Research Article

Neoseiulus californicus preying on *Tenuipalpus heveae*[1]

Eliamara Marques da Silva[2], Luciana Cláudia Toscano[3],
Milene Alves-Eigenheer[4], Wilson Itamar Maruyama[3], Abimael Gomes da Silva[5]

ABSTRACT

The spread of *Tenuipalpus heveae* Baker (Acari: Tenuipalpidae) can be controlled by managing predatory species such as *Neoseiulus californicus* (McGregor) (Acari: Phytoseiidae). This study aimed to evaluate the predation of *N. californicus* at different biological phases on *T. heveae* at different development stages. The experiments were carried out under laboratory-controlled conditions, counting the number of predated individuals by development stage after 24, 48 and 72 h. *N. californicus*, in all phases, consumed *T. heveae*, with a higher consumption of nymphs and larvae by adult predators. Both sexes of adult predators exhibited predation efficiency, but females showed a greater acceptance of adult preys than males. The daily rate of adult predation decreased over time; however, the highest consumption took place in the first 24 h.

KEYWORDS: *Phytoseiidae*, biological control, predatory mite.

RESUMO

Neoseiulus californicus predando *Tenuipalpus heveae*

A propagação de *Tenuipalpus heveae* Baker (Acari: Tenuipalpidae) pode ser controlada utilizando-se o manejo de espécies predadoras como *Neoseiulus californicus* (McGregor) (Acari: Phytoseiidae). Objetivou-se avaliar a predação de *N. californicus* em diferentes fases biológicas sobre *T. heveae* em diferentes estágios de desenvolvimento. Os experimentos foram conduzidos em condições laboratoriais controladas, contando-se o número de indivíduos predados por fase de desenvolvimento após 24, 48 e 72 h. *N. californicus*, em todas as fases, consumiu *T. heveae*, com maior consumo de ninfas e larvas por predadores adultos. Ambos os sexos de predadores adultos demonstraram eficiência de predação; porém, as fêmeas apresentaram maior aceitação a presas adultas do que machos. A taxa diária de predação de adultos foi reduzida ao longo do tempo; contudo, o maior consumo ocorreu nas primeiras 24 h.

PALAVRAS-CHAVE: *Phytoseiidae*, controle biológico, ácaro predador.

INTRODUCTION

Phytophagous mites are an economic problem due to their effect on crops (Vacante 2010, Navia et al. 2013, Kumari & Srinivas 2018). The rubber-tree red flat mite *Tenuipalpus heveae* Baker (Acari: Tenuipalpidae) is the most important phytophagous mite in southeastern Brazil (Vieira et al. 2010, Martins et al. 2012), Mato Grosso (Ferla & Moraes 2008) and Mato Grosso do Sul (Rocha et al. 2019) states, directly affecting the rubber tree yield. Its occurrence at a density level that causes defoliation in plants is seasonal, with the highest population peaks observed in the first half of the year, in Brazil, usually after periods of low rainfall and decreasing temperatures (Martins et al. 2010). These species develop preferentially along the ribs on the abaxial face of the leaves, causing symptoms such as bronzing and early drop (Pontier et al. 2001, Martins et al. 2010).

The tactic most widely used to control phytophagous mites on rubber trees is the application of synthetic acaricides (Van Leeuwen et al. 2015), which can cause environmental problems such as soil and water contamination and reduction in the amount of natural enemies (Castiglioni et al. 2002,

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[2] Universidade Estadual Paulista, Faculdade de Ciências Agrárias e Veterinárias, Jaboticabal, SP, Brasil.
E-mail/ORCID: eliamaramarques@outlook.com/0000-0002-4152-2046.
[3] Universidade Estadual de Mato Grosso do Sul, Unidade Universitária de Cassilândia, Cassilândia, MS, Brasil.
E-mail/ORCID: toscano@uems.br/0000-0001-9634-8535, wilsonmaruyama@uems.br/0000-0003-4208-1841.
[4] Universidade Estadual Paulista, Instituto de Biociências, Rio Claro, SP, Brasil.
E-mail/ORCID: mileneaae@gmail.com/0000-0002-6287-290X.
[5] Universidade Estadual Paulista, Faculdade de Engenharia, Ilha Solteira, SP, Brasil.
E-mail/ORCID: ag.silva@unesp.br/0000-0001-7146-9226.

