CROP PROTECTION

Mites (Acari) of Rubber Trees (*Hevea brasiliensis* Muell. Arg., Euphorbiaceae) in Piracicaba, State of São Paulo, Brazil

Raf M.J. De Vis[1,2], Gilberto J. de Moraes[1,3] and Marcos R. Bellini[1]

[1]*Depto. Entomologia, Fitopatologia e Zoologia Agrícola, Escola Superior de Agricultura "Luiz de Queiroz", USP 13418-900, Piracicaba, SP, Brazil*
[2]*Present address: Proefstation voor de Groenteteelt, 2860 Sint-Katelijne-Waver, Belgium, raf.de.vis@pstdrc.be*
[3]*CNPq Researcher*

Neotropical Entomology 35(1):112-120 (2006)

Ácaros (Acari) da Seringueira (*Hevea brasiliensis* Muell. Arg., Euphorbiaceae) em Piracicaba, SP

RESUMO - Foram determinadas as principais espécies de ácaros que ocorrem em seringueira (clone RRIM-600) em Piracicaba, SP, de junho de 2002 a maio de 2003 e avaliadas as relações entre elas. O estudo foi realizado numa plantação de 5 ha com arvores de 11 anos de idade e 15 m de altura, circundada de cultivos de milheto, algodão, milho ou feijão. As amostras foram coletadas mensalmente e consistiram de cinco folíolos, cinco pecíolos (a partir de outubro de 2002) e cinco extremidades de ramos (10 cm de comprimento) de 15 seringueiras. Todos os ácaros de um dos cinco folíolos, pecíolos e ramos de cada árvore foram montados para identificação até gênero/espécie para estimar a ocorrência proporcional de cada espécie. Foram encontrados 84.850 ácaros pertencentes a 38 espécies de 34 gêneros e 16 famílias. Tydeidae foi a família com maior número de espécies (11), seguida por Phytoseiidae e Stigmaeidae (4 cada). As famílias mais abundantes foram Eriophyidae, Tenuipalpidae e Tydeidae (totais de 43.023, 26.390 e 13.644 indivíduos, respectivamente). Os maiores níveis populacionais dos ácaros-praga *Calacarus heveae* Feres e *Tenuipalpus heveae* Baker ocorreram no final da estação chuvosa. Os predadores mais abundantes foram *Metaseiulus camelliae* (Chant & Yoshida-Shaul), *Amblyseius compositus* Denmark & Muma e *Euseius citrifolius* Denmark & Muma. Os predadores não conseguiram evitar o aumento populacional de *C. heveae* e *T. heveae* a partir de março. No entanto, a presença daqueles predadores pode ter evitado o surgimento mais precoce e níveis ainda maiores daqueles ácaros-praga.

PALAVRAS-CHAVE: Ecologia, manejo de pragas, controle biológico

ABSTRACT - This study determined the main mite species on rubber trees (clone RRIM-600) in Piracicaba, southeast of São Paulo State, from June 2002 to May 2003 and evaluated the possible relation between them. It was conducted in a plantation of 5 ha on 11 year old trees, 15 m high, surrounded with crops as pearl millet, cotton, bean or corn. Samples were taken monthly and consisted of five leaflets, five petioles (only from October 2002 on) and five terminal sections of twigs (10 cm) from 15 rubber trees. All mites of one leaflet, one petiole and one twig section of each plant were mounted for identification to genera/species to estimate the proportional occurrence of each species. A total of 84,850 mites belonging to 38 species of 34 genera and 16 families were found. Tydeidae was the family with the highest number of species (11), followed by Phytoseiidae and Stigmaeidae (4 each). The most abundant families were Eriophyidae, Tenuipalpidae and Tydeidae (totals of 43,023, 26,390 and 13,644 individuals, respectively). The highest population levels of the pest mites *Calacarus heveae* Feres and *Tenuipalpus heveae* Baker occurred at the end of the rainy season. The most abundant predators were *Metaseiulus camelliae* (Chant & Yoshida-Shaul), *Amblyseius compositus* Denmark & Muma and *Euseius citrifolius* Denmark & Muma. The predators could not prevent the increase of *C. heveae* and *T. heveae* from March on. However, their presence might have prevented an earlier increase and even higher levels of those mites.

