CONFRONTATION OF HUNTING SPIDERS (ARANEAE: ANYPHAENIDAE AND SALTICIDAE) WITH SPIDER MITES (ACARI: ERIOPHYIDAE E TENUIPALPIDAE) IN RUBBER TREE (*Hevea brasiliensis*)

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ABSTRACT

The mites *Tenuipalpus heveae* (Tenuipalpidae) and *Calacarus heveae* (Eriophyidae) are the main rubber tree pests in the State of São Paulo, Brazil. Spider interactions, such as direct predation, web immobilization, and dispersal with these mites have never been observed. Anyphaenidae and Salticidae have been reported as the most abundant spiders in rubber tree crops. To study the effects of these confrontations, six experimental treatments were conducted: *T. heveae* X Anyphaenidae, *T. heveae* X Salticidae, *C. heveae* X Anyphaenidae, *C. heveae* X Salticidae, control *T. heveae*, and control, *C. heveae*. The most affected mites were *C. heveae,* which were preyed and/or immobilized by Salticidae (21.5%), and *T. heveae,* which were dispersed from the feeding arena by Anyphaenidae and Salticidae (35% and 29.5%, respectively). The highest total mortality caused by the spiders was 42% for *T. heveae* and 36% for *C. heveae*, indicating that the tested spiders are potential agents to manage these phytophagous populations.

Key words: natural enemies, phytophagous mites, biological control, dispersal

CONFRONTO DE ARANAHAS CAÇADORAS (Araneae: Anyphaenidae and Salticidae) COM ACAROS (Acari: Eriophyidae e Tenuipalpidae) EM SERINGUEIRA (*Hevea brasiliensis*)

RESUMO

Os ácaros *Tenuipalpus heveae* (Tenuipalpidae) e *Calacarus heveae* (Eriophyidae) são as principais pragas de seringueira no Estado de São Paulo, Brasil. Interações de aranhas e ácaros, como predação direta, imobilização na teia e dispersão nunca foram observadas. Anyphaenidae e Salticidae foram relatadas como as aranhas mais abundantes em cultivos de seringueira. Para estudar os efeitos destes confrontos, seis tratamentos experimentais foram conduzidos: *T. heveae* X Anyphaenidae, *T. heveae* X Salticidae, *C. heveae* X Anyphaenidae, *C. heveae* X Salticidae e os tratamentos controle de *T. heveae* e *C. heveae*. Os ácaros mais afetados foram *C. heveae*, que foram predados e/ou imobilizados por Salticidae (21,5%), e *T. heveae*, que foram dispersos da arena de alimentação por Anyphaenidae e Salticidae (35 % e 29%, respectivamente). As maiores taxas de mortalidade total causadas pelas aranhas foram de 42% para *T. heveae* e 36% para *C. heveae*, indicando que as aranhas testadas são agentes potenciais na regulação das populações destes fitófagos.

Palavras-chave: inimigos naturais, ácaros fitófagos, controle biológico, dispersão.

INTRODUCTION

The rubber tree, *Hevea brasiliensis* Muell. Arg., a Brazilian native species, from which latex is extracted, is the main source of natural rubber produced in the world; the rubber is also an essential raw material for industries in general. There are approximately 200 thousand hectares of rubber tree plantations in Brazil (Tanzini, 1998). In the State of São Paulo, the approximately 60 thousand hectares have an average productivity of 1,300 kg/ha of rubber per year and in the São José do Rio Preto region the crop occupies nearly 8,300 hectares (IAC, 2006).

The false spider mite *Tenuipalpus heveae* Baker, 1945 (Tenuipalpidae) and the eriophyiid *Calacarus heveae* Feres, 1992 are important pests in rubber tree plantations (Benesi, 1999), being *C. heveae* responsible for about 75% of the senescence and abnormal fall of rubber tree leaves (Vieira & Gomes, 1999); and according to Feres (2000), some farmers estimate up to 30% decrease in latex production due to *C. heveae* attack.