Castelo-Grande et al. 2010, Montagner et al. 2014). Thus, alternative strategies are recommended, with emphasis on biological control using predatory mites.

The most common predatory mites naturally found in 61 Brazilian rubber plantations belong to the 60 Phytoseiidae and Stigmaeidae families (Feres et al. 2002, Bellini et al. 2005, Ferla & Moraes 2008, Castro 2016). The main species used as biological agents are *Phytoseiulus macropilis* (Banks) and *Neoseiulus californicus* (McGregor), which have been successfully used in strawberry, tomato and ornamental crops, among others (Ferla et al. 2007, Bellini 2008, Sato 2009). The presence of *N. californicus* was reported in *Syagrus oleracea* (Mart.) Becc, when intercropped with rubber tree (Bellini et al. 2005).

The predatory mite *N. californicus* varies from straw to dark yellow color and feeds preferentially on *Tetranychus urticae* Koch (Tetranychidae), with a higher consumption by adult females. However, in the absence of this prey, they can consume other species of mites and thrips, what allows them to remain on plantations for prolonged periods (McMurtry et al. 2013). Except for the potential of *N. californicus* in the management of phytophagous mites, no information is available regarding its effect on *T. heveae*. As such, this study aimed to evaluate the predation of *N. californicus* at different biological phases on *T. heveae* at different development stages.

MATERIAL AND METHODS

The experiments were carried out at the Universidade Estadual de Mato Grosso do Sul, in Cassilândia, Mato Grosso do Sul state, Brazil, from May to July 2016, in a room under controlled conditions (temperature = 25 ± 2 ºC; relative humidity = 70 ± 10 %; photophase = 14 h).

The experimental design was randomized, in a 4 x 4 factorial arrangement, totaling 16 treatments, with 12 replications, comprising the groups predatory (larva, nymph, adult male and adult female) and phytophagous (eggs, larvae, nymphs and adults) mites.

The predatory mites were obtained from a colony provided by the Instituto Biológico do Estado de São Paulo (Campinas, São Paulo state, Brazil). The breeding stock was placed in Petri dishes (14-cm diameter), each containing a piece of polyethylene foam moistened with distilled water and a common jack bean leaf (*Canavalia ensiformes*) wrapped in hydrophilic cotton wool (Sato 2009). Cotton threads covered with a coverslip (20 x 20 mm), some empty and some with castor bean pollen (*Ricinus communis* L.), were placed on the bean leaf to shelter and feed the predatory mites. The individuals were not fed for 24 h before each experiment, preventing interference from previously supplied food. Pregnant adults were isolated in individual dishes for oviposition and subsequent larval eclosion and, only then, the larvae were collected. The other stages were transferred immediately after the stage change (Cardoso et al. 2010).

To gather the *T. heveae*, leaves of the rubber clone RRIM 600 were collected at the experimental field of the Universidade Estadual de Mato Grosso do Sul. In the laboratory, 5-cm leaf disks were obtained using a puncher and stylus, separating the mites into groups of 20 individuals, according to their development stage (egg, larva, nymph or adult). The disks were deposited in Petri dishes (9-cm diameter) containing a cotton layer moistened with distilled water.

In order to confirm both the predator and phytophagous mite development stages, nymphs and adults collected directly from the breeding dishes were analyzed in a stereomicroscope and mounted on slides. The larval stage was easily identifiable, since they have three pairs of legs, as opposed to nymphs and adults (4 pairs), and testing started after eclosion.

The evaluations were performed according to the development phase of the predatory mite, that is, after 24 h for larvae and nymphs, and after 24, 48 and 72 h for adult females and males. After this evaluation period, the natural mortality of the preys was verified. The numbers of predated and non-predated *T. heveae* were counted. The values of predated mites were compared at 1 % of significance by applying the Scott-Knott test.The period effect (h) was evaluated by regression analysis, adopting, as a criterion for model selection, the magnitude of the regression coefficients (R^2) at 5 % of significance. The data were submitted to analysis of variance using the Sisvar statistical software.

