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Original Research Paper

Multiple choice for mites: First food, then home

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The use of biocontrol plants to enhance IPM is an alternative to pesticide use. The presence of predatory mites, employed to control pest mites, may be enhanced by the banker plants which bear domatia and by the addition of pollen as alternative food. Our objective was to understand whether the presence of domatia and added pollen influence the predatory mites' selection of a leaf type of a certain plant species in a positive or negative way. We hypothesized that a leaf offering shelter in form of domatia is more attractive for predatory mites if food is available on the same plant, as compared to leaves without food in form of pollen or prey. We analyzed the preferences of the predatory mite, *Neoseiulus* (*Amblyseius*) *californicus* (McGregor) (Arachnida: Acari: Mesostigmata: Phytoseiidae), commonly employed for biological pest control of the two-spotted spider mite. We offered two food options to *N. californicus* in an experiment lasting nine days on eight plant species considered as potential banker plants for *N. californicus*, two of them with domatia. On detached leaves in the laboratory, we compared the presence of mite on leaves with pollen and/or *T. urticae* as food and with/without domatia. There were clear differences of the number of mite individuals depending on the species of host plants and on food availability. The results of our study indicate that: (i) if available, the predatory mites prefer to be on the plants harboring *T. urticae* (roses and sweet pepper, *Capsicum annuum*), (ii) if only pollen is available, the two plant species which bear domatia are preferred (*Vitis riparia* and *Viburnum tinus*), and (iii) overall, the predatory mites prefer certain plant species where they can hide in domatia, even if their prey *T. urticae* is absent.

Key words: *Neoseiulus californicus*, *Tetranychus urticae*, acarodomatia, pollen, banker plants.

INTRODUCTION

The predatory mite, *Neoseiulus californicus* (McGregor) (Arachnida: Acari: Mesostigmata: Phytoseiidae) is commonly employed for biological pest control of the two-spotted spider mite, *Tetranychus urticae* C.L. Koch (Tetranychidae) (Greco et al., 2005; Canlas et al., 2006). For this purpose, it may be reared on banker plants, i.e. "the plant components of the banker plant system in a rearing and releasing system purposefully established in a crop for control of pests in greenhouses or open field" (Huang et al., 2011). Banker plants are a special plant type within the biocontrol plants, defined as plants which are intentionally added to a crop system aiming the enhancing of crop productivity by pest attraction and/or pest regulation, and thus, contribute to increasing biocontrol services, which ultimately can lead to increase sustainability of the cropping systems (Parolin et al., 2014). Out of the many possible biocontrol plants, banker plants help to increase and stabilize the presence of predatory mites in biological control. Banker plants are used to form a reservoir and increase the probability of the long-term establishment of predators (Murphy, 2004; Osborne et al., 2005; Sanderson and Nyrop, 2008; Huang et al., 2011). Due to their characteristic functional types, certain plant species are suited to maintain a population of predators and release them over long time periods so that they protect the crop plants from present pests and provide long-term pest

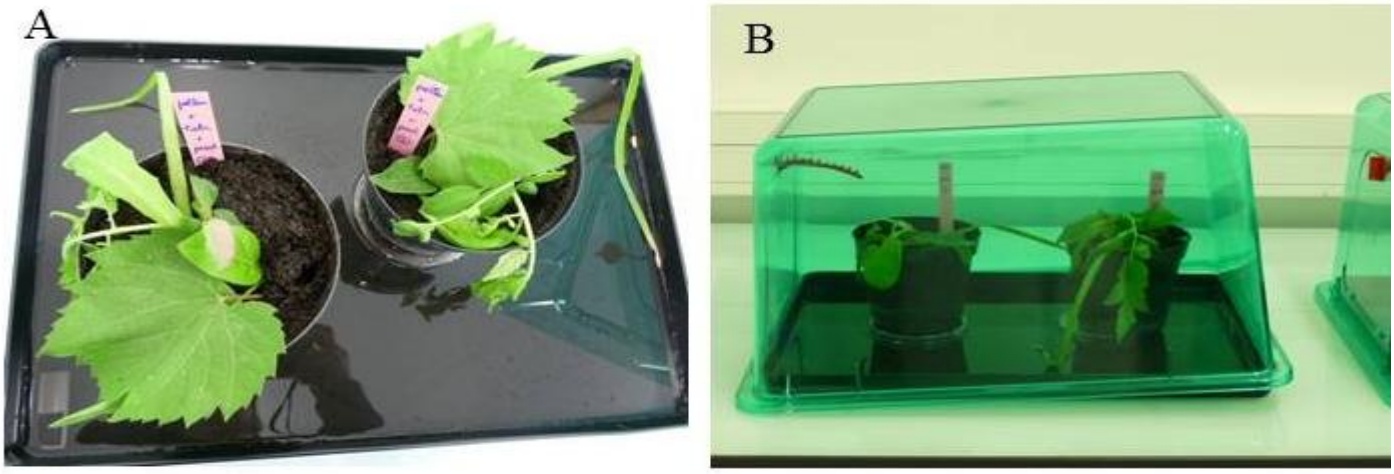

Figure 1:Experimental setting with detached leaves of eight plant species per pot filled with wet soil.

suppression (Frank, 2010; Huang et al., 2011) e.g. if they provide shelter or food. However, many banker plants are efficient in that they offer domatia (Pemberton and Turner, 1989; Walter and O'Dowd, 1992; Grostal and O'Dowd, 1994; Karban et al., 1995) not food. Therefore, in their employment for biological pest control it may be necessary to provide additional food. Pollen is frequently used as alternative food source, but it may have different impacts on the behavior and distribution of the mites (Venzon et al., 2002; Wäckers et al., 2005, 2007; Sarwar et al., 2011).

With the aim to analyze the efficiency of selected plant species as banker plants (Frank, 2010; Huang et al., 2011), a series of experiments was performed in the last years. The present study aims at testing the influence of the presence of domatia and pollen on the host plant choice of *N. californicus* with or without presence of the prey *T. urticae*. For this purpose, we employed eight potential banker plant species with different leaf functional characteristics.

The main question is whether the presence of domatia and added pollen influences the predatory mites' selection of a leaf type in a positive or negative way. We hypothesize that a leaf offering shelter in form of domatia is more attractive for predatory mites if food is available on the same plant, as compared to leaves without food (in form of pollen or prey). Their eggs however are independent of food availability and should be found to higher extents on leaves which offer shelter rather than food. We hope that our study may contribute to a better understanding of trophic interactions in general, and of the employment of biocontrol plants in particular, for biological pest control.

MATERIALS AND METHODS

We used the predatory mite *Amblyseius* (*Neoseiulus*) *californicus* (McGregor) (Arachnidae, Acari, Phytoseiidae) and the pest mite *Tetranychus urticae* Koch (Acari, Tetranychidae). The commercial strains Spical® of predatory species were ordered at Koppert's.

We set up an experiment with detached leaves of eight species of potential banker plants (Figure 1). The species were chosen basing on the results of earlier studies, including crop plants: *Capsicum annuum* L. 'Poivron doux d'Espagne' (Solanaceae, sweet pepper), *Crepis nicaeensis* Balb. (Asteraceae), *Eleusine coracana* (L.) Gaertn. (Poaceae), *Solanum lycopersicum* (Solanaceae, tomato), *Rosa sonia* Meilland var. 'Sweet Promise' (Rosaceae, rose), *Sonchus oleraceus* L. (Asteraceae), *Viburnum tinus* L. (Caprifoliaceae, laurel tinus), *Vitis riparia* var. Gloire de Montpellier (Vitaceae, grape). In the following we refer to the plant species by genus name only. The morphological characteristics of the leaves differed, with more or less hairy leaves or waxy surfaces. Two species bear domatia on the lower leaf side, *Viburnum* and *Vitis* (Figure 2), but not the other species.

Five replicates in pots were placed in the laboratory of INRA Sophia Antipolis for nine days (Figure 1). We used detached leaves of the eight plant species placed close together in pots filled with wet soil allowing for connectivity (Skirvin and Roberts 2007). The placement of the leaves in the replicates differed at random.

The leaves were inoculated with 30 individuals of the pest mite *T. urticae* previously grown on bean plants. They were placed in the middle between the detached leaves. One week later we installed 30 predatory mites, *Amblyseius californicus*, also in the middle between the detached leaves of the eight plants.

In the experiment we offered three food options: "pollen +*T. urticae*" vs. "only pollen"vs. "only *T. urticae*" available as food for the predatory mites. We had five replicates of

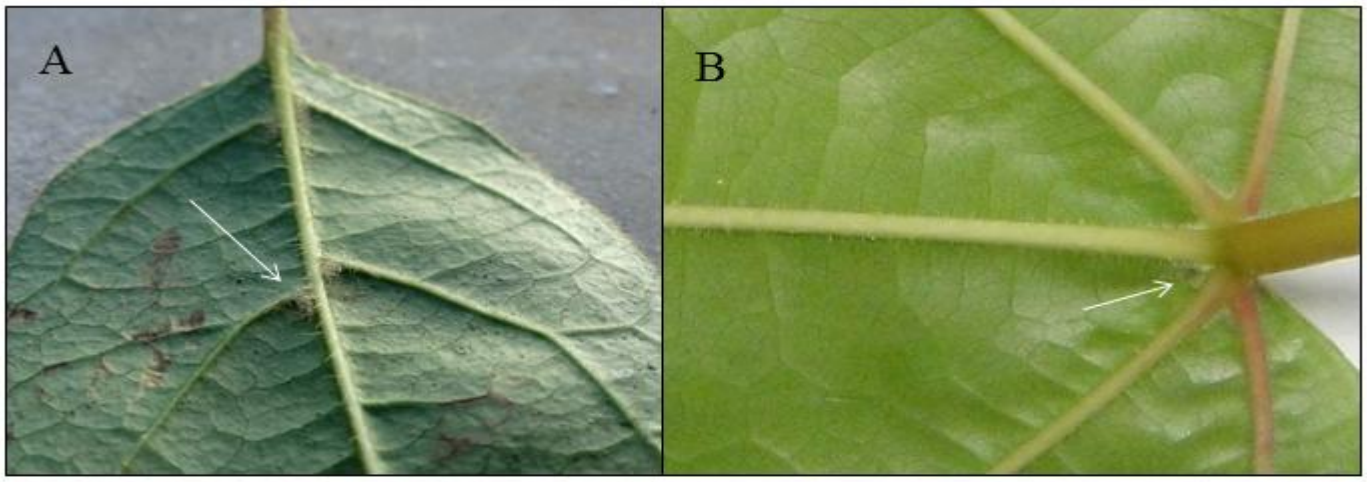

Figure 2:Domatia in vein axils on lower leaf site of *V. tinus* (A) and *V. riparia* (B).

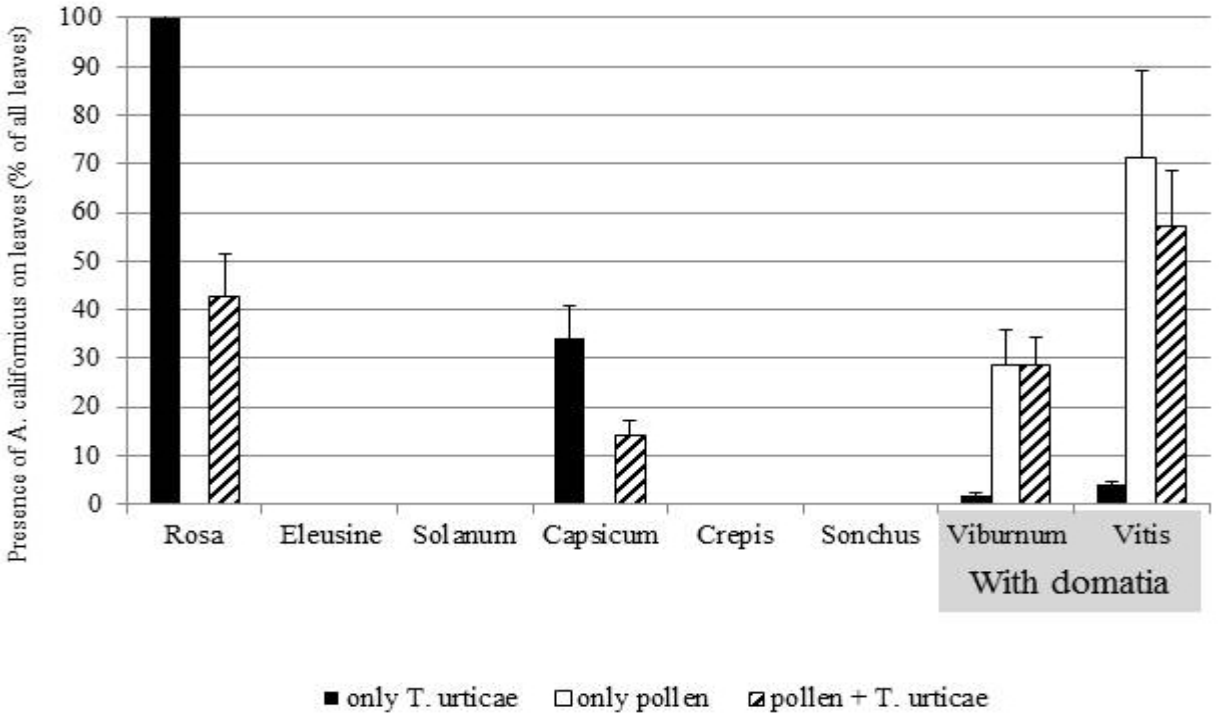

Figure 3:Presence of the predatory mite *A. californicus* on detached leaves of the 8 plant species with different food options (only prey *T. urticae*, only pollen, pollen + prey *T. urticae* put on the leaves), in percent – where 100 % means that at least one mite individual is present on the leaves of one plant species in the five replicates.

each condition.

Pollen was collected from *Pinus halepensis* P. Mill. on trees outside the INRA. It was sprayed in a possibly equal quantity over all leaves in the pots.

Nine days after beginning the experiment, 24 hours after inoculation with the mites, we counted all mites on the leaves. The experiment was supposed to last longer but the leaves wilted strongly after 9 days so we ended the experiment.

For final mite counting, we separated all leaves at the same time, 4 persons with 8 hands took the 8 leaves of each pot away synchronously and put them directly into small plastic bags prepared before and labelled. Then we counted the individuals of *A. californicus* on the different species of

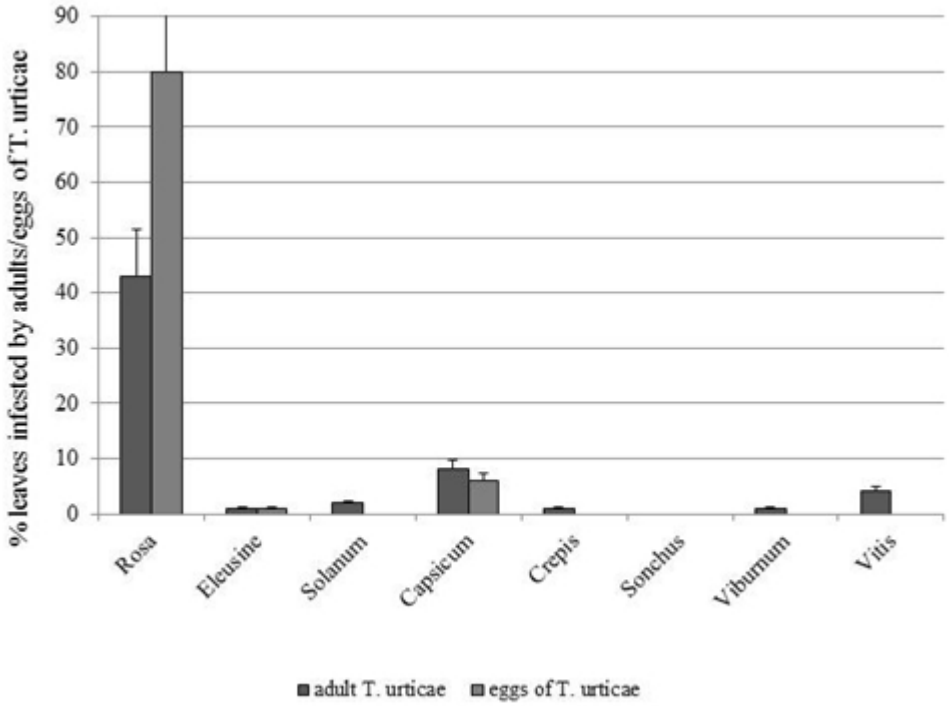

Figure 4:Presence of the pest mite *T. urticae* (adults and eggs) on detached leaves of the 8 plant speciesin percent – where 100 % means that at least one mite individual is present on the leaves of one plant species in the five replicates.

detached leaves and calculated % presence, where 100 % means that at least one mite individual was present on the leaf of one plant species.

RESULTS

The presence of the predators on the detached leaves differed between the chosen eight plant species, and differed between treatments with different food availability (Figure 3).

A. californicus was found only on *Rosa*, *Capsicum*, *Viburnum* and *Vitis*. We did not find any adult individuals in any treatment on *Eleusine*, *Solanum*, *Crepis* and *Sonchus*.

The plants with *T. urticae* as food resource showed a high presence of *A. californicus*: individuals of *A. californicus* were present on all leaves of *Rosa* (100%), and on 32% of the leaves of *Capsicum*, less on the leaves of *Vitis* and *Viburnum*.

When both *T. urticae* and pollen were available as food source, the distribution of *A. californicus* was different: fewer mites were found on *Rosa* and *Capsicum*, and many more on *Vitis* (58%) and *Viburnum* (29%).

When only pollen was the food resource, *A. californicus* was present only on the leaves of *Vitis* (58%) and *Viburnum* (29%), the species with domatia.

Eggs of *A. californicus* were not found at all due to the short duration of the experiment (24h).

The distribution of *T. urticae* shifted from an initial equal distribution on all leaf species at the moment of inoculation to a strong presence on *Rosa* and a lower presence on *Capsicum* and *Vitis* (Figure 4). Some individuals were found on *Solanum*, *Eleusine*, *Crepis* and *Viburnum*, none on *Sonchus*.

Eggs of the pest mite *T. urticae* were found on Rosa (80% of leaves showed presence of eggs), Capsicum (6%) and Eleusine (1,5%), none on the other plant species (Figure 4).

DISCUSSION

Food availability and presence of domatia both influenced the distribution of the predatory mite *A. californicus*. Four plant species were not colonized by *A. californicus* at all even when pollen and/or *T. urticae* were available as food. The four plant species mostly colonized by the predatory mites probably were colonized for two reasons by *A. californicus*: commercial roses *Rosa* and sweet pepper *Capsicum* because of the high amount of *T. urticae* present on them; *Viburnum* and *Vitis* because of the characteristics of the leaves, most probably the presence of domatia where a high number of predatory mites was found (Figure 2).

When no *T. urticae* were present, *A. californicus* chose the leaves of *Vitis riparia* and *Viburnum tinus*, both bearing domatia (Figure 3).This emphasizes the importance of domatia for these species, as documented in earlier studies (Walter and O'Dowd, 1992; Grostal and O'Dowd, 1994).

The high number of *A. californicus* present on *Viburnum* and *Vitis* when pollen was available points out the helping role of additional pollen which enhanced the presence of *A. californicus* on the plant species with domatia. This underlines earlier findings that pollen has an influence on the distribution of mites (Sabelis 1990, Venzon et al. 2002, Sarwar et al. 2011).

When *T. urticae* were present (Figure 4), most *A. californicus* were found close by on the same plant species indicating that the predators also choose a plant because most food is found there. As *T. urticae* prefer roses (Landeros et al. 2004, Poncet et al 2008), predators preferred roses in our experiment when pollen was not available.

In order to be efficient as banker plant for *A. californicus*, it is important that the predatory mites reproduce on them. The efficiency of banker plants should be related to the reproduction and not merely to the presence of the released predatory mites. Thus it is necessary to assess whether they lay their eggs on the leaves. This was not possible in our present experiment as time for their installation was too short. For longer experiments, a different set up is needed so that the leaves remain vital for longer periods than a few days after predator inoculation. The pest mites were able to reproduce because they had more than a week time on the leaves. Not so the predators. After only 24 hours the number of encountered eggs was zero.

Our study indicates that the distribution of predatory mites is related to the availability of pollen and of plant functional types such as acarodomatia (Walter and O'Dowd, 1992; Grostal and O'Dowd, 1994). We expect that in a long-term experiment, eggs of the predatory mites are found on the leaves and in the domatia of *Vitis* and *Viburnum*, especially if pollen is added as a food source. However, the right quantity of pollen has to be employed so that the predatory mites still feed on the target pest, *T. urticae*.

Conclusions

The results of our study point in the same direction as earlier studies did in that the employment of banker plants which bear domatia play an important role for the installation of predatory mites, and underline the helping role of additional pollen which enhanced the presence of *A. californicus* on the plant species with domatia. However, in the present study, we tested the hypotheses employing only few replicates and very short time. 24 hours is not long enough for a real installation including reproduction of the predators which gives evidence whether a plant is suited to act as banker plant for these organisms or not. We suggest to explore this field of knowledge in more detail in future studies by testing the outcomes with a higher number of replicates and with a longer duration.

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