first treatment consisted of six first instar larvae of the thrips + six larvae of heterospecific phytoseiid and the second treatment contained five second instar larvae of the thrips + six larvae of heterospecific phytoseiid, which were offered to an adult female of the predatory mite separately.

2. The second experiment was similar to the first one differed in having additional 20 nymphal stages of *T. urticae* per replicate. The experimental unit was a cucumber leaf disc (3 cm diameter) placed upside down on a water-saturated cotton layer in a plastic Petri dish (3 cm diameter × 1 cm height) with a hole in center of bottom (5 mm diameter) to allow insertion of a cotton layer to the container (6.5 cm diameter × 9 cm height) to supply water for keeping leaf discs fresh in the Petri dish. To prevent escaping the predators, the margins of the leaf discs were covered with water sub-saturated cotton layer. In order to keep the leaves fresh, water was added daily to the containers. The lids of the containers had a ventilation hole, which was covered with a fine mesh. Each treatment was carried out in ten replicates. Every 24 h, the number of preys consumed (determined by prey carcasses) and the number of eggs laid by the female predator was recorded for ten days. Non-preyed individuals were eliminated and replaced by new ones. All rearings and experiments were conducted at $25\pm 1^{\circ}\text{C}$, $60\pm 5\%$ RH and a photoperiod of 16 h: 8 h (light: dark).

Data analysis

All data were tested for normality (by Ryan-Joiner) with MINITAB 16. The number of prey consumed per female per day and the number of eggs laid per female per day were analyzed by one-way ANOVA for each species. Differences between treatments were compared by Duncan's multiple range test. Un-paired t-tests were used to compare the mean number of phytoseiid and thrips preys consumed by females of the phytoseiid.

Results

The results of predation preference of *N. californicus* and *T. bagdasarjani* on *S. longicornis* and heterospecific phytoseiid on cucumber leaf disc in absence and presence of *T. urticae* are shown in Tables 1 and 2. In the first experiment, the females of *N. californicus* and *T. bagdasarjani* attacked and fed on the first instar larvae of the thrips (1.82 and 1.41 larvae per day, respectively) compared with heterospecific phytoseiid (0.78 and 0.53 larva per day, respectively). Consumption of two mentioned phytoseiid species on second instar larvae of the thrips (0.96 and 0.60 larva per day, respectively) and the phytoseiid (0.91 and 0.62 larva per day, respectively) was not significantly different. The females of both phytoseiid species were able to oviposit when fed on the thrips and phytoseiid preys. In the second experiment, despite the availability of *T. urticae*, both phytoseiid species could prey upon all three species but *T. urticae* was significantly consumed more [5.52 *T. urticae* per day by *N. californicus* ($F_{2,27}= 1921.33, P < 0.0001$) and 4.46 *T. urticae* per day by *T. bagdasarjani* ($F_{2,27}= 480.23, P < 0.0001$)] (Table 2). The oviposition and predation rate of *N. californicus* was more than *T. bagdasarjani* (Tables 1 and 2).

Table 1. Predation and daily fecundity of *N. californicus* and *T. bagdasarjani* females kept singly on leaf discs and provided simultaneously with hetero-specific phytoseiid and *S. longicornis* for 10 days

Predator	Prey	Predation		Oviposition*	
		Phytoseiid**	<i>S. longicornis</i> ***	Daily	Total
<i>N. californicus</i>	Tb+Sl(1)	0.789 ± 0.042b	1.822 ± 0.12 a	0.911 ± 0.10 a	9.11 ± 1.07 a
	Tb+Sl(2)	0.912 ± 0.035 a	0.963 ± 0.068 a	0.650 ± 0.090 b	6.50 ± 0.90 b
<i>T. bagdasarjani</i>	Nc+Sl(1)	0.530 ± 0.075 b	1.41 ± 0.096 a	0.410 ± 0.069 c	4.10 ± 0.69c
	Nc+Sl(2)	0.622 ± 0.074 a	0.600 ± 0.071 a	0.311 ± 0.026 c	3.11 ± 0.26c

Sl(1): First instar larvae of *S. longicornis* ; Sl(2): Second instar larvae of *S. longicornis*; Tb: *T. bagdasarjani*; Nc: *N. californicus*. *Egg/female/day. ** Larva/female/day. *** First or second instar larvae/female/day. The means followed by same letters within rows are not significantly different ($P < 0.000$, Un-paired test) for predation. The means followed by same letters within column are not significantly different ($\alpha = 0.01$) (Duncan's Multiple Range) for oviposition.

Discussion

The present study showed that both phytoseiids can consume larval stage of thrips and heterospecific phytoseiid. The females of both phytoseiids discriminated between thrips and phytoseiid larvae and preferred prey upon thrips. Predation on thrips and heterospecific phytoseiid was somewhat reduced by the availability of *T. urticae*, while MacRae and Croft (1997) showed that the generalist phytoseiid, *Typhlodromus pyri* Scheuten switched to feed on heterospecific phytoseiid larvae when the phytoseiid and spider mite were offered simultaneously. *Neoseiulus californicus* and *T. pyri* have the ability to feed on other food sources in case of low prey, so their population levels are sustained (Hatherly *et al.* 2005).

Table 2. Predation and daily fecundity of *N. californicus* and *T. bagdasarjani* females kept singly on leaf discs and provided simultaneously with hetero-specific phytoseiid, *S. longicornis* and *T. urticae* for 10 days

Predator	Prey	Predation			Oviposition*	
		Phytoseiid* *	<i>S. longicornis</i> ***	<i>T. urticae</i> ****	Daily	Total
<i>N. californicus</i>	Tb+ SI(1)+Tu	0.35 ±0.045 c	1.04 ±0.079 b	5.29±0.22 a	1.50±0.105 b	14.90±1.04b
	Tb+ SI(2)+Tu	0.45±0.05 b	0.48 ± 0.041 b	5.52±0.095 a	1.83±0.066 a	18.10±0.67a
<i>T. bagdasarjani</i>	Nc+ SI(1)+Tu	0.24±0.034 c	1.15±0.096 b	4.46±0.14 a	0.91±0.038 c	9.0±0.39 c
	Nc+ SI(2)+Tu	0.32±0.047 b	0.390±0.043 b	4.30±0.098 a	1.01±0.080 c	10.0±0.78c

SI(1): First instar larvae of *S. longicornis* ; SI(2): Second instar larvae of *S. longicornis*; Tb: *T. bagdasarjani*; Nc: *N. californicus*; Tu: *T. urticae*. *Egg/female/day. ** Larvae/female/day. *** First or second instar larvae/female/day. **** Nymph /female/day. The means followed by same letters within rows are not significantly different ($\alpha = 0.01$) for predation. The means followed by same letters within column are not significantly different ($\alpha = 0.01$) for oviposition (Duncan's Multiple Range).

Uckan and Ergin (2002) stated that when food quality is low, longevity of a female parasitoid increases due to an adaptation for a parasitoid species to maintain its generation. In a study, Rahmani (2009) examined life history and population growth parameters of *N. californicus* on *T. tabaci* and *T. urticae*. They determined total developmental time of *N. californicus* as 9 days on *T. tabaci* while this parameter on *T. urticae* was estimated to be 5.71 days. Also mean longevity of female adults on *T. urticae* and *T. tabaci* was estimated to be 21.85 and 29.45 days, respectively. Walzer *et al.* (2004) reported 63% and 0% mortality in *N. californicus* when fed on *F. occidentalis* and *T. urticae*, respectively. Also, they showed that *F. occidentalis* larvae are alternative preys for juvenile *N. californicus* and *P. persimilis*, enabling them to reach adulthood. Developmental time of *N. californicus* fed on *F. occidentalis* was 10.42 days. In the current study, the mean daily fecundity of both phytoseiids fed on *S. longicornis* and phytoseiid as prey was less than 1 while the daily fecundity of *N. californicus* fed on *T. tabaci* as prey was 2.42 egg/female/day (Rahmani *et al.* 2009).

Hatherly *et al.* (2005) stated that in biological control programs it could be appropriate to release a generalist predator as *N. californicus* and a specialized predator like *Phytoseiulus persimilis* (Athias-Henriot). Walzer *et al.* (2001) showed that *N. californicus* and *P. persimilis* can decrease spider mite population when used together. The specialized predator can provide effective short term pest suppression while the generalist predator can persist at low prey densities.

Since these two predators belong to the type III phytoseiids (McMurtry and Croft 1997; Croft *et al.* 1998), it seems that both species were able to survive in absence of *T. urticae* and tend to prey more on thrips compared with phytoseiid. Therefore, both species will be able to utilize thrips (*T. tabaci* or *S. longicornis*) when tetranychid prey is unavailable and stabilize their population levels.

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ترجیح شکارگری *Typhlodromus bagdasarjani* و *Neoseiulus californicus* بر فیتوزئید ناهم‌گونه و تریپس *Scolothrips longicornis* در حضور و غیاب *Tetranychus urticae*

چکیده

ترجیح شکارگری *Typhlodromus bagdasarjani* و *Neoseiulus californicus* (McGregor) روی *Scolothrips longicornis* Priesner و فیتوزئید غیر هم‌گونه روی دیسک‌های برگ‌گی خیار در حضور و غیاب کنه تارتن دولکه‌ای بررسی شد. آزمایش‌ها در شرایط

آزمایشگاهی ۲۵ درجه سلسیوس، رطوبت نسبی ۶۵ درصد و دوره نوری ۱۶ ساعت روشنایی انجام شد. لارو سن یکم و دوم تریپس و مراحل لاروی فیتوزئیدها به عنوان شکار درون رسته انتخاب شدند. در آزمایش نخست، لارو سن یکم یا دوم تریپس و لارو فیتوزئید (با توجه به گونه شکارگر) در اختیار یک ماده بالغ فیتوزئید قرار داده شد. ماده‌های *N. californicus* و *T. bagdasarjani* به طور معنی داری ترجیح دادند از لارو سن یکم تریپس (به ترتیب ۱/۸۲ و ۱/۴۱ لارو در روز) در مقایسه با فیتوزئیدها (به ترتیب ۰/۷۸ و ۰/۵۳ لارو در روز) تغذیه کنند. میزان مصرف دو گونه کنه فیتوزئید اشاره شده روی لارو سن دوم تریپس (به ترتیب ۰/۹۶ و ۰/۶۰ لارو در روز) و فیتوزئیدها (به ترتیب ۰/۹۱ و ۰/۶۲ لارو در روز) تفاوت معنی داری نداشت. ماده‌های هر دو گونه قادر بودند روی شکار لارو سن یکم تریپس و فیتوزئید تخم‌ریزی کنند. در آزمایش دوم هنگامی که کنه تارتن، کنه فیتوزئید و تریپس هم‌زمان با هم در اختیار یک ماده بالغ فیتوزئید قرار گرفتند هر دو گونه قادر بودند از سه گونه شکار تغذیه کنند اما کنه تارتن به طور معنی داری بیشتر (به ترتیب ۵/۵۲ کنه تارتن در روز توسط *N. californicus* و ۴/۴۶ کنه تارتن در روز توسط *T. bagdasarjani*) مورد تغذیه قرار گرفت. از آنجایی که این دو شکارگر متعلق به شکارگرهای تیپ سوم هستند به نظر می‌رسد هر دو گونه قادر باشند بدون غذای اصلی (کنه تارتن دولکه‌ای) زنده بمانند و تمایل دارند از تریپس بیش از فیتوزئید تغذیه کنند.

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