

## Article

### Effect of a heterospecific predator on the oviposition behavior of *Phytoseiulus persimilis*

Bahador Maleknia; Azadeh Zahedi Golpayegani; Farhad Farhoudi; Seyed Ramin Mirkhalilzadeh; Hossein Allahyari

Department of Plant Protection, College of Agriculture, University of Tehran, Karaj, Iran; E-mails: b.maleknia@ut.ac.ir, zahedig@ut.ac.ir

#### Abstract

Oviposition rate is affected by several factors such as con- and heterospecific competitors, food availability and patch quality. When the species have interacted for a sufficient period of time, the predator could profit from the ability to associate odors from the competitor with the risk of its eggs being attacked or eaten by that competitor. We examined the oviposition rate of *Phytoseiulus persimilis* for a response for signals emanating from its heterospecific competitor, *Frankliniella occidentalis* in the presence of their shared prey, *Tetranychus urticae* on rose and bean leaf patches. In the treatments in which the predatory mite and thrips were exposed to each other, a significant reduction was observed in the number of deposited eggs compared to the control experiment. The same result was found in an experiment in which the exposure time was limited to the pre-oviposition period of the predatory mite. Increasing the time elapsed since the two competitors were exposed to each other to 2 days, the effect of thrips on the oviposition rate of the predatory mite had vanished and approached the oviposition rate in the control experiment. The plant species used as a substrate for the interspecific interactions did not significantly alter the results. We discuss the potential consequences of the presence of thrips for the ability of *P. persimilis* to control the two spotted spider mite.

**Key words:** Biological control, competition, oviposition, predatory mite, heterospecifics

#### Introduction

The predatory mite, *Phytoseiulus persimilis* Athias-Henriot (Acari: Phytoseiidae) has been well studied with respect to its capacity to effectively control spider mites in greenhouses. Sabelis & Dicke (1985) have emphasized that *P. persimilis* development and reproduction depends on the density of *Tetranychus* mites. Also Walzer and Schausberger (1999) have noted that the predatory mite disappears from

the greenhouse when the *Tetranychus* mites have been eliminated. So they supposed a combined release of this predator accompanied with a generalist predator. This is why several studies have focused on mixed release of predators. Despite the fact that combined releases may involve negative interactions, such as competition and reduced reproduction (e.g. due to egg retention), combined releases may still be a worthwhile objective, to achieve long term biological control. This will be more critical when the alternative species is not the one we have selected but has already been present in the greenhouse and is unlikely to be of enormous potential as a predator. *Frankliniella occidentalis* Pergande (Thysanoptera: Thripidae) is polyphagous thrips which not only feeds on leaves, but also attacks eggs of spider mites and even eggs of *P. persimilis*.

Previous studies have demonstrated that when a phytoseiid predator and its con- or hetero-specific competitor are present together, the former should adopt strategies in order to decrease the risk of its offspring to predation by its competitor. One way to achieve reduced predation risk is egg retention (or alternatively egg resorption) which results in a decreased oviposition rate of the predatory mite, as known by Montserrat *et al.*(2007), or in oviposition away from the food source (Faraji *et al.* 2001; Janssen *et al.* 2003; Magalhaes *et al.* 2005; Choh and Takabayashi 2007).

Little is known about whether cues left by the heterospecifics suffice to elicit such behavioral changes in phytoseiids. For example, *Neoseiulus cucumeris* (Oudemans) (Acari: Phytoseiidae) retains eggs when its predator, *Iphiseius degenerans* (Berl.) (Acari: Phytoseiidae) is present (Montserrat *et al.* 2007), while a previous experience with *P. persimilis* is enough for female *Tetranychus urticae* to keep their eggs inside the body (Choh *et al.* 2010). Here we have examined the effect of western flower thrips, *Frankliniella occidentalis* on oviposition rate of the predatory mite, *Phytoseiulus persimilis*. We have carried out these experiments on two different host plants that both suffer from attack by spider mites as well as thrips: bean (*Phaseolus vulgaris*), the plant generally used for experiments in our laboratory, and rose (*Rosa L. Hybrid* var. Black Magic), an ornamental plant grown in greenhouses. The predatory mite *Phytoseiulus persimilis* is not native for Iran but because it is highly specialized predator of web spinning spider mites, its imported populations are being reared under laboratory conditions for preliminary ecological and behavioral studies for further release programs.