KEY WORDS: Ecology, pest management, biological control

Rubber tree, *Hevea brasiliensis* Muell. Arg. (Euphorbiaceae), is native to the Amazon region and represents the major source of natural rubber in the world (Gonçalves *et al*. 2001). In the last two decades, the rubber production in the State of São Paulo has been growing considerably. In 2001, about 63 thousand tons of coagulated latex was produced in that state, corresponding to almost twice the production in the State of Mato Grosso, the second largest producer in Brazil.

Chiavegato (1968) was apparently the first to evaluate the mite diversity on rubber trees in the State of São Paulo, mentioning five species on that plant. Feres (2000) reported 28 mite species on rubber trees in the States of Minas Gerais, Mato Grosso, Mato Grosso do Sul and São Paulo. Ferla & Moraes (2002) found 41 species on rubber trees in Mato Grosso. Information on rubber tree mites increases at each year, not only in relation to the faunal diversity but also in relation to the ecology of those mites (Bergmann *et al*. 1994, Feres 2000, Feres *et al*. 2002, Ferla & Moraes 2002).

Calacarus heveae Feres and *Tenuipalpus heveae* Baker have been reported as major pests of rubber trees in São Paulo. *C. heveae* causes severe defoliation, which apparently results in significant yield losses (Vieira & Gomes 1999; Feres 1992, 2000). *T. heveae* seems to have similar effects (Pontier *et al*. 2001).

Experimental plantations of rubber trees have been established at the campus of Escola Superior de Agricultura Luiz de Queiroz, USP, in Piracicaba, SP. Data on mite diversity and population dynamics are important to develop management strategies, but no studies on this sense have been published for the region of Piracicaba. The principal objective of this study was to determine the main mite species on rubber trees in Piracicaba during a period of about one year, and to evaluate the possible relationship between them.

Material and Methods

This study was conducted in an experimental plantation of 5 ha of rubber trees, clone RRIM 600, in the campus of ESALQ/USP. The trees were about 11 years old, 15 m high and planted at a spacing of 7 m between lines and 3 m between trees on each line. During the sampling period annual crops as pearl millet, cotton, bean or corn were cultivated on the neighboring fields.

From June 2002 to May 2003, 15 trees were monthly sampled by taking 5 random samples (twig of about 20 cm with about 15-20 leaves) of each tree. Samples were collected in the upper third part of the tree. Each sample was put individually in a paper bag. The paper bags were put together in a plastic bag, which was placed in a cool box for transport to the laboratory, where the samples were stored in a refrigerator; they were processed on the same day on which they were collected. At processing, one random leaf was detached from each twig and the terminal section of the twig was cut to 10 cm. The mites on the central leaflet, the petiole (from October 2002 on) and the twig section were then counted using a stereomicroscope. All mites from one sample (consisting of the central leaflet, petiole and twig section of 10 cm) of each tree were mounted on slides for subsequent identification to estimate the proportional occurrence of each species. When a large number of mites assumed to belong to a single species was found (e.g. at high infestation levels of *T. heveae* or *C. heveae*), only a sample of those mites was mounted. All predatory mites present on all samples (consisting of the central leaflet, petiole and twig section of 10 cm) were mounted. Voucher specimens of each taxon were deposited at the Mite Reference Collection, Setor de Zoologia, Departamento de Entomologia, Fitopatologia e Zoologia Agrícola, ESALQ-USP. Climatic data were obtained from the Departamento de Ciências Exatas, ESALQ-USP.

Results

A total of 84,850 mites belonging to 38 species of 34 genera and 16 families was found in this study (Table 1). Approximately 18.4% of the species belonged to families composed exclusively of phytophagous species (Eriophyidae, Tenuipalpidae and Tetranychidae), 29% belonged to families composed predominantly of predaceous species (Bdellidae, Cheyletidae, Eupalopsellidae, Phytoseiidae and Stigmaeidae) and 52.6% belonged to families composed of species of variable or inadequately known feeding habits (Acaridae, Tarsonemidae, Tydeidae, Winterschmidtiidae and families of the suborder Oribatida). Considering the abundance of the mites collected, approximately 81.8% belonged to the first class, 1.8% to the second and 16.4% to the third, respectively.