RESULTS AND DISCUSSION

The results confirm that the *N. californicus* mite consumes *T. heveae*. In all stages, the predator consumed *T. heveae* in a 24-h period (Table 1), except for the predator larvae x adult phytophagous mite

Table 1. Mean (± standard error) predation of *Tenuipalpus heveae* at different development stages predated by *Neoseiulus californicus* at different stages during a 24-h period.

Tenuipalpus heveae	*Neoseiulus californicus* development stages			
	Larvae	Nymphs	Females	Males
Egg	0.08 ± 0.08 bB[(1)]	1.08 ± 0.22 cA	1.58 ± 0.23 cA	1.75 ± 0.22 dA
Larva	1.41 ± 0.26 aB	10.25 ± 0.45 aA	9.91 ± 0.61 aA	10.25 ± 0.35 aA
Nymph	0.83 ± 0.02 aB	8.00 ± 0.30 bA	9.50 ± 0.65 aA	8.58 ± 0.70 bA
Adult	0.00 ± 0.00 bC	1.25 ± 0.21 cB	4.83 ± 0.47 bA	3.83 ± 0.32 cA
F (predator x prey)		22.15**		
CV (%)		12.12**		

(1) Means followed by the same lowercase letter in the column and uppercase letter in the row do not differ at 1 % of significance by the Scott-Knott test, converted to $(x + 0.5)^{1/2}$ for data analysis.

interaction, probably due to the difference in size and difficulty in handling (Franco et al. 2007), although the predator larvae are considered facultative feeders (Schausberger & Croft 1999). The predator nymphs also exhibited a greater preference for larva and nymph preys (Argolo et al. 2020). Eggs and adults were poorly accepted by the predator nymphs, corroborating Cardoso et al. (2010), for *Euseius citrofolius* Denmark & Muma (Acari: Phytoseiidae). The phytophagous mite egg was the least predated development phase, consumed most by male adults and least by larvae. These results may be related to the difficulty in breaking the egg chorion (Franco et al. 2007).

Adult predators of both sexes were efficient in consuming *T. heveae* in a 24-h period (Table 1). Male predators displayed a mean predation capacity of 10.25 for larvae, 8.58 for nymphs and 3.83 for adult preys, while the females exhibited 9.91 for larvae, 9.5 for nymph and 4.83 for adult preys, showing a greater acceptance than that found by Cardoso et al. (2010), when evaluating *T. heveae* and *E. citrofolius*. Adult females of Phytoseiidae show a high potential predation, due to their agile locomotion and larger size, in addition to greater nutritional requirements and energy expenditure during the oviposition period (Shipp & Whitfield 1991, Franco et al. 2007).

In general, the mobile immature stages of the phytophagous mite faced the highest predation by all the predator stages. The same preference for immature stages was observed by Marafeli (2011), for *N. californicus* feeding on *T. urticae*, but with even higher intake rates, likely because it has a preference for *T. urticae* (McMurtry et al. 2013). Concerning the sex of adult predators during the study period, males and females demonstrated acceptance to the *T. heveae* stages, except for the adult stage of preys, which was better accepted by females (Table 2), similarly to what was reported by Franco et al. (2007) and Cañarte et al. (2017).

The daily adult predator consumption of *T. heveae* decreased after each 24-hour period (Figure 1). The highest intake rate was in the first 24 h, with a higher predation of nymphs, larvae and eggs and a lower acceptance of adult preys. In the 48-h period, the rates were lower, but in the same order of preference for immature stages of the rubber tree red flat mite. After 72 h, the adult prey stage was still the least preferred by the predator. This decrease in the larval consumption over time can be attributed to the lower amount of food supplied. The rate of consumed adult *T. heveae* was similar in the 48-h and 72-h assessments, differently from the other stages, where the consumption decreased

Table 2. Mean (± standard error) predation ratio of *Tenuipalpus heveae* at different development stages by *Neoseiulus californicus* males and females over a 72-h period.

Neoseiulus californicus	*Tenuipalpus heveae*			
	Eggs	Larvae	Nymphs	Adults
Males	1.19 ± 0.31 aD[(1)]	5.75 ± 0.34 aA	4.50 ± 0.23 aB	2.63 ± 0.34 bC
Females	1.11 ± 0.26 aC	5.58 ± 0.23 aA	5.11 ± 0.29 aA	5.58 ± 0.24 aA
F (predator sex x prey phase)	3.7**			
CV (%)	14.0			

(1) Means followed by the same lowercase letter in the column and uppercase letter in the row do not differ at 1 % of significance by the Scott-Knott test, converted to $(x + 0.5)^{1/2}$ for data analysis.

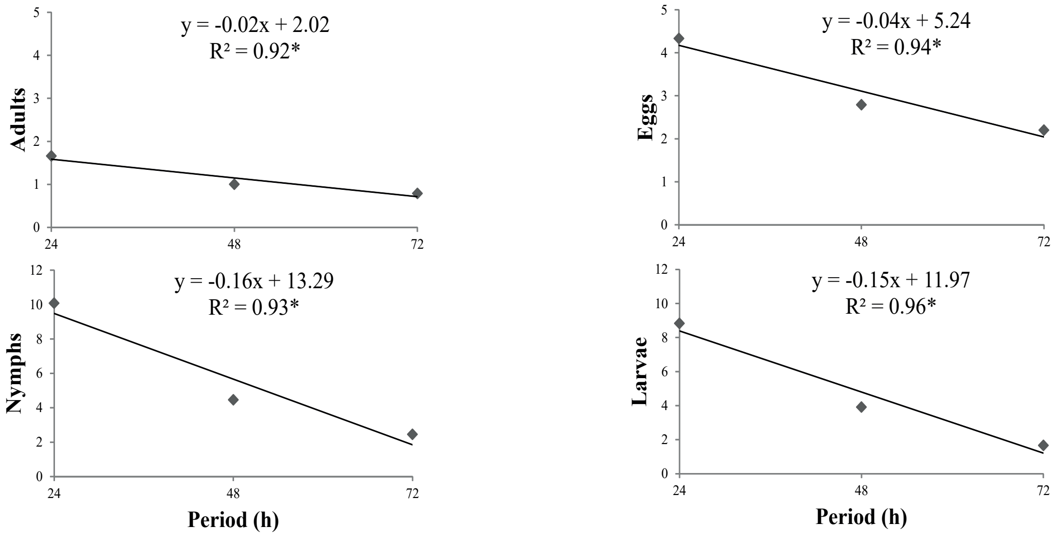

Figure 1. Predation of *Tenuipalpus heveae* at different development stages by adult *Neoseiulus californicus* over 24, 48 and 72 h.

according to the evaluated period. This decrease in the number of predated mites over time was also observed by Cardoso et al. (2010), whose results for the consumption behavior of *E. citrofolius* on *T. heveae* were similar to the findings of this study, and possibly associated with predator satiation.

The present study is a preliminary step to understand *T. heveae* as food for *N. californicus*. Thus, the predator biology and its release in the field have not been evaluated yet. It is believed that, if there is a high predator mortality associated with a reduced consumption in the period, it could be suggested that the prey would not be suitable for the predator. This predatory mite has been reported in crops intercropped with rubber tree (Bellini et al. 2005), being present in the same agrosystem. Thus, further studies must be carried out.

The results obtained in this study indicate the predation potential of *N. californicus* biological phases on *T. heveae* development stages. Understanding the relationship between predatory and phytophagous mites is essential for assessing the behavior of these organisms.

CONCLUSIONS

1. The biological phases of phytophagous mites interfere with the feeding behavior of predatory mites;
2. The food preference stages of the pest are variable among adult female and male predator mites;
3. The daily adult predator intake of *Tenuipalpus heveae* decreases after each 24-h period. Possibly, this food source is not suitable for the predator.

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