## Materials and methods

### *Plants and mites*

Common bean (*Phaseolus vulgaris* L. (Fabaceae)) and rose (*Rosa* L. (Rosaceae) *Hybrids* var. Black Magic) plants were grown in plastic pots containing mixture of soil and perlite. Plants were irrigated every day with tap water and a solution of NPK fertilizer (20 × 20 × 20) and were kept in controlled conditions (23±2°C, 16:8 h L:D, 60-70% R.H.) in growth chambers in Plant Protection Department, College of Agriculture, University of Tehran, Karaj, Iran.

Spider mites (*Tetranychus urticae*) and western flower thrips (*Frankliniella occidentalis*) were reared in two separate growth chambers (25±2°C, 16:8 h L:D, 60–70% R.H.) in Department of Plant Protection, College of Agriculture, University

of Tehran, Karaj, Iran on bean and cucumber plants, respectively. Corn pollen was added to thrips colonies once every 3-4 days. Next to the cucumber pots there were soil trays in which thrips pupae could develop into adults. Predatory mites were reared on detached rose leaves infested with *T. urticae* under the conditions specified above for the climate in the growth chambers.

#### *General experimental conditions*

We measured the oviposition rate of *P. persimilis* females for 24 hours under the three treatments differing in whether the female predators were exposed (1) to odor from the heterospecific competitor, *F. occidentalis*, (2) to odors from and contact with this competitor and (3) nor to odors nor to contacts related to this competitor. We cut rose leaf patches (2×3 cm<sup>2</sup>) and put them on water-saturated cotton in a Petri dish (6 cm in diameter, 1.5 cm high). Each leaf patch was infested with 25 same aged female spider mites. Same aged (3-day old) *P. persimilis* females in the oviposition phase, starved for 5 hours, were prepared for tests, each was put in a single patch, so that a total number of 20 patches were monitored for 24 hours and the eggs were counted during 15-20 min. A control experiment was performed in which there was no exposure to thrips nor to odors to record the number of *P. persimilis* eggs within 24 hours in absence of thrips or its cues. In addition to this control, the following treatments were applied. The egg number was recorded after 24 hours and in 20 replicates.

#### *The oviposition rate of P. persimilis when encountered F. occidentalis*

In this experiment, each predatory mite was introduced to an excised leaf disc infested with spider mites and two same aged female thrips. All Petri dishes (20 replicates) were kept under controlled conditions (23±2°C, 16:8 h L:D, 60-70% R.H.). Eggs were counted after 24 hours.

#### *The oviposition rate of P. persimilis when had experienced F. occidentalis for 24 hours prior to oviposition*

In this experiment, first we put all 20 same aged predators in one spider mite infested patch with 40 adult thrips for 24 hours. After one day, each of the predators were transferred to a separate *Tetranychus* (25 same aged females) infested patch but without thrips so that the egg number recorded 24 hours later. *i. e.* one after we obtained predatory mites from leaf discs with thrips (the total time required for counting did not exceed 15 min).

#### *The oviposition rate of P. persimilis when had experienced F. occidentalis for 48 hours prior to oviposition*

This treatment was prepared by 35 same aged female predators put in one spider mite infested patch (20 female spider mites) with 70 adult female thrips for 24 hours. After one day, each of the predators were transferred to a separate *Tetranychus* (25 same aged females) infested patch but without any thrips. After 24 hours this was repeated by putting each predator in to a new infested patch but without thrips. After 24 hours, the number of eggs in each patch was recorded (the total time required for counting did not exceed 15 min.).

All experiments were repeated in exactly the same way on bean leaf discs of the same size and under the same controlled conditions.

Data for egg numbers were analyzed by paired t-test. Differences between mean densities of eggs among treatments were examined using Duncan posthoc in SPSS 19.

## Results

### *The oviposition rate of P. persimilis when exposed to encounters with F. occidentalis during oviposition*

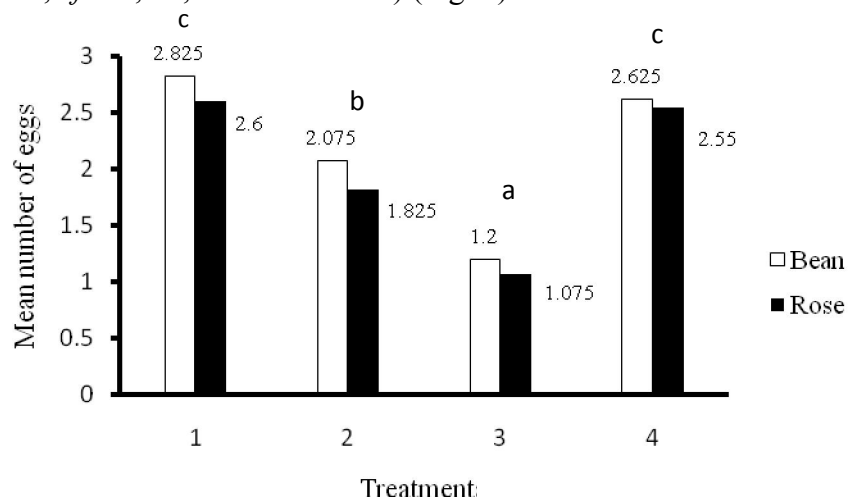
When the predatory mite, was exposed to cues from and encounters with thrips on bean and rose leaves prior to and within the first 24 hours of oviposition, the number of eggs ( $1.14 \pm 0.117$  totally) was significantly lower than that in the control experiment ( $2.71 \pm 0.114$ ) ( $t = 3.131$ ,  $df = 1, 39$ ,  $P = 0.003$  on bean,  $t = 4.206$ ,  $df = 1, 39$ ,  $P = 0.001$  on rose) where it was not exposed to encounters with thrips (Fig. 1). The reduced number of predator eggs was not due to thrips egg consuming, as all replicates were monitored regularly and no egg shell remnants was observed in the patch.

### *The oviposition rate of P. persimilis when experienced F. occidentalis 24 hours prior to oviposition*

Recording the number of *P. persimilis* eggs on bean leaves, since the 24<sup>th</sup> hour after exposure to thrips, we observed a significant difference in comparison with the number of eggs in the control experiment. *P. persimilis* deposited a lower number of eggs ( $1.95 \pm 0.113$  totally) in this experiment ( $t = 7.029$ ,  $df = 1, 39$ ,  $P = 0.001$  on bean,  $t = 5.85$ ,  $df = 1, 39$ ,  $P = 0.001$  on rose) (Fig. 1). Here, the mean number of eggs was 1.075 in the treatment as opposed to 1.2 in the control on bean.

### *The oviposition rate of P. persimilis when exposed to F. occidentalis 48 hours prior to oviposition*

The number of *P. persimilis* eggs on bean leaves ( $2.59 \pm 0.142$  totally), 48 hours after being exposed to thrips, did not differ significantly from the number of eggs ( $2.71 \pm 0.122$ ) in the control experiment ( $t = 0.96$ ,  $df = 1, 39$ ,  $P = 0.33$  on bean,  $t = 0.213$ ,  $df = 1, 39$ ,  $P = 0.83$  on rose) (Fig. 1).



**Figure 1.** Mean number of eggs *P. persimilis* deposited in each of the treatments on rose and bean patches: 1. control (in the absence of thrips), 2. with previous 24 hour experience with *F. occidentalis*, 3. with permanent exposure to *F. occidentalis*, 4. with previous 48 hour experience with *F. occidentalis*. There was a significant difference between the mean number of eggs among treatments ( $F= 37.918$ ,  $d_f= 3, 319$ ,  $P= 0.001$ ) indicated by the letters above each bar.

## Discussion

It has previously been shown that several factors affect the predatory mite decision whether to deposit eggs or wait till a safe patch is available. One of the determinants for such a behavior is offspring survival as female predators are supposed to choose the most beneficial circumstances e.g. con- and heterospecific free patches (Blaustein *et al.* 2004; Walzer *et al.* 2006; Nagelkerke *et al.* 1996) or patches in which the predator survival and reproduction might be increased (Villanueva and Childers 2006). Our experiments showed that predators from the laboratory population of *P. persimilis* were able to recognize *F. occidentalis* as its heterospecific competitor and adjust their oviposition behavior according to the level of risk of predation by the latter. This is to some extent consistent with Choh *et al.* (2010) who reported a significant decrease in spider mite oviposition rate when exposed to their predator. They discussed that as *Tetranychus* females keep on depositing fewer eggs even when food was available, this behavior could just be interpreted as an effect by the predator (anti-predator behavior) and not the effect of spider mite less feeding on the patch. Patch leaving is another reported response in spider mites when exposed to odors associated with *P. persimilis* (Choh and Takabayashi 2007). A similar behavior was reported on pepper plant, between *Iphiseius degenerans* (Acari: Phytoseiidae) and the same thrips species by Faraji *et al.* (2001). They observed that when exposed to the presence of thrips, the predatory mite shifted its oviposition site to leaves and commuted between leaves and flowers back and forth to keep its progeny safe from attack by thrips larvae in flowers. All these behavioral responses have been interpreted as anti-predator behavior. During our treatment prior to the oviposition experiment, the direct contact between *P. persimilis* and *F. occidentalis* provides sufficient information for the predator about the potential threat to its eggs, whereas in absence of thrips during the subsequent oviposition experiment this information on potential threats waned.

By reducing the period of time in which the predatory mite and thrips were exposed to each other, *P. persimilis* was still observed to reduce the oviposition rate on next day, although this response was weaker than in the treatment where the exposure was continuous. Similar behavior has been recorded for herbivorous mites e.g. *Tetranychus urticae* has also been observed to respond similarly at a similar time scale since last exposure to its predator (Choh *et al.* 2010). Therefore, it is possible that the predatory mite we studied could have stored the information it gained 24 hours ago and behaved accordingly. Interestingly, increasing the time interval (from thrips removal to *P. persimilis* oviposition) to 48 hours, we observed no remarkable reduction in egg numbers, which may indicate that experience wanes over time.

Our experiments showed that the effect of thrips on the oviposition rate of *P. persimilis* does not differ with the host plant species offered as a substrate. The effect of host plant might be important on plants with specific morphological characters

e.g. tomato with densely packed glandular hairs which have reported to decrease *P. persimilis* oviposition rate ( Drukker 1997). Further studies are needed to clarify how herbivore-induced plant volatiles influence predator oviposition.

The joint presence of *P. persimilis* and *F. occidentalis* in greenhouses with commercial roses (as well as in our greenhouses with bean plants for experiments and rearing) may have a negative effect on the impact of *P. persimilis* in controlling spider mites. This needs further investigation. We did not test whether the reduced oviposition of *P. persimilis* due to thrips emerged directly after receiving cues from thrips or through *P. persimilis* reaction by reducing feeding activity. We propose to test biocontrol strategies in which the *F. occidentalis* population is reduced before releasing *P. persimilis*.

## References


- Blaustein, L., Kiflawi, M., Eitam, A., Mangel, M. & Cohen, J. E. (2004) Oviposition habitat selection in response to risk of predation in temporary pools: mode of detection and consistency across experimental venue. *Oecologia*, 138: 300–305.
- Drukker, B., Ravensberg W. J. & Sabelis, M. W. (1997) improve control capacity by *Phytoseiulus persimilis* in tomato. *Experimental and Applied Acarology*, 21: 507–518.
- Choh, Y. & Takabayashi, J. (2007) Predator avoidance in phytophagous mites: response to present danger depends on alternative host quality. *Oecologia*, 151(2): 262–267.
- Choh, Y., Uefune, M. & Takabayashi, J. (2010) Predation-related odours reduce oviposition in a herbivorous mite. *Experimental and Applied Acarology*, 50(1): 1–8.
- Croft, B. A., McMurtry, J. A. & Luh, H. K. (1998) Do literature records of predation reflect food specialization and predation types among phytoseiid mites (Acari: Phytoseiidae)? *Experimental and Applied Acarology*, 22(8): 467–480.
- Faraji, F., Janssen, A. & Sabelis, M. W. (2001) Predatory mites avoid oviposition near counterattacking prey. *Experimental and Applied Acarology*, 25(8): 613–623.
- Janssen, A., Willemse, E. & van der Hammen, T. (2003) Poor host plant quality causes omnivore to consume predator eggs. *Journal of Animal Ecology*, 72(3): 478–483.
- Magalhães, S., Brommer, J. E., Silva, E. S., Bakker, F. M. & Sabelis, M. W. (2003) Life-history trade-off in two predator species sharing the same prey: a study on cassava-inhabiting mites. *Oikos*, 102(3): 533–542.
- Magalhães, S., Janssen, A., Montserrat, M. & Sabelis, M. W. (2005) Prey attack and predators defend: counterattacking prey trigger parental care in predators. *Proceedings of Royal Society of London B*, 272: 1929–1933.
- Montserrat, M., Bas, C., Magalhães, S., Sabelis, M., de Roos, A. & Janssen, A. (2007) Predators induce egg retention in prey. *Oecologia*, 150(4): 699–705.
- Nagelkerke, C. J., van Baalen, M. & Sabelis, M. W. (1996) When should a female avoid adding eggs to the clutch of another female? A simultaneous oviposition and sex allocation game. *Evolutionary Ecology*, 10(5): 475–497.

- Sabelis, M.W. & Dicke, M. (1985) Long-range dispersal and searching behaviour. In *Spider mites: their biology, natural enemies and control*. (Eds W. Helle and M. W. Sabelis) Amsterdam: Elsevier, Vol. 1B, 141–160.
- Sabelis, M. W., Janssen, A., Bruin, J., Bakker, F. M., Drukker, B., Scutareanu, P. & van Rijn, P. C. J. (1999) Interactions between arthropod predators and plants: A conspiracy against herbivorous arthropods? In *Ecology and Evolution of the Acari*, 207-229 (Eds J. Bruin, L. P. S. van der Geest and M. W. Sabelis). Dordrecht, The Netherlands: Kluwer Academic Publishers.
- Villanueva, R. T. & Childers, C.C. (2006) Evidence for host plant preference by *Iphiseiodes quadripilis* (Acari: Phytoseiidae) on Citrus. *Experimental and Applied Acarology*, 39(3): 243–256.
- Walzer, A., Paulus, H. & Schausberger, P. (2006) Oviposition behavior of interacting predatory mites: response to the presence of con- and heterospecific eggs. *Journal of Insect Behavior*, 19(3): 305–320.
- Walzer, A. & Schausberger, P. (1999) Cannibalism and interspecific predation in the phytoseiid mites *Phytoseiulus persimilis* and *Neoseiulus californicus*: predation rates and effects on reproduction and juvenile development. *Biological Control*, 43(4): 457–468.

Received: 23 February 2011

Accepted: 15 June 2011

#### COPYRIGHT

 Maleknia *et al.* Persian Journal of Acarology is under free license. This open-access article is distributed under the terms of the Creative Commons-BY-NC-ND which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original author and source are credited.

#### چکیده

سرعت و میزان تخم‌گذاری در شکارگران با چندین عامل مانند حضور شکارگر هم‌گونه و غیر هم‌گونه، میزان غذای موجود در لکه تغذیه‌ای و کیفیت لکه تغذیه‌ای تحت تاثیر قرار می‌گیرد. در صورتی که گونه‌ها زمانی کافی را با یکدیگر سپری کرده باشند، توانایی تشخیص و دوری‌گزینی از خطر و حفاظت از نتاج خود را در قالب رفتارهایی مانند تغییر مکان تخم‌گذاری، تعویق تخم‌گذاری و مجموعه‌ای از رفتارهای محافظه‌کارانه را پیدا می‌کنند. در این پژوهش میزان تخم‌گذاری کنه شکارگر *Phytoseiulus persimilis* Athias-Henriot روی دو گیاه رز و لوبیا و در شرایط دسترسی کامل به شکار (*Tetranychus urticae*) و دریافت رایحه‌های شکارگر غیر هم‌گونه *Frankliniella occidentalis* (Pergande) بررسی شد. در تیمارهایی که کنه شکارگر و

تریپس در طول آزمایش یا پیش از آن با یکدیگر برهم‌کنش داشتند، میزان تخم‌گذاری نسبت به شاهد به میزان معنی داری کاهش نشان داد. کاهش تعداد تخم، در تیماری که بر خورد کنه شکارگر و تریپس، تنها به پیش از آزمایش محدود می‌شد نیز مشهود بود. این در حالی است که با افزایش طول زمان برهم‌کنش کنه و تریپس به ۴۸ ساعت، میزان تخم‌گذاری کنه‌های شکارگر افزایش یافته و به تعداد ثبت‌شده در تیمار شاهد نزدیک شد. تغییر گونه گیاه میزبان رز و لوبیا، تفاوت معنی‌داری در نتایج این بررسی ایجاد نکرد. در این پژوهش، درباره تأثیرات حضور این گونه‌ها در کنار یکدیگر و اثر آن بر برنامه کنترل بیولوژیک بحث خواهد شد.