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Responses to stimuli from *Schizotetranychus nanjingensis* on bamboo leaves by two predatory mite species (Acari: Tetranychidae, Phytoseiidae)

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Abstract

Arrestment responses to stimuli from *Schizotetranychus nanjingensis* on bamboo leaves by the predatory mites *Typhlodromus bambusae* and *Amblyseius cucumeris* were examined in the laboratory using two-choice tests. Both predator species responded to spider mite females and web-nests, but not to their feces. Furthermore, *T. bambusae* responded more strongly to intact web-nests than to empty web-nests, whereas *A. cucumeris* responded more strongly to empty web-nests.

Key words: Acari, predator-prey interaction, searching behaviour, stimuli, arrestment

Introduction

The spider mite *Schizotetranychus nanjingensis* Ma & Yuan is one of the serious pests of the moso bamboo (*Phyllostaychs pubescens*), which is a major forestry crop in southern China (Cui 1989; Yu & Shi 1991; Zhang *et al.* 1998a, b). This species has a specialized life type that is similar to *S. longus* Saito, a closely related species inhabiting dwarf bamboo plants in Japan (Saito & Ueno 1979). Females of *S. nanjingensis* construct web-nests with a very dense webbing roof on the underside of bamboo leaves. The web-nest may function as a shelter in which all spider mites live and feed on leaf tissue (Zhang *et al.* 1999a). The intact webbing of *S. nanjingensis* is also effective in preventing the invasion by non-specialist predators such as *A. longispinosus* (Zhang *et al.* 1999c) and *A. cucumeris* (Zhang *et al.* 2000b), although it could not prevent the attacks of the specialized predator of *S. nanjingensis*, *T. bambusae* Ehara, which is adapted to the web-nests of *S nanjingensis* (Y.-X. Zhang, unpublished data).

Although *T. bambusae* is the dominant predator of *S. nanjingensis* in bamboo forests in Fujian and is capable of responding to densities of S. *nanjingensis* in laboratory functional response experiments, *S. nanjingensis* has reached pest status in most bamboo forests in Fujian, presumably because of the low density of *T. bambusae* in disturbed monoculture forests (Zhang *et al.* 1999b; Zhang 2000c; Zhang *et al.* 2001). One approach for the biological control of this pest mite is to use the augmentative releases of predatory mites (e.g. *A. longispinosus* and *A. cucumeris*) that are relatively easy to produce on a large scale (Zhang *et al.* 2001).

A series of studies on the potential of these predators as biocontrol agents of *S. nanjingensis* has been conducted. Studies on the predation of *A. longispinosus*, *A. cucumeris* and *T. bambusae* on *S. nanjingensis* were published elsewhere (Zhang *et al.* 1999b,c; Zhang *et al.* 2000b). Zhang *et al.* (2000b) observed that *A. cucumeris* can invade web-nests of *S. nanjingensis* that have openings and

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prefers to lay its eggs inside these nests. Zhang *et al.* (2000a) examined the arrestment response of *A. longispinosus* to stimuli from *S. nanjingensis* on bamboo leaves and showed that this predator can respond to stimuli from web-nests of *S. nanjingensis*. In this paper, we compare the responses of *T. bambusae* and another predator (*Amblyseius cucumeris* Oudemans) to stumuli from *S. nanjingensis* on bamboo leaves to evaluate the searching ability of these mite predator species.

Materials and methods

Bamboo leaves and mites

Bamboo leaves of different ages without *S. nanjingensis* web-nests and *T. bambusae* were collected from bamboo forests in Nanping City, Fujian, China. Leaves were brought back to the laboratory in plastic bags and used in the experiments.

Schizotetranychus nanjingensis and *T. bambusae* used in this experiment originated from the same forests where bamboo leaves were collected and were reared in the laboratory for experiments.

The predatory mite *A. cucumeris* was introduced from Biological Crop Protection Limited in England and reared in the laboratory.

Experimental design

The experimental set-up, procedure and data analysis were described in detail in Zhang *et al.* (2000a). All experiments were carried out at 25°C. A piece of water-soaked foam plastic (10cm in diameter and 1cm thick) was placed in a petri dish (12cm in diameter) and a sheet of filter paper was placed onto the foam plastic. Pairs of detached leaves of moso bamboo were placed on the substrate and subjected to the following four different treatments. In treatment A, one leaf contained a web-nest with all the stages of *S. nanjingensis* and the other leaf was a control without any mites, nor mite damage. In treatment B, the treated leaf contained an empty web-nest of *S. nanjingensis*, whereas the other leaf was an untreated control. In treatment C, feces of *S. nanjingensis* were placed on one leaf and the other leaf was an untreated control. In treatment D, 5 females of *S. nanjingensis* were introduced on one leaf, whereas the other leaf was an untreated control.

During each behavioural test, a female of *T. bambusae* or *A. cucumeris* was released onto the bottom of the T-shaped bridge using a fine brush and allowed to select between the two leaves freely. The location of each predator female was then checked at 1-hour intervals for 5 hours. The behaviour of the predator was also observed from time to time. There were at least 30 replicates for each treatment.

Results

Responses of T. bambusae

In treatment A, one hour after the start of the experiment, 53.3% of predators were found on the leaves with the web-nests of *S. nanjingensis*, whereas 43.3% were on the other leaves (Fig 1). The proportion of predators on leaves with web-nests increased to 60% at the end of 2-3 hours and to >80% at the end of 4-5 hours. The difference in the proportion of predators between the two leaves at the end of 4-5 hours was highly significant (*t-test*, $P<0.001$).

In treatment B, the response of predators to treatment became significant after three hours, when 63.0% of the predators were found on the leaves with an empty web-nest, whereas 26.6% were on the clean, control leaves (Fig. 2; $P<0.001$). The observation showed that *T. bambusae* females

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selectively stayed on leaves with web-nests and they often stayed inside the empty nests. On the contrary, they frequently moved about on clean leaves and often escaped (Fig. 2).

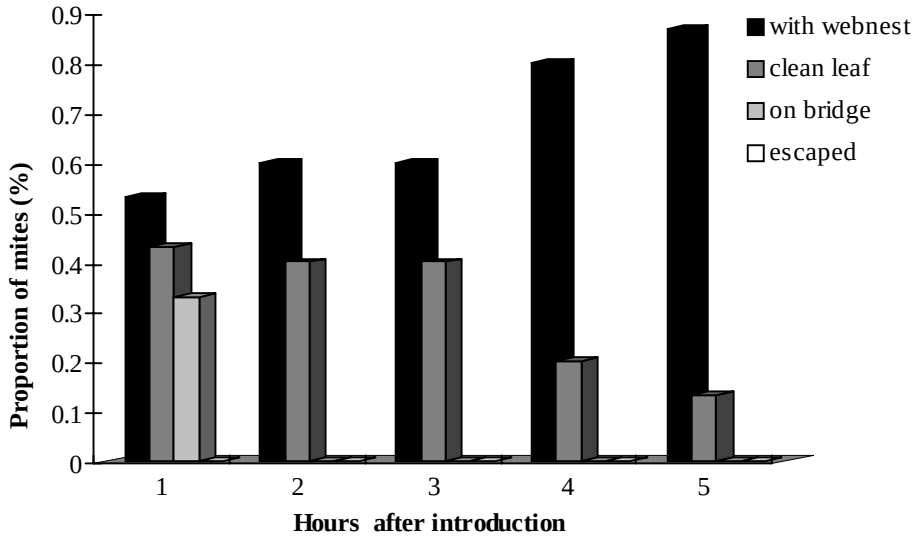


FIGURE 1. Proportions of *T. bambusae* adult females on bamboo leaves with intact web-nest of *S. nanjingensis* and on clean leaves (at 25°C).

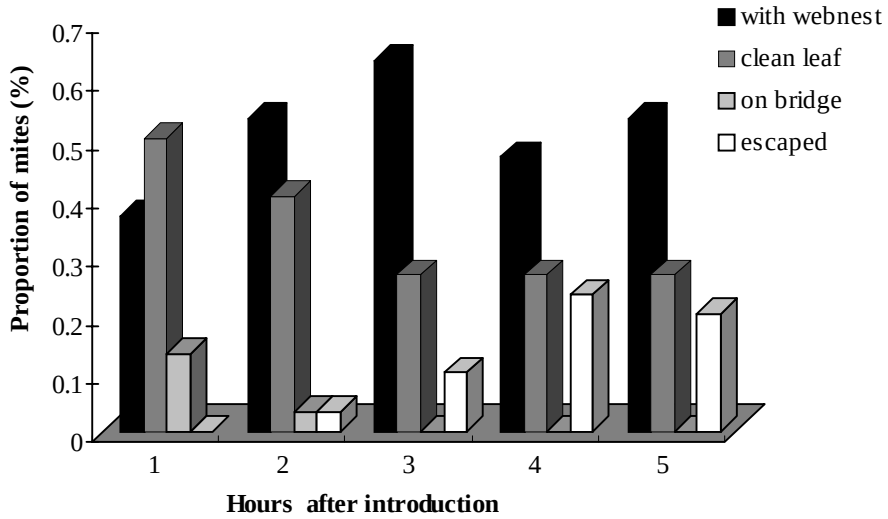


FIGURE 2. Proportions of *T. bambusae* adult females on bamboo leaves with empty web-nest of *S. nanjingensis* and on clean leaves (at 25°C).

In treatment C, the proportion of predator females on leaves with *S. nanjingensis* feces was not significantly different from that on clean leaves and some of the mites frequently moved about and often escaped (Fig. 3).

In treatment D, the proportion of predator females on leaves with spider mite adults was over 60% at the end of the first and second hour but was half as much on control leaves (Fig. 4; *t-test*, $p<0.001$). The difference between the two became less significant at the end of the 3rd hour and non-

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significant at the end of 4-5 hours, because the spider mites on treated leaves had been consumed by *T. bambusae*.

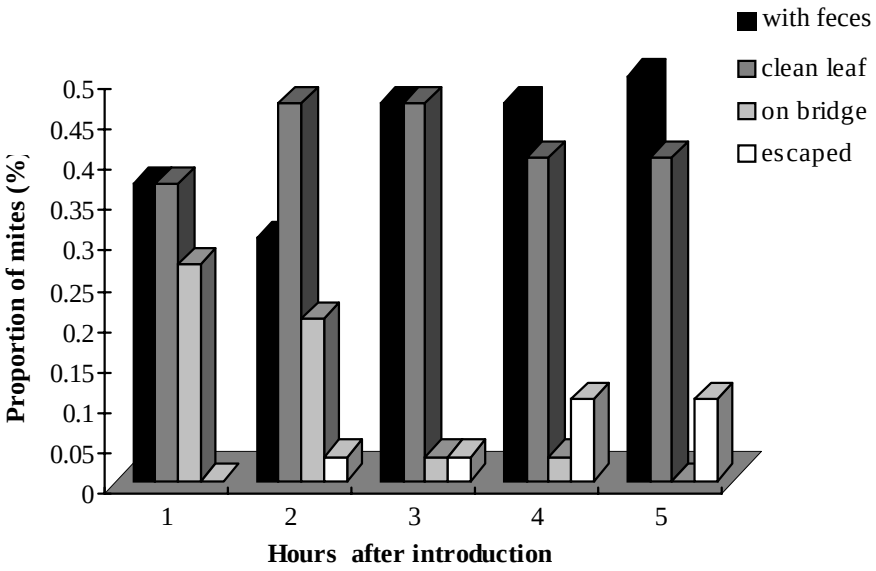


FIGURE 3. Proportions of *T. bambusae* adult females on bamboo leaves with feces of *S. nanjingensis* and on clean leaves (at 25°C)

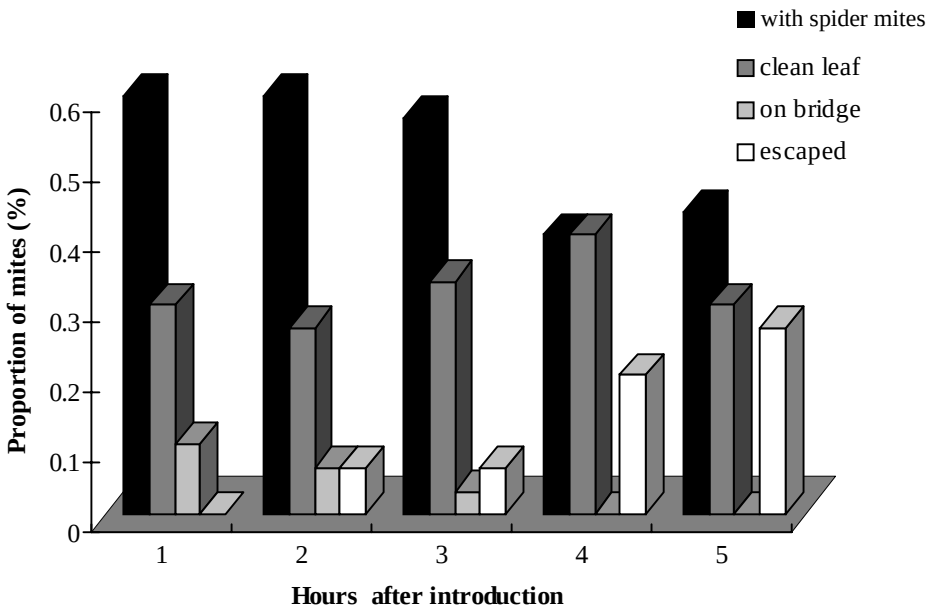


FIGURE 4. Proportions of *T. bambusae* adult females on bamboo leaves with females of *S. nanjingensis* and on clean leaves (at 25°C).

Response of A. cucumeris

In treatment A, one hour after predator introduction, 70% of the predators were found on the leaves with a web-nest of *S. nanjingensis*, whereas only 20% were on the control leaves; the rest of

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the predators (10%) were on the bridge and no mites escaped from the system (Fig. 5). During the next 4 hours, 16-26% of the mites escaped, but the preference of predator females for leaves with web-nests over those without web-nests was still significant (P<0.001), although its strength was not as great as during the first hour (Fig. 5).

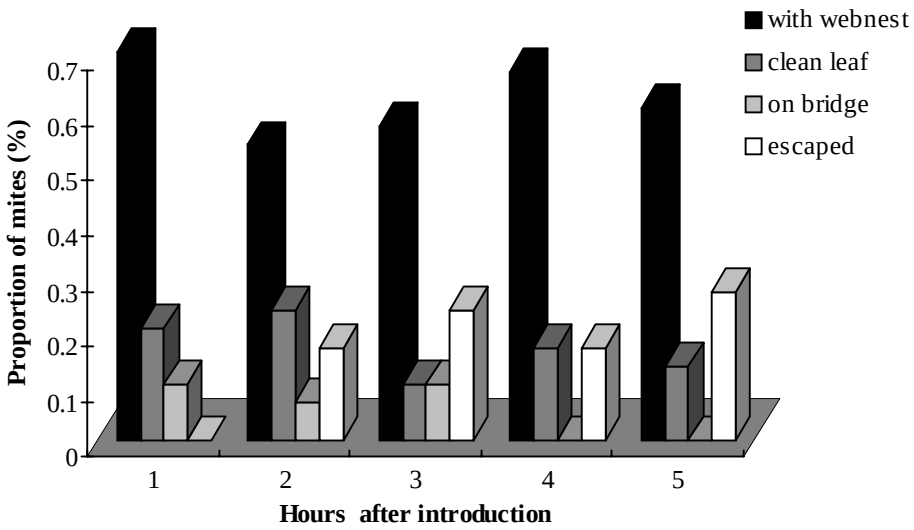


FIGURE 5. Proportions of *A. cucumeris* adult females on bamboo leaves with intact web-nest of *S. nanjingensis* and on clean leaves (at 25°C).

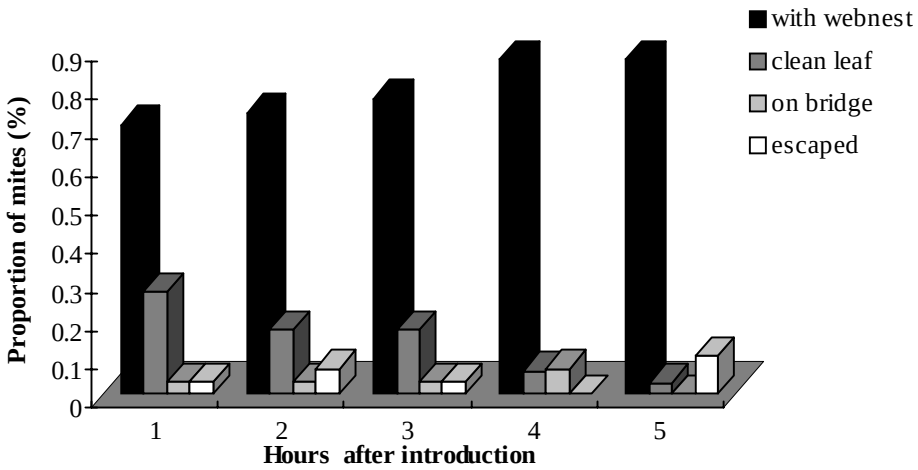


FIGURE 6. Proportions of *A. cucumeris* adult females on bamboo leaves with empty web-nests of *S. nanjingensis* and on clean leaves (at 25°C).

In treatment B, the preference of predator females for leaves with empty web-nests was consistently significant for the five hours (*t-test*, P<0.001) (Fig. 6).

In treatment C, predators showed no apparent preference for leaves with feces of *S. nanjingensis* (Fig. 7). They frequently moved off the leaves and often escaped from the system.

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In treatment D, the proportion of predators on the leaves with 5 females of *S. nanjingensis* increased from 50% at the end of the first hour to 70% at the end of the fifth hour, whereas the proportion of predators on the control leaves fluctuated around a quarter. As a result, the preference of predator females for leaves with live mites of *S. nanjingensis* over those of the control ones was very significant (*t-test*, $P<0.001$) (Fig. 8).

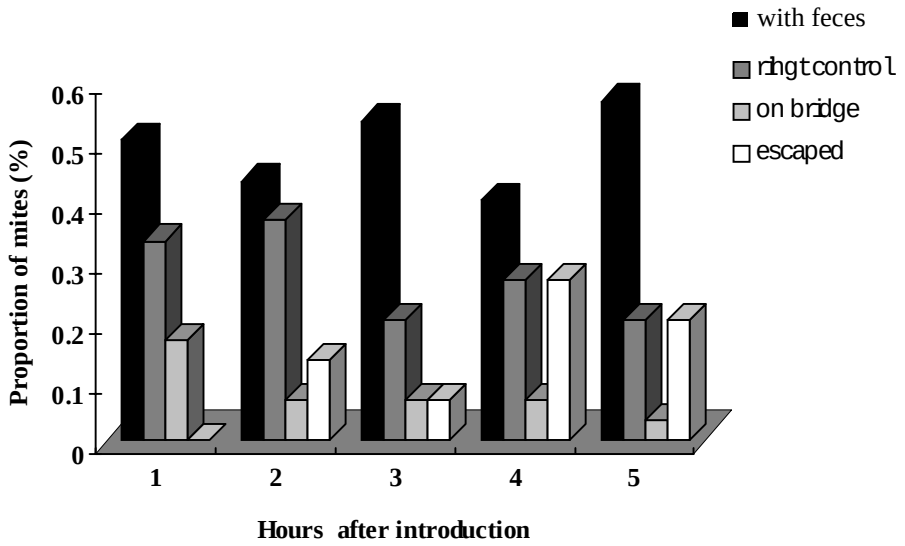


FIGURE 7. Proportions of *A. cucumeris* adult females on bamboo leaves with feces of *S. nanjingensis* and on clean leaves (at 25°C).

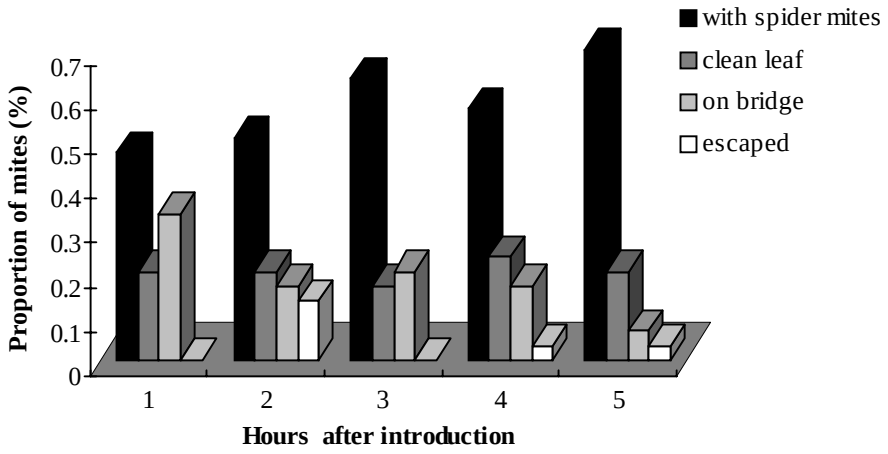


FIGURE 8. Proportions of *A. cucumeris* adult females on bamboo leaves with females of *S. nanjingensis* and on clean leaves (at 25°C).

Discussion

Arrestment responses to tactile stimuli from webbing and other products of spider mites have been shown in several species of Phytoseiidae (e.g. Schmidt 1976; Hislop & Prokopy,1981; Hoy &

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Smilanick 1981; Rasmy *et al.* 1991). In a previous paper, we showed that females of *A. longispinosus* preferred bamboo leaves with empty web-nests of *S. nanjingensis* (Zhang *et al.* 2000a). This study shows that *T. bambusae* and *A. cucumeris* also have similar preferences (Figs. 2 and 6). Furthermore, we showed in this study that feces alone did not arrest the movement of *T. bambusae* and *A. cucumeris* (Figs. 3 and 7), and that spider mite females themselves also arrested these two predators (Figs. 4 and 8), as did intact web-nests containing spider mites (Figs. 1 and 5). This indicates that these two predators responded to stimuli associated with webbing and the body of *S. nanjingenses*, but not their feces. The chemical nature of these stimuli should be interesting topics for future studies.

Although *T. bambusae* and *A. cucumeris* both responded to spider mites and their web-nests, they differed in the way they responded. *T. bambusae*, a specialist predator of *S. nanjingensis*, responded more strongly to intact web-nests than to empty nests and their response to intact nests became stronger with time, but their response to spider mites themselves decreased with time. In contrast *A. cucumeris*, a more generalist feeder, responded more strongly to empty web-nests and their response to intact nests become less strong with time, but their responses to spider mites increased with time.

In an integrated control programme, we released *A. cucumeris* into moso bamboo forests in early May-June for the control of *S. bambusae, Aponychus corpuzae* and *Aculus bambusae*, and also used it to disrupt the migration of *S. nanjingensis* from the ground to new leaves, especially in one year shoots. The results from this study are encouraging in that *A. cucumeris*, although it has no natural association with *S. nanjingensis*, can respond to stimuli from female spider mites and also their web-nests. Coupled with the results of a previous study on the predation of *A. cucumeris* on *S. nanjingensis*, *A. cucumeris* shows promising potential as a biocontrol agent for *S. nanjingensis*.

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