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Occurrence and population trends of spider mite specialist predators under field and greenhouse conditions

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Abstract: The objective of this study was to examine the population growth of spider mites in cucumber fields and greenhouses, followed by identification of the main specialist predators and monitoring their synchronization with prey population dynamics. The samples were taken for 150 days in spring and summer 2007 in two pilot plots in the Tehran Province. The results showed the predatory thrips, *Scolothrips longicornis* as a persistent predator in both conditions able to function at lower prey population densities than *Stethorus gilvifrons*. Good synchronization in both prey-predator populations showed the direct effect of prey availability on predator survivorship followed by direct and indirect effects of temperature.

Keywords: *Scolothrips longicornis, Stethorus gilvifrons*, population growth, Iran

Introduction

Carnivores that exploit patchily distributed herbivores have to move among prey patches to obtain sufficient prey for their survival and reproduction (Sabelis & van de Baan, 1983). During such inter-patch migration, predators benefit from detecting prey patches at a distance as they migrate into and out of greenhouses to search their host (Takahashi *et al*., 2001).

Different predator species that prey on spider mites, with different feeding habits from specialist to generalist, often coexist in the same field (Shimoda & Ashihara, 1996). They search for their hosts and preys according to different cues (Dicke & Vet, 1999).

Predator-prey models provide insight into how predator attraction and arrestment affect local population dynamics. In their simplest form, these models assume exponential growth of prey and predator population with a constant per capita predation rate (pancake predation models (Pels & Sabelis, 1999)). Sabelis *et al.* (1999) distinguished between three types of prey-predator dynamics: 1) continual increase, 2) initial increase followed by a decrease and 3) immediate decrease. Apart from the initial condition, assumptions on predator emigration appear to be critical. If predators emigrate during the interaction, type-3 will show up.

In this study, we investigated the seasonal occurrence of the dominant spider mite species *Tetranychus urticae* Koch (Acari: Tetranychidae) in a research field of cucumber and a greenhouse with the same cultivar in the Tehran province. Then we followed the population dynamics of the species and their synchronization until their disappearance. We hypothesize that predators follow their prey population and three questions arose to be answered: 1) which predators appear consistently on spider mites infested plants, 2) do predator populations synchronize with that of their preys, 3) do all developmental stages of prey and predators increase by the same rate?

Material and methods

A screening trial was conducted from May to October 2007 (20 weeks) to examine the population trends in the two spotted spider mite, *T. urticae* and its potential predators *Stethorus gilvifrons* Mulsant (Coleoptera: Coccinellidae) (in the field) or *Scolothrips longicornis* Priesner (Thysanoptera: Thripidae) (in the greenhouse) in cucumbers (*Cucumis sativus* cv. Sultan) in two areas. No fungicides or acaricides were used either in the field or in the greenhouse.

The samplings started in a cucumber field in the southeast of the Tehran Province, Varamin. The number of active mites plus eggs was counted with 10-day intervals by sampling either a fully expanded young leaflet (upper) or an old one (lower) from each cucumber plant. During eighty days (10^{th} May – 30^{th} July), nine samplings were performed. Twenty plants were sampled in each plot (20 plants × 2 leaves). The leaflets were examined microscopically and mites were counted in a 1-cm^2 area on each leaflet. On the same leaflets, the different developmental stages of predators were counted by the use of a 10x lens on the whole leaflet. Sampling was maintained until the predators disappeared and the plants in the field were harvested (July 2007). Temperature was recorded on each sampling date.

Sampling in the greenhouse started exactly 10 days after the field harvesting. The greenhouse was located in an area in north of Tehran (Velenjak, at PPRI campus) with an average of 5-10°C cooler than Varamin during the summer months. The same procedure for sampling was used with the time intervals decreased to 4 days (for predator monitoring) or 7 days (for *T. urticae*) giving a total of 10 samplings for *T. urticae* and twenty for the predators. Sampling continued into October at which time the predators disappeared completely.

An analysis of variance was done to compare mite levels and levels of its predators between dates and between young and old leaflets and for the different developmental stages. Due to the difference in sampling area for pest and predators, the data was converted to logarithmic scale.

Results and discussion

In field the dominant insect predator was *S. gilvifrons* while in greenhouse *S. longicornis* was the main biological agent. In the field both specialist predators were observed in addition to some generalist predators like *Orius niger* Wolff (Hemiptera: Anthocoridae) and a few chrysopid individuals (Neuroptera: Chrysopidae). A few numbers of the predatory mites *Phytoseiulus persimilis* Athias-Henriot (Acari: Phytoseiidae) as well as *Orius* sp. were also recorded in the greenhouse. The population of predatory mites and *Orius* was very low and these species were consequently not included in the sampling program.

In the field, the population density of *S. gilvifrons* was at each sampling date 1.5-1.8 times higher than that of the second most abundant predator, *S. longicornis*, although the latter appeared sooner and disappeared immediately after the prey densities dropped to less than 0.01 mites per cm^2 leaf (Figure 1a). The patterns of population growth were the same for all the three species. In general, the populations of spider mites and its predators remained rather low throughout the sampling period with a slight increase on the warmest days of June and beginning of July (37±3°C), followed by a decline in populations on upper leaves. The lower leaves provided shade for spider mites and the predatory thrips both seemingly migrating to these plant parts to escape from warm weather and sunshine. However, populations were significantly higher on upper leaves before this increase in temperature ($P<0.05$).

For both the pest and the predatory thrips, the population dynamic followed the same pattern for all developmental stages, except for spider mites, which at the end of the field season showed significantly different oviposition rates. Apparently, the spider mites responded to the increase in temperature by producing more eggs. But following the decline in spider mites population, *S. gilvifrons* left the canopy and disappeared, perhaps caused by migration to adjacent infected fields or by as an escape from competitors (*S. longicornis*).

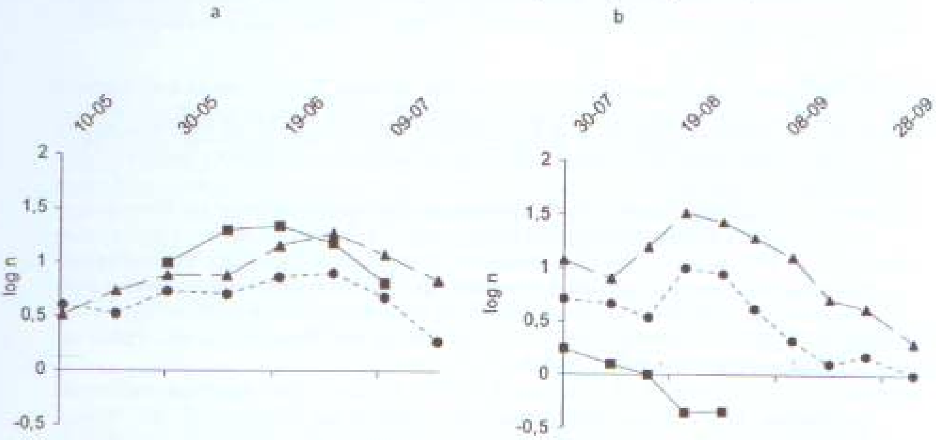

Figure 1. Log density of spidermites (▲), *Scolothrips* (•) and *Stethorus* (■) on upper leaves a) in field, b) in greenhouse.

In the greenhouse, the spider mite population peaked (Figure 1b) in August when the temperature was at favourite levels for mites (30±2°C) hereby providing sufficient numbers of prey for the predators. In response to increasing numbers of *S. longicornis*, the other predator left the greenhouse due to low prey number (12.4±0.7 mites/cm^2; Kheradpir *et al.*, 2006). In the greenhouse, the prey-predator interaction ended after 80 days when predators were no longer present, contrasting the situation in the field where predators persisted through to harvest. No significant differences (P>0.01) were found in the densities on lower and upper leaves so the results for whole plants were used for analyzing. The growth rate for the prey and the main predator *S. longicornis* showed great synchronization – for example when prey density increased from the initial 16±1.8 to 300±26 per two leaves per plant in 30 days, predator density increased from 1.2±0.7 to 9±2.3, the latter being due mainly to an increase in density of larvae. For the predator, the population increase was a result of ample supply of spider mites (43±1.8 mites/cm^2 at its peak) and a temperature stimulating oviposition.

Other similar studies have shown that the main predators in field and greenhouses infected by spider mites are different species of *Scolothrips* (Takahashi *et al.*, 2001) and *Stethorus* (Chazeau, 1974) in addition to *Orius* sp. as the main generalists (Baniameri *et al.*, 2006). Chazeau (1974) reported *S. gilvifrons* as the most effective spider mites predator with high temperature needs. Apparently in our greenhouse, the main factor to exclude this predator was low temperature (Roy *et al.*, 2002) and in the field, pest density was seemingly a limitation. In intra-guild predation interactions, the predatory thrips could win the competition with *S. gilvifrons* due to its lower feeding rate (Huffaker *et al.*, 1999). On the other hand, Shimoda and Takabayashi (2001) mentioned the flight capacity of *S. longicornis* as the major reason for its ability to search out prey patches more efficiently than other specialist predators. The prey-predator population dynamic model in the greenhouse followed the type-3 (Sabelis *et al.*, 1999) and in the field we saw a smoothed type-3 of a longer duration. The specialist predators did not allowed generalists to establish in the system. *S. longicornis* requires only relatively few numbers of preys to survive, produces a high numbers of eggs (Gilstrap, 1995), has a high searching capacity and a good synchronization with its prey. These characteristics are the likely explanation for its effectiveness as a predator of spider mites in our experiments.

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