Global species composition. Tydeidae was the most diverse family (11 species), followed by Phytoseiidae and Stigmaeidae (4 species each). Eriophyidae, Tenuipalpidae and Tydeidae were the most abundant families, with 43,023, 26,390 and 13,644 individuals, respectively (Table 1).

The eriophyids, represented mostly by *C. heveae*, occurred principally on the upper surface of the leaflets. On the lower surface, the dominant eriophyids were *Shevtchenkella petiolula* Feres, which occurred at a much lower proportion. The tenuipalpids, represented basically by *T. heveae*, occurred predominantly on the lower surface; they were only found on the upper surface and on the petioles when their densities on the lower surface of leaflets were very high. A single specimen of *Brevipalpus phoenicis* (Geijskes) was found in this study.

Phytoseiidae and Stigmaeidae were the most abundant of the families composed predominantly of predatory species. The phytoseiid *Metaseiulus camelliae* (Chant & Yoshida-Shaul) was the most numerous predator. Among the stigmaeids, the most numerous species was *Zetzellia malvinae* Matioli, Ueckermann & Oliveira. The majority of the phytoseiid and stigmaeid species was found on twigs and in leaf and axillary domatias.

In the family Tydeidae, eight species of Tydeinae (*Lorryia* sp. 1, *Lorryia* sp. 2, *Neolorryia* sp., *Pausia* sp., *Pretydeus* sp., *Pseudolorryia* cf. *nicaraguensis*, *Triophtydeus* sp. 1 and *Triophtydeus* sp. 2) were found, predominantly on twigs and in leaf domatias. *Lorryia* sp. 1 was by far the most

Table 1. Total number of mites per family, estimated proportion of the species within each family and distribution in relation to the microhabitat observed in 12 samples taken monthly from June 2002 to May 2003, Piracicaba, SP.

Family (total number)	Species	Prop. (%)	Distribution of each species in relation to the microhabitat (%)				
			Leaflet				Twig
			D	Lo	Up	P	
PROSTIGMATA							
Bdellidae (3)	*Spinibdella* sp.	100	33	-	-	-	67
Cheyletidae (76)	*Hemicheyletia* sp.	100	5.3	-	-	-	94.7
Eriophyidae (43,023)	*Calacarus heveae* Feres	94	3.2	0.5	96.3	-	-
	Shevtchenkella petiolula Feres	6	0.5	47.5	11.3	1.7	39
Eupalopsellidae (20)	*Exothorhis caudata* Summers	100	-	-	-	-	100
Stigmaeidae (207)	*Agistemus* sp.	1.3	100	-	-	-	-
	Eryngiopus sp.	1.3	-	-	-	-	100
	Mediolata sp.	0.7	-	-	-	-	100
	Zetzellia malvinae Matioli, Ueckermann & Oliveira	96.7	31.4	2.9	1.5	-	64.2
Tarsonemidae (77)	*Tarsonemus* sp.	41.6	81	-	-	-	19
	Daidalotarsonemus sp. 1	33.4	-	-	-	-	100
	Daidalotarsonemus sp. 2	25	-	-	-	-	100
Tenuipalpidae (26,390)	*Brevipalpus phoenicis* (Geijskes)	< 0.01	-	-	-	-	100
	Tenuipalpus heveae Baker	> 99.9	0.4	93.1	3.1	0.3	3.1
Tetranychidae (24)	*Eutetranychus banksi* (McGregor)	55.5	-	10	90	-	-
	Mixonychus sp.	16.5	-	-	-	-	-
	Oligonychus gossypii (Zacher)	28	-	100	-	-	-
Tydeidae (13,644)	*Lorryia* sp. 1	67.5	35.3	6.4	-	0.5	57.8
	Lorryia sp. 2	10	10.3	3.4	-	-	86.3
	Neolorryia sp.	3	12.5	-	-	-	87.5
	Parapronematus acaciae Baker	3	10	80	-	-	10
	Pausia sp.	0.6	-	-	-	-	100
	Pronematus ubiquitus (McGregor)	0.3	-	100	-	-	-
	Pretydeus sp.	12	2.8	2.8	-	-	94.4
	Pronematus sp.	1	-	100	-	-	-
	Pseudolorryia cf. *nicaraguensis*	0.3	-	-	-	-	100
	Triophtydeus sp. 1	2	-	-	-	-	100
	Triophtydeus sp. 2	0.3	-	-	-	-	100
MESOSTIGMATA							
Phytoseiidae (1,261)	*Amblyseius compositus Denmark & Muma*	30	8.2	2.4	1.4	-	88
	Euseius citrifolius Denmark & Muma	15.4	30.1	14.4	0.5	1.5	53.5
	Metaseiulus camelliae (Chant & Yoshida-Shaul)	54.4	19.5	2.2	0.5	0.4	77.4
	Proprioseiopsis ovatus (Garman)	0.2	-	-	-	-	100

