THE INFLUENCE OF LEAF HAIRS OF *GERBERA JAMESONII* ON THE SEARCHING BEHAVIOUR OF THE PREDATORY MITE *PHYTOSEIULUS PERSIMILIS*

P.W. Kleijn, O.E. Krips, P.E.L. Willems & M. Dicke

Department of Entomology, Wageningen Agricultural University,
P.O. Box 8031, 6700 EH Wageningen, The Netherlands.

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Summary
Some natural enemies of herbivores are hampered by leaf hairs during their search for prey or hosts. In this study it was determined whether the predatory mite *Phytoseiulus persimilis* is hampered by leaf hairs of gerbera (*Gerbera jamesonii*) while searching for its prey, the spider mite *Tetranychus urticae*. Three parameters of the predator's searching behaviour were quantified: walking speed, walking activity and encounter time with prey eggs. The results show that the walking speed and walking activity decreased when the hair density increased. The time needed by the predator to find its first prey item (encounter time) increased when the hair density increased. Finally the effect of leaf hair density on predation rate was studied. Predation rate was negatively influenced by leaf hairs at low prey egg densities (1.3 and 2.5 eggs/cm^2). At 8.0 prey eggs/cm^2, predation rate was not affected by leaf hair density. At this prey density rate of encounter between predator and prey does not appear to be the factor limiting predation rate.

INTRODUCTION

Plant characteristics can have an important effect on the searching behaviour of natural enemies of herbivores. One of the characteristics that can negatively influence the behaviour is the presence of leaf hairs. Hulspas-Jordaan & van Lenteren (1978) showed that *Encarsia formosa* is hampered by leaf hairs as it is searching for its hosts on host plants with a high hair density. The parasitoid *Trichogramma exiguum* and the predator *Scolothrips longicornis* are also negatively influenced by leaf hairs during searching for their host or prey (Keller, 1987; Obrycki, 1986).

The predatory mite *Phytoseiulus persimilis* Athias-Henriot is a well known biological control agent against the two-spotted spider mite *Tetranychus urticae* Koch (Helle & Sabelis, 1985). It may well be that *P. persimilis* is also hampered by leaf hairs. This paper therefore addresses the question whether the searching efficiency of *P. persimilis* is indeed affected by leaf hairs. For this purpose three *Gerbera jamesonii* cultivars were chosen because the cultivars show large differences in hair density on the lower surface of the leaves and because gerbera is an interesting crop for applying biological control (O.E. Krips, unpub. data; Sütterlin *et al.*, 1992).

In a prey patch *P. persimilis* searches randomly for prey. Therefore walking speed and walking activity (defined as the percentage of time that the predator is walking) are important aspects of its searching behaviour (Sabelis, 1981). The time needed by the predator to find its first prey item (encounter time) and the predation rate of the predatory mite upon spider mite eggs are also measured because these parameters are important aspects of the predator's foraging success. Differences in encounter rate will not necessarily lead to differences in predation since the motivation of the predator to consume an egg depends on more factors than the encounter rate alone, such as gut filling of the predator.

MATERIAL AND METHODS

Plant material. Gerbera jamesonii cultivars were grown in a greenhouse at 20-30°C and 50-70% RH under a 16:8 light:dark photoperiod. For each experiment, leaves of the cultivars Bianca, Sirtaki and Bourgogne were used. The leaf hair density on the under surface of these leaves was respectively 105 ± 17, 400 ± 75 and 730 ± 78 hairs/cm^2 (mean ± SD). The leaves used in the experiments were young but completely unfolded.

Mite colonies. Predatory mites (*Phytoseiulus persimilis* Athias-Henriot) were originally obtained from Entocare, a commercial mass rearing for biological control. Predatory mites used for the experiments were reared in petri dishes on leaves of Lima bean (*Phaseolus lunatis*) infested with spider mites (*Tetranychus urticae* Koch) at a temperature of 23 ± 1°C. Only females of uniform age (between 7 and 8 days old) were used in the experiments. Since the background of the spider mites differed between the experiments, the background of the spider mites will be described per experiment.

Walking behaviour. Leaf discs of 16 cm^2 were cut from leaves of each gerbera cultivar and placed upside down in a petri dish on 1 % (w/v) agar. No food for the predatory mites was present on the leaf discs. Subsequently, the petri dish was placed under a camera above a ring of fluorescent light. A female predatory mite that was starved for 24 h was placed on the leaf disc. The images from the camera were sent to a computer which recorded the position of the female every 1.04 seconds. Both the walking speed and the walking activity were calculated by using the image analysis software Ethovision version 1.70 (Noldus Information Technology Inc.). The recording started immediately after the female was placed on the leaf disc and stopped after 10 minutes. The female was removed after recording and both female and leaf disc were replaced by a new one. When a female had walked on the leaf disc for less than 3 minutes before she walked off the disc and disappeared, the track was not included in the analysis. Females that did not walk at all or walked only on the edge of the discs were removed from the experiment. All recordings were made at 23 ± 1°C. Per cultivar 20 recordings were made. The results were analysed by using a Kruskal-Wallis test (a = 0.05) followed by a non parametric multiple comparison test.

Time needed to find one prey item (encounter time). Leaf discs of 4 cm^2 were cut from leaves of each gerbera cultivar and were placed upside down on wet cotton wool to prevent desiccation of the discs. Spider mite eggs that originated from a spider mite colony on Lima bean were placed randomly on the leaf discs. Two egg densities were used; 2.5 and 5.0 eggs/cm^2. Subsequently, predatory mites that were starved for 24 h were placed on the leaf discs. One female was introduced per disc. The time between the placement on the disc and the first encounter with a spider mite egg was determined. Females that did not search at all, or females that only walked on the edge of the discs were removed from the experiment. Each treatment was repeated 20 times. The results were analysed by using a Kruskal-Wallis test (a = 0.05) followed by a non parametric multiple comparison test.

Predation rate. Leaf discs of 4 cm^2 were cut and placed upside down on wet cotton wool to prevent dessication of the leaf discs. Spider mite eggs that originated from a spider mite colony on the cultivar on which the predation rate was going to be determined, were placed on the discs in regular rows. Three egg densities were used; 1.3, 2.5 and 8.0 eggs/cm^2. After the eggs were placed on the discs, the petri dishes were placed in a climate cabinet during the night (15°C). The next day the discs were transferred to 23 ± 1°C where the experiment took place. After checking the egg densities, one female spider mite was placed on each leaf disc. A period of conditioning (8 h) preceded the experiment. During this conditioning period, egg densities were checked and consumed eggs were replaced at a time interval that allowed the egg density to vary by maximally 5 %. The time interval was 0.5 h for the lowest egg density, 1 h for 2.5 eggs/cm^2 and 2 h for the highest egg density. Immediately after the conditioning period, the experiment started on the same leaf discs. The experiment lasted 8 h as well. During this time, the egg densities were kept constant as well by replacing consumed eggs at the same time intervals as during the conditioning period. Subsequently the amount of consumed eggs per female was determined. Each treatment was repeated 20 times. The data was tested for normality and homogeneity of group variance and were analysed by using a one-way ANOVA test (a = 0.05) followed by an LSD multiple comparison test.

RESULTS

Walking behaviour. Figure 1 shows the mean walking speed (cm/sec) of the predatory mites on different gerbera cultivars. The walking speed of the predatory mites is significantly higher on leaves of the cultivar Bianca with the lowest hair density than on leaves of the cultivars Sirtaki and Bourgogne with a higher hair density. The walking speed of the mites on leaves of the cultivars Sirtaki and Bourgogne did not differ significantly. The walking activity is given in Figure 2. Walking activities on the three cultivars were not significantly different.

Encounter time. Figure 3 shows the encounter time between a female predatory mite and a spider mite egg at two different egg densities. This encounter time differed significantly on the three gerbera cultivars for both egg densities. At both egg densities, the encounter time is shortest on the cultivar Bianca (105 ± 17 hairs/cm^2) and highest on the cultivar Bourgogne that has the highest hair density (730 ± 78 hairs/cm^2).

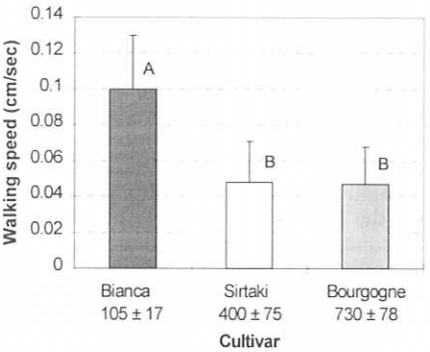

Figure 1. Mean walking speed (cm/s) on three gerbera cultivars. The vertical bars indicate the SD, different letters indicate significant differences (Kruskal-Wallis, P<0.05).

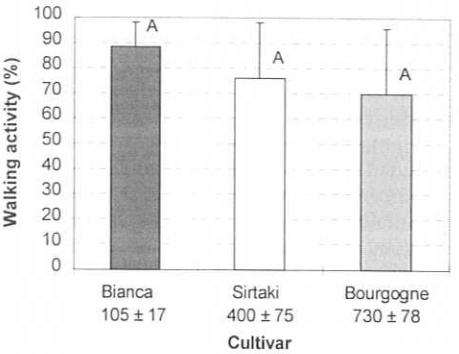

Figure 2. Mean walking activity (%) on three gerbera cultivars. The vertical bars indicate the SD, different letters indicate significant differences (Kruskal-Wallis, P<0.05).

Predation rate. The amount of spider mite eggs that was consumed by the predatory females strongly depended on egg density (Fig. 4). The females consumed, irrespective of the used cultivar, more eggs when the egg density on the disc was higher. At an egg density of 1.3 eggs/cm^2, the predation of eggs significantly decreased with increasing hair density. At an egg density of 2.5 eggs/cm^2, the predation on the cultivar Bourgogne was significantly lower than the predation on both other cultivars with lower leaf hair density. At an egg density of 8.0 eggs/cm^2, there was no significant difference in the predation rate on the three gerbera cultivars.

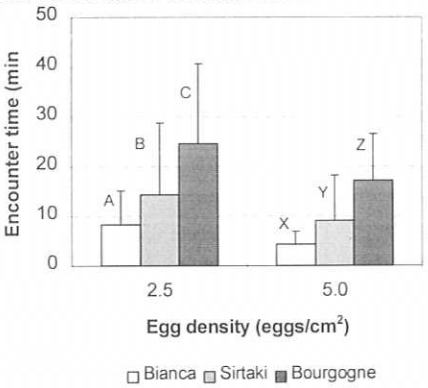

Figure 3. Mean encounter time (min) per cultivar at two egg densities. The vertical bars indicate the SD, different letters indicate significant differences within separate egg densities (Kruskal-Wallis, P<0.05).

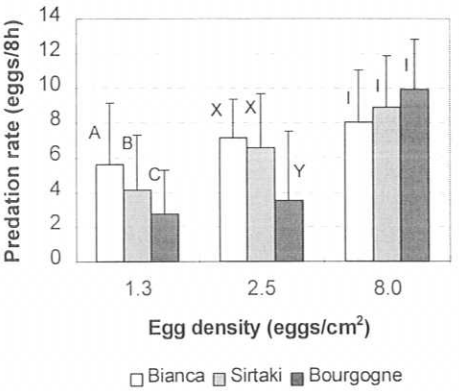

Figure 4. Mean amount of consumed eggs in 8 h per cultivar at three egg densities. The vertical bars indicate the SD, different letters indicate significant differences within separate egg densities (Kruskal-Wallis, P<0.05).

DISCUSSION

Our data show that the searching efficiency of *P. persimilis* on a gerbera leaf decreases when gerbera cultivars have a higher density of leaf hairs on the under surface of the leaves. This is in agreement with the results reported for other insects like *Encarsia formosa* on cucumbers with and without leaf hairs (Van Lenteren *et al.*, 1995). No significant difference in walking speed and walking activity was found between predatory mites that searched on leaves of the cultivar Sirtaki (400 ± 75 hairs/cm^2) and mites that searched on leaves of the cultivar Bourgogne (730 ± 78 hairs/cm^2). It may well be that the hair densities of Sirtaki and Bourgogne are above the density range in which hair density and searching behaviour are correlated.

The observation that the high leaf hair density of the cultivars Sirtaki and Bourgogne causes a decrease in both the walking speed and the walking activity, leads to the assumption that the mean encounter time between a predatory mite and a spider mite egg on these cultivars would be much longer than on the cultivar Bianca with the lowest hair density. This assumption proved to be true; the encounter time increased when the hair density on the leaves increased. It was striking that there was a significant difference in encounter time between the mites that were searching on the cultivars Sirtaki and Bourgogne, while the walking behaviour on these cultivars did not show any differences. It is likely that the walking behaviour is indeed the same for both cultivars but that the mites on the cultivar Bourgogne with the highest leaf hair density have to search longer because the eggs are better hidden between the hairs.

The predation rate at low egg densities (1.3 and 2.5 eggs/cm^2) clearly decreases as the density of hairs on the under surface of the leaves increases. When the egg density was high (8.0 eggs/cm^2), no significant differences in predation rates could be found for the predatory mites on the different cultivars. Most likely, the egg density reached such a high level that the predatory mites did not have to search for the eggs. Therefore differences in encounter times do not influence the predation rate. Based on the measured encounter times a prediction could be made for the predation of spider mite eggs by the predatory mite. Surprisingly, the actual predation rate was much lower than the expected predation rate. This can be explained by the observation that not every contact with an egg leads to predation. Whether a predatory mite consumes an encountered egg or not, depends on the food content of the gut of the mite. At high egg densities the food content of the gut is high which results in a low motivation to consume an encountered egg (Sabelis, 1981). At high prey densities digestion rate is a limiting factor in predation rate, rather than encounter rate.

Since the searching efficiency of the predatory mite *P. persimilis* is lower at higher hair density, the success of the predator in biological control of the spider mite *T. urticae* on gerbera may be influenced by leaf hair density.

Acknowledgements

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