For the control of *C. heveae* and *T. heveae*, the use of chemical pesticides has often resulted in serious resistance problems, as well as in workers and environmental contamination, and the pathogenic fungi used used only on *C. heveae* control are less efficient in drier months (Tanzini, 1998, 2002). Therefore, research on alternative control methods involving natural enemies is highly important (Costa et al,. 2003).

Spiders can control arthropod populations directly by predation or indirectly, by superfluous killing (Riechert, 1999; Rinaldi, 1995; Maloney et al., 2003; Sunderland, 1999). Spiders can also scare arthropods away from their host plant (Mansour et al., 1981; Mansour & Whitcomb, 1986; Losey & Denno, 1998), or cause arthropod imprisonment in their silk threads (Nentwig, 1987; Nyffeler et al.,1994; Alderweireldt, 1994; Sunderland, 1999). They are naturally present in agricultural systems, where they can be surprisingly diverse (Young & Edwards, 1990; Rinaldi, 1995; Rinaldi & Forti, 1997; Maloney et al., 2003).

In *H. brasiliensis* plantations, The communities of mites in rubber tree plantations of the north-western region of São Paulo State were registered by Feres et al. (2002), together with the survey on spider fauna conducted by Rinaldi & Ruiz (2002). According to both studies, *T. heveae* and *C. heveae* were the most abundant mites and Anyphaenidae and Salticidae the most abundant hunting spiders.

The objectives of this study were to observe, record, and compare the lab confrontations between the most abundant predators (hunting spiders) and their preys (phytophagous mites), as well as to demonstrate their effects and potential as agents of biological control against mite pests in rubber trees.

MATERIAL AND METHODS

1. Areas of study and the target arthropods

All the arthropods were collected in commercial rubber tree plantations at the Felicidade and the Genética Triálogo farms

(20°46'S, 49°15'W) in São José do Rio Preto, São Paulo State, in March and April 2004.

T. heveae and *C. heveae* were collected from leaves of *H. brasiliensis*. Spiders were collected according to the entomological beat sheet method. The most abundant hunting spiders coexisting in the fields with the target spider mites were tested: the foliage runners (Anyphaenidae) and the stalkers (Salticidae). Although the mites occur in plantations throughout the year, a higher frequency was observed from March through May (Feres et al., 2002). Guilds were adopted as in Uetz et al. [1999] and Höefer & Brescovit [2001]. Spider sizes were standardized.

2. Experimental design

The rubber tree leaves used as substrates in experiments with *T. heveae* were washed to remove all residues and arthropods; in experiments with *C. heveae*, outnumbered mites and other arthropods were removed from the leaves by hand, to prevent damage. The mites were collected on the same day of the experiments, as opposed to the spiders, which were kept in laboratory before the tests started.

During the experiments, mites were kept in separated arenas prepared with 4x4cm tetragonal sections of rubber tree folioles, placed in plastic Petri dishes (8.5cm diameter and 1.3cm high), with bottom lined with hydrophilous cotton moistened with distilled water. Petri dish lids had a 2.5 cm diameter central orifice covered by an ethamine-like fabric, to prevent spiders from escaping and for aeration. This system was kept in a rearing chamber at 28°C temperature, 90% relative air humidity, and 12 h photoperiod.

Nymphs of stalkers (Salticidae) and foliage running spiders (Anyphaenidae) were reared until they reached the maturity required for species identification. During rearing, spiders were fed twice a week with adults of *Drosophila* sp. (Diptera: Drosophilidae) and submitted to a five-day fast before the beginning of the experiment, a time-period considered the shortest possible by Jackson et al. (1998) and Gravena (2001).

Six treatments with ten replications each were designed, four with spiders and two were control treatments: a) *T. heveae* X Anyphaenidae, b) *T. heveae* X Salticidae, c) *C. heveae* X Anyphaenidae, d) *C. heveae* X Salticidae, e) Control *T. heveae,* and f) Control *C. heveae.* In these confrontation experiments, the spiders were placed in prey arenas at the ratio of one predator for every 20 mites that were daily observed, for seven consecutive days. The observations consisted of spider role in reducing prey population, where the following variables were qualified: predation, web immobilization - also referred by Sunderland (1999) as "prey mortality in the web, not caused by spider predation", dispersion and accidental mortality of phytophagous mites (dead preys independently of predators action). The preying diagnosis was at first a result of the deformed appearance of the preys, being later supported by the signs of exoskeleton perforation seen through a magnifying glass. Immobilization referred to the mites held in the spider silk and dispersion to the mites that migrated to the cotton surrounding the arena.

3. Data Analysis

The resulting mite dispersion in the presence of spiders was obtained by the subtraction of the arithmetic mean from the total absent mites in each treatment with spiders, minus the mean of absent mites in the corresponding control treatments. The arithmetic mean of mite predation/immobilization in each treatment indicated the percentage of preyed and immobilized mites in relation to the total.

The Student T-Test of independence was used to compare spider and mite treatments and their respective controls. To determine the occurrence of significant differences between the treatments with spiders and mites, we used one-criterion ANOVA followed by the Tukey Test (p 0.05). The D'Agostino Test for $n \geq 10$ and K samples was applied to find out whether the data were parametric.

RESULTS

1. Tests with Anyphaenidae and *T. heveae*

The spiders used in the experiments were: *Xiruana* sp. (three replicates), *Teudis comstocki* Soares & Camargo, 1948 (six replicates), and one non-identified nymph because it did not reach the adult stage.

As compared with the control, the presence of Anyphaenidae in mite arenas caused a 35% dispersion of individuals, with a mean of 7 dispersed mites per arena (Table 1, Figure 1). Because they were independent samples with normal distributions (Anyphaenidae X *T. heveae*: D = 0.2734 and p 0.05; control *T. heveae*: D = 0.2699 and p 0.05), the Student T-Test was used to compare the treatments. The t value was highly significant (t =10,3712; p = 0.000000).

The preying rate was extremely low (only two specimens of *T. heveae*), and therefore, although discriminated, it was computed with immobilization. A mean of 1.4 preyed and immobilized mite per arena, with 7% of the total mites being preyed and immobilized. Similarly to dispersion, these data also had normal distribution (D = 0.2556 and p 0.05) (Table 1, Figure 1).

When the effects of dispersal (35%) and predation/immobilization (7%) are added, we found the 42% impact of Anyphaenidae on the total mortality of *T. heveae.*

2. Tests with Salticidae and *T. heveae*

The spiders used in the experiments were: *Chira distincta* Bauab, 1983 (three replicates), *Chira simoni* Galiano, 1961 (three replicates), *Phiale tristis* Mello-Leitão, 1945 (three replicates), and *Thiodina* sp. (one replicate).

Compared with the control of *T. heveae*, these spiders led to 29.5% dispersion and a mean of 5.9 dispersed mites per arena (Table 1, Figure 1). Being independent samples with normal distribution (Salticidae X *T. heveae*: D = 0.2794 and p 0.05; control *T. heveae*: D = 0.2699 and p 0.05), the Student T-Test was used to compare the treatments. The t value was highly significant (t = 6.222989; p = 0.000007).

As in the previous treatment, the preying rate was extremely low (only one specimen of *T. heveae*) and therefore, although discriminated, predation was computed with immobilization. There was a mean of 1.4 preyed and immobilized mite per arena, with 7% of the total mites preyed/immobilized (Table 1, Figure 1). Similarly to dispersion, these data also had normal distribution (D = 0.2784 and p 0.05).

The addition of dispersion (29.5%) and predation (7%) effects show the 36.5% impact of Salticidae on the total mortality of *T. heveae*.

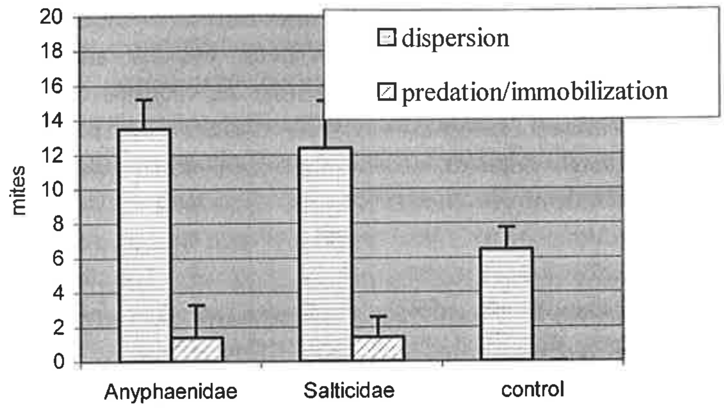

Figure 1. Dispersion, predation and immobilization of the mite, *Tenuipalpus heveae* in treatments with the spiders, Anyphaenidae and Salticidae, and no spiders (control).

Table 1. Treatments with the mite, *Tenuipalpus heveae* and the spiders, Anyphaenidae and Salticidae: **e**-development stage, **p/i**- predated or immobilized; **d**-dispersed; **m**-accidental mortality, **n**-nymph; **am**-adult male, and **af**- adult female:

Anyphaenidae	e	p/i	d	m
1	n	0	15	1
2	n	1	13	6
3	n	0	10	2
4	n	0	12	4
5	n	0	15	3
6	n	0	16	1
7	n	4*	14	1
8	n	1	13	2
9	n	5*	14	0
10	n	3*	13	1
	-	14	135	21
Mean	-	1,4	7(13.5-6.5)	2.1
%	-	7%	35%	10,50%

Salticidae	e	p/i	d	m
1	am	3*	8	4
2	n	1*	16	3
3	af	3*	15	2
4	n	1	11	5
5	n	0	12	6
6	n	2*	10	3
7	n	2*	11	3
8	af	2*	14	1
9	n	0	16	2
10	n	0	11	1
	-	14	124	30
Mean	-	1,4	5.9(12.4-6.5)	3
%	-	7%	29.50%	15%

Control	p/i	d	m
1	x	8	1
2	x	7	4
3	x	7	4
4	x	7	4
5	x	8	5
6	x	4	3
7	x	6	3
8	x	6	4
9	x	7	4
10	x	5	3
	x	65	35
Mean	x	6,5	3,5
%	x	32,50%	17,50%

*Immobilized mites

3. Tests with Anyphaenidae and *C. heveae*.

The spiders used in the experiments were: *Xiruana* sp. (six replicates) and *T. comstocki* (four replicates).

Compared with the control of *C. heveae*, these spiders caused 15.5% dispersion and a mean of 3.1 dispersed mites per arena (Table 2, Figure 2). For these independent samples with normal distribution (Anyphaenidae X *C. heveae*: D = 0.2817 and p 0.05; control *C. heveae*: D = 0.2789 and p 0.05), the Student T-Test was used to compare treatments. The t value was significant (t = 2.993776; p = 0.007790).

There was a mean of 2.5 preyed or immobilized mites per arena, with 14.5% of all mites preyed and immobilized mites (Table 2, Figure 2). Similarly to dispersion, these data had normal distribution (D = 0.2693 and p 0.05).

Theses spiders did not prey mites. By adding dispersion (15.5%) and immobilization (14.5%) effects, we have the 30% impact of Anyphaenidae on the total mortality of *C. heveae*.

4. Tests with Salticidae and *C. heveae*

The spiders used in the experiments were: *Thiodina* sp. (one replication), *C. simoni* (five replicates); *C. distincta* (two replicates), *P. tristis* (one replicate) and a non-identified nymph that did not reach the adult stage.

These spiders led to a 14.5% dispersion as compared with the control, and a mean of 2.9 mites dispersed per dish (Table 2, Figure 2). The samples were independent with normal distributions (Salticidae X *C. heveae*: D = 0.2844 and p 0.05; control *C. heveae*: D = 0.2789 and p 0.05), and the Student T-Test was used to compare the treatments. The t value was significant (t = 2.502108; p = 0.022210).

The mean was 4.3 preyed or immobilized mites per arena, with 21.5% of the total preyed and immobilized (Table 2, Figure 2). As for dispersion, these data had a normal distribution (D = 0.2812 and p 0.05).

Theses spiders did not prey mites. When the effects of predation (14.5%) and immobilization (21.5%) were added, the impact of Salticidae on total mortality of *C. heveae* was 36%.

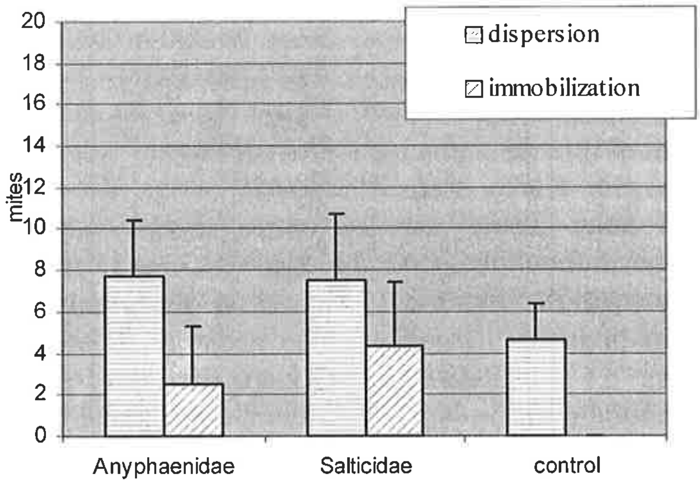

Figure 2. Dispersion and immobilization of the mite, *Calacarus heveae* in treatments with the spiders, Anyphaenidae and Salticidae, and no spiders (control).

Table 2. Treatments with the mite *C. heveae*: **e**-development stage, **i**- immobilized; **d**-dispersed; **m**-accidental mortality, **n**-nymph; **am**-adult male, and **af**- adult female:

Anyphaenidae	e	i	d	m
1	n	0	8	5
2	n	0	5	5
3	n	2	11	4
4	n	0	8	4
5	n	5	10	2
6	n	8	3	1
7	n	4	7	4
8	n	0	12	3
9	n	5	6	3
10	n	1	7	4
	-	25	77	35
Mean	-	2.5	3.1(7.7-4.6)	3,5
%	-	12.50%	15.50%	17.50%

Salticidae	e	i	d	m
1	n	8	6	4
2	n	0	6	5
3	n	4	12	4
4	n	6	5	2
5	am	4	8	3
6	n	8	3	2
7	n	0	10	3
8	n	5	9	2
9	n	7	4	4
10	n	1	12	4
	-	43	75	33
Mean	-	4.3	2.9(7.5-4.6)	3.3
%	-	21.50%	14.50%	16.50%

Control	i	d	m
1	x	8	5
2	x	4	3
3	x	4	5
4	x	5	3
5	x	3	3
6	x	3	2
7	x	2	2
8	x	6	3
9	x	5	4
10	x	6	3
	x	46	33
Mean	x	4.6	3,3
%	x	23%	16,50%

5. Comparison of treatments

When the different treatments are compared, *T. heveae* treatments showed higher dispersal rate (35% for Anyphaenidae and 29.5% for Salticidae) than the treatments with *C. heveae* (ANOVA: $p = 0.0000$, $F = 13.8450$). In the treatments with *C. heveae*, Salticidae had the highest rate (ANOVA: $p = 0.0301$, $F = 3.3156$), with 21.5% immobilized mites per arena (Figure 3).

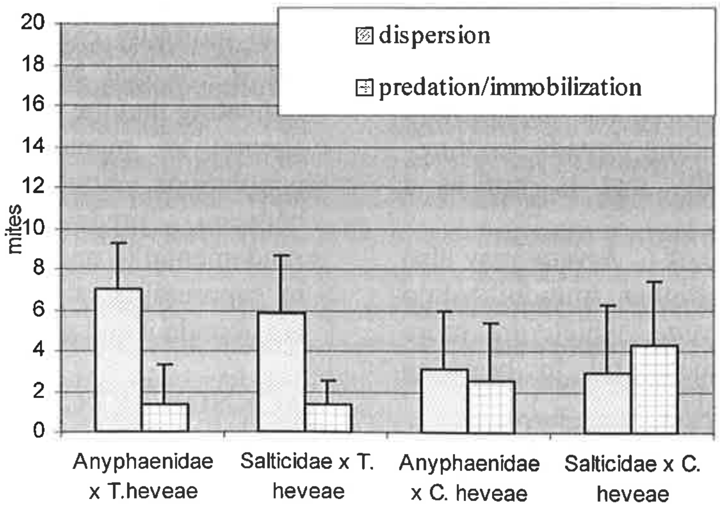

Figure 3. Dispersion, predation and immobilization in the interactions of spiders, Anyphaenidae and Salticidae with the mites, *Tenuipalpus heveae* and *Calacarus heveae*.

DISCUSSION

By observing, recording and comparing the confrontations between the spiders and the rubber tree mite pests, our records surprisingly showed a no significant predation, but a significant mortality caused by dispersal (*T. heveae*) and immobilization (*C. heveae*).

The low preying rate was probably due to the large differences in the sizes of predators and preys. Spiders were 3-10mm long, *C. heveae* adults were 0.18mm and *T. heveae* adults were 0.3mm. Variation in body size of both predators and preys also contributed to the reduction of predation (Nentwig & Vissel, 1986; Nyffeler et al., 1994). In addition to their small size, the slight mite displacement may have limited their perception by Salticidae spiders, which are predominantly visual hunters, and by Anyphaenidae spiders, which rely on prey vibrations in the substrate.

The killing and no consumption of arthropods held in the webs have already been described for weavers (Riechert & Maupin, 1998), but it was the first time that mites were trapped in the hunter silk, promoting a significant mortality. In our experiments with mites and hunting spiders, the spiders shelters in "tunnel" shape built on leaves or their guiding threads "capture" the mites accidentally, that is, not as a predatory function.

The small size of *C. heveae* may also have determined a higher immobilization rate than for *T. heveae*, which are more robust and more successful in breaking through the silk threads.

Spiders caused mite dispersion by being present physically, that is, walking on leaf surface, as they moved the mites away from the feeding site. The greatest dispersion occurred among *T. heveae* mites, which had greater body volume than the other mites and perhaps were more perceptible by the spider. Mansour et al. (1981) referred to the dispersion of phytophagous mites by spiders as the "phenomenon of larval disaggregation". Those authors registered that in apple trees, larvae of the Lepidoptera *S. littoralis* when in the presence of Miturgidae spiders, dispersed, leading to 34% control of the pest because the phytophagous mites died after dispersion. Yamanaka et al. (1973) studied the dispersion of *S. litura* also in the field, caused by Micryphantidae, an orb-weaving spider, and found 38% dispersion of the pest larvae. The same result was obtained by Nakasuji et al. (1973) for *S.litura* in the field, with the orb-weavers Linyphiidae. These dispersion results are similar to those observed in our study (35% in the treatment Anyphaenidae X *T. heveae*), and even though the arthropods and the experimental design we used are different, it must be said that the spiders decreased prey populations by dispersion.

The experiments conducted in our study are the first ones of the kind and were needed to reveal the relationships between spiders and mite pests in rubber tree. The total mortality caused by spiders was 42% for *T. heveae* and 36% for *C. heveae*, indicating that the tested spiders are potential agents to manage these phytophagous populations. Studies on the interactions between predators and preys are fundamental to understand the role of spiders in suppressing pest populations, as spiders are abundant and endemic enemies in crops.

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