Continue

Table 1. Continuation

Family (total number)	Species	Prop. (%)	Distribution of each species in relation to the microhabitat (%)				
			Leaflet				Twig
			D	Lo	Up	P	
ASTIGMATA							
Acaridae (95)	*Neotropacarus* sp.	100	19	3.2	1	-	76.8
Winterschmidtiidae (12)	*Oulenzia* sp.	100	-	16	-	-	84
ORIBATIDA							
Oribatulidae (4)	*Spinoppia* sp.	100	-	-	-	-	100
Oripodidae (11)	*Pirnodes* sp.	100	-	-	-	-	100
Unidentified (3)	unidentified	-	-	-	-	-	100

Prop. = estimated proportion of species within each family; D = domatia; Lo = lower leaf side; Up = upper leaf side; P = petiole

abundant tydeid on twigs. In the same family, 3 species of Pronematinae [*Parapronematus acaciae* Baker, *Pronematus ubiquitus* (McGregor) and *Pronematus* sp.], were found, mostly on the lower surface of the leaflets.

Population dynamics on leaflets. Among the phytophagous mites, eriophyids and tenuipalpids were frequent throughout the period of study (Fig. 1). A small increase of the eriophyid population level occurred from September to November, when the only species representing the family was *S. petiolula*. From March on, the abundance of eriophyids increased rapidly, reaching a maximum in April and declining afterwards. Practically the only species representing the family during that period was *C. heveae*.

The abundance of tenuipalpids increased considerably from February on. Similarly to the eriophyids, the maximum abundance of tenuipalpids occurred in April, and the population decreased from then on. Another economically important family of phytophagous mite, Tetranychidae, was rare in this study. Only 24 individuals were found, from February to May.

In relation to the predators, the phytoseiids were frequent throughout the study. The first peak of the population level of those mites occurred in November, when nearly 65, 19 and 16% of the phytoseiids corresponded to *Euseius citrifolius* Denmark & Muma, *Metaseiulus camelliae* (Chant & Yoshida-Shaul) and *Amblyseius compositus* Denmark & Muma, respectively. Phytoseiid population decreased after November, reaching a minimum level from January to February, after which it increased again to reach the maximum level in May. At that time, 69, 21 and 10% of the phytoseiids corresponded to *M. camelliae*, *E. citrifolius* and *A. compositus*, respectively.

The stigmaeids were also frequent throughout the study, but they were almost always less abundant than the phytoseiids. The population level of the stigmaeids varied little during the study, ranging generally between 0.1 and 0.2 individuals per leaflet. More than 95% of the stigmaeids corresponded to *Z. malvinae*. Other families known for their predominantly predatory species (Bdellidae, Cheyletidae and Eupalopsellidae) were neither frequent nor abundant.

Of the mites with variable or inadequately known feeding habits, the tydeids were both frequent and abundant throughout the study. Their highest levels were observed in June (first month of the observation period), September and February. The most abundant tydeid species were *Lorryia* sp. 1 and *Lorryia* sp. 2, corresponding to approximately 68% and 10% of the tydeid specimens, respectively. Other mites of this group (Acaridae, Tarsonemidae and Winterschmidtiidae) were frequent, but occurred always in very low population levels.

Population dynamics on twigs. Eriophyids and tenuipalpids were also frequent on twigs (Fig. 2), but they were much less abundant than on leaflets. Their highest levels never exceeded six mites per twig. All eriophyids and tenuipalpids were *S. petiolula* and *T. heveae*, respectively.

The population dynamics of the predatory mites on twigs was similar to that observed on leaflets but the abundance of phytoseiids was always considerably higher than those of other families. In November, nearly 44, 33 and 23% of the phytoseiids corresponded to *M. camelliae*, *A. compositus* and *E. citrifolius,* respectively, whereas in May the proportion of those species corresponded, respectively, to nearly 64, 2 and 12% of the phytoseiids.

Also on twigs stigmaeids were much less abundant than phytoseiids and almost all were *Z. malvinae*. Other families represented mostly by predatory species (Bdellidae and Cheyletidae) were frequent, but rare.

Of the mites with variable or inadequately known feeding habits, the pattern of population variation of the tydeids was quite different from that observed on leaflets. In this case, the highest level occurred in August/September and the population level was rather constant from December to May. In contrast, considering all sampling dates, the average number of tydeids per twig was approximately the same as that per leaflet. Other mites of this group (Acaridae, Oribatida and Tarsonemidae) were frequent but occurred always in very low population levels.

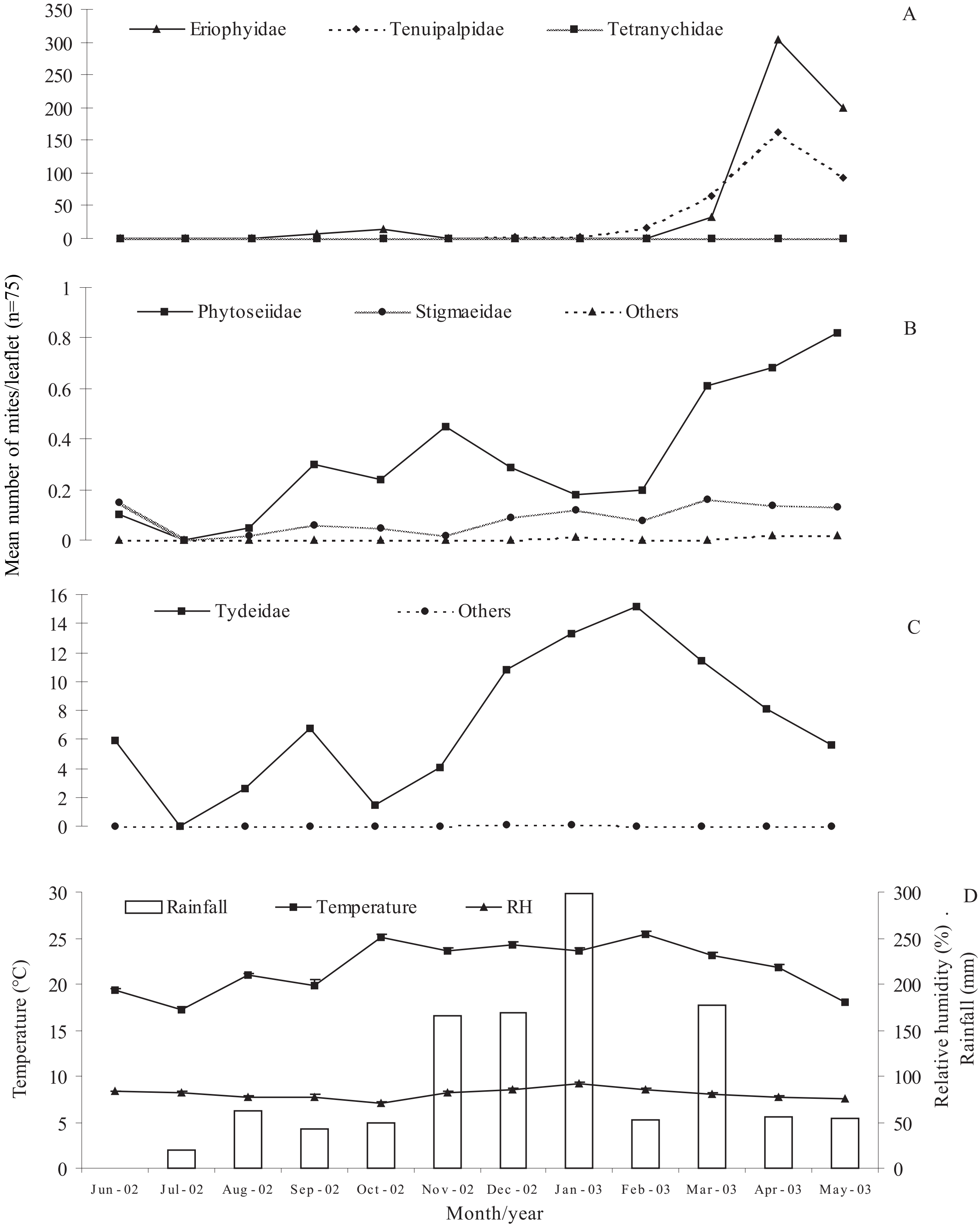

Figure 1. Fluctuation of the population of mite groups on rubber tree leaflets in Piracicaba - SP. A) families of phytophagous mites; B) families of predatory mites; C) families of mites with variable or little known feeding habits; D) climatic parameters during the study.

Discussion

Global species composition. The number of taxa collected in this study show the great mite diversity on rubber trees in Piracicaba. This high diversity has also been observed in other parts of southeast and southwest Brazil (Feres 2000, Feres *et al*. 2002, Ferla & Moraes 2002), where rubber trees are mostly cultivated in that country. The highest abundance of phytophagous mites in comparison with mites of other feeding habits is typical of ecosystems with low heterogeneity, in this case a monoculture of rubber trees. In agroecosystems, phytophagous species commonly reach high population levels due to lower diversity of natural enemies (Altieri *et al*. 2003).

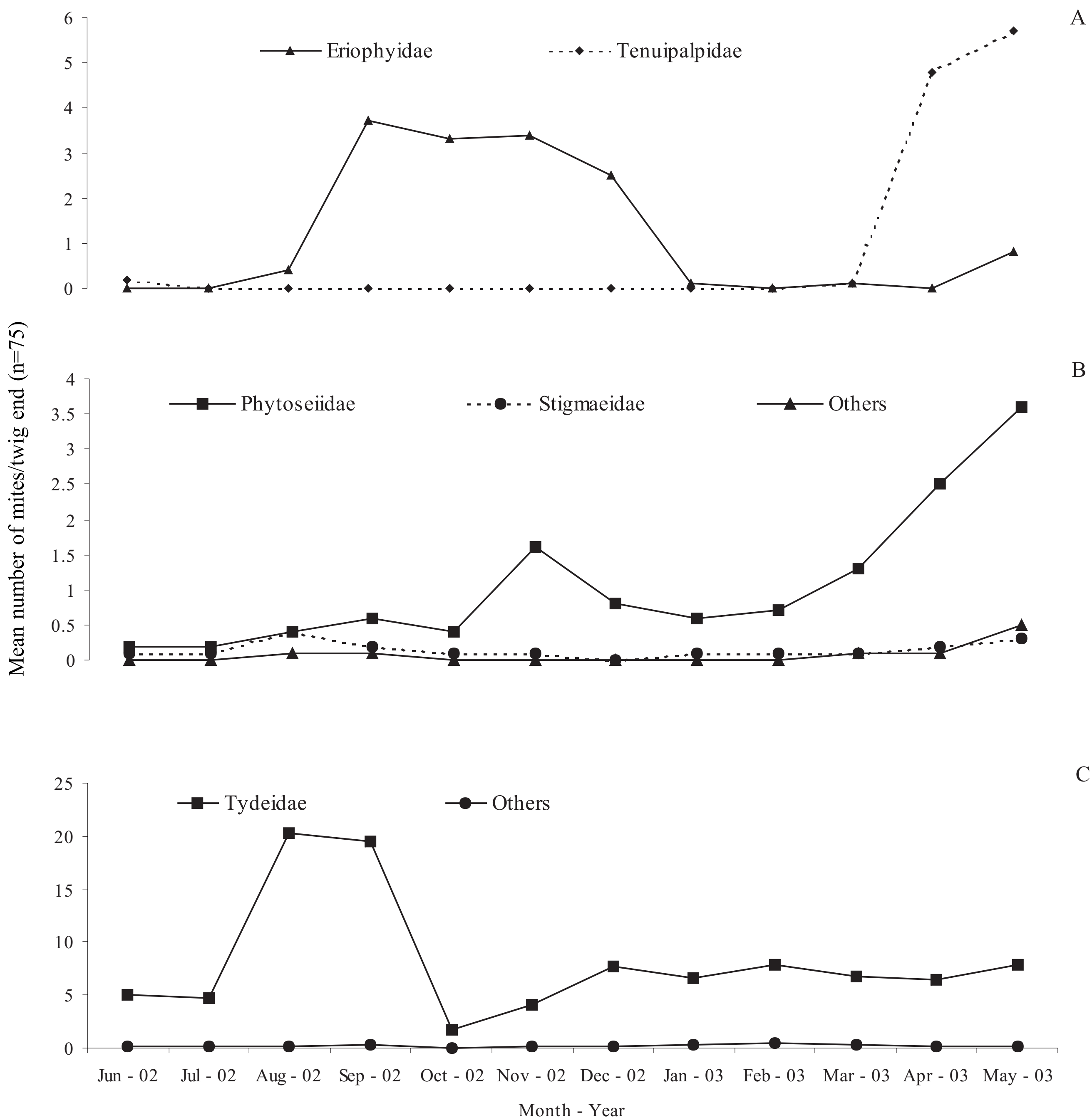

Figure 2. Fluctuation of the population of mite groups on rubber tree twig (distal 10 cm) in Piracicaba - SP, Brazil. A) families of phytophagous mites; B) families of predatory mites; C) families of mites with variable or little known feeding habits.

The highest species diversity of tydeids is probably due to the variable feeding habits of members of this family, that include phytophages, predators, mycophages and mites of other feeding habits. The variable feeding habits allow those mites to explore different types of microhabitats. Feres (2000) and Ferla & Moraes (2002) also found a great diversity of tydeids in rubber tree plantations. Probably, a similar reasoning can be applied to the phytoseiids and stigmaeids, composed mostly by species that can consume different types of food, including prey species, pollen, fungi, plant exudates etc. (Gerson *et al*. 2003).

The most abundant families (Eriophyidae and Tenuipalpidae) were those that include the principal pest species of rubber trees in Brazil: *C. heveae* and *T. heveae*. Feres (2000), Feres *et al*. (2002) and Ferla & Moraes (2002) also reported those as the most abundant species on rubber trees. However, the high abundance of tydeids in this study, principally *Lorryia* sp. 1, contrasts with the results of the previously mentioned studies, in which tydeid populations were always low. A possible explanation is that tydeids seem to be by far most common in domatias and on twigs, which apparently were not examined as extensively in those studies as in the present one.

The highest abundance of eriophyids on the upper surface of the leaflets was expected, as *C. heveae*, by far the predominant eriophyid in this study, is known to prefer this habitat (Vieira & Gomes 1999, Ferla & Moraes 2003). However, the occurrence of *S. petiolula* mainly on the lower surface of leaflets and on twigs contrasts with the observations of Feres (1998, 2000, 2001), who found this mite mostly on the petioles. The occurrence of tenuipalpids mostly on the lower surface of leaflets coincides with the results of other authors (Feres 2000, Pontier *et al*. 2001, Feres *et al*. 2002, Ferla & Moraes 2002).

Most tydeids were found in places where they could hide, as in domatias and in grooves, empty parasitized scales, in axils of petioles and in or underneath insect or spider webs on leaves or twigs. Tydeids (*Lorryia* sp. 1) were only found on petioles when the latter had irregular areas where those mites could hide. They were usually found in colonies, as typical for *Lorryia*, the predominant genus (Jeppson *et al.* 1975). *Z. malvinae* was also found mostly in secluded places, frequently sharing domatias and other hiding places on leaves and twigs with tydeids.

Population dynamics. The patterns of the fluctuation of eriophyid and tenuipalpid population levels observed in this study were similar to those observed in previous studies in the State of São Paulo (Feres *et al*. 2002, Bellini *et al*. 2005). The period of highest population levels of those families (in other words, of *C. heveae* and *T. heveae*) corresponded to the end of the rainy season, when there was also a marked reduction of the temperature and a small reduction of the relative humidity. When the population of those mites started to increase, from January to March, the trees had plenty of new and seemingly physiologically adequate leaves for their development. Except for a brief reference to an apparent positive effect of high humidity levels on the biology of *C. heveae* (Ferla & Moraes 2003), and an apparent negative effect of high humidity levels on the biology of *T. heveae* (Pontier *et al.* 2001), nothing is known on the effect of climatic conditions or physiological state of the food source on the life history of *C. heveae* and *T. heveae*. The quick increase of the populations of these mites caused considerable damage to the leaflets, apparently turning them unfavorable for the development of the mites. This could be one of causes of the reduction of their populations in May.

Although not quantified, the area of a leaflet of rubber tree seems to be larger than that of a twig section. Even so, the number of phytoseiids per twig was markedly higher than the number per leaflet. As the species composition is basically the same on both structures it is possible that the higher density of phytoseiids on twigs be related to the higher availability of hiding places. If so, it is possible that these predators hide in these places during the day (when the samples were collected), and move to the leaflets at night. Onzo *et al*. (2003) observed this type of behavior in relation to *Typhlodromalus aripo* DeLeon, a predaceous phytoseiid found on cassava (*Manihot esculenta* Crantz), also an Euphorbiaceae. During the day, this predator is found almost exclusively in the growing tips of the plant, but at night it is found on nearby leaves, searching for the prey *Mononychellus tanajoa* (Bondar).

The peak phytoseiid population in November, on leaflets and twigs, seems to be related to the blooming of the rubber trees, at least in relation to *E. citrifolius*. This predator was proportionally most abundant in November (33% of all phytoseiids found on leaflets and twigs) than in May (14%), when the second peak in the population of phytoseiids was observed. In November, *E. citrifolius* corresponded to 65% of the phytoseiids found on leaflets. *Euseius* species are known to develop well on pollen; most of them develop better on this than on other types of food (McMurtry & Croft 1997). Some studies have shown that *E. citrifolius* can develop and oviposit well on pollen of different plant species (Moraes & McMurtry 1981, Daud & Feres 2004). *M. camelliae*, the most abundant phytoseiid species in the course of this study on leaflets and twigs, was probably consuming other types of food than pollen. Repeated attempts to establish a colony of this species with pollen of *T. angustifolia* were unsuccessful. *A. compositus*, which in November and May was the third most abundant phytoseiid on leaflets and the second most abundant phytoseiid on twigs, was also probably feeding on other food items than pollen.

The increasing population levels of phytoseiids and stigmaeids from March on coincided with the high population levels of phytophagous mites. This could explain the increase of the population of *A. compositus* in relation to that of *E. citrifolius*. Detailed laboratory studies on the effect of *A. compositus* on rubber tree pest mites seem desirable. The combined actions of phytoseiids and stigmaeids could be one of the reasons for the reduction of the population of *C. heveae* and *T. heveae* between April and May.

On both leaflets and twigs an apparent negative relation was observed between the population levels of phytoseiids and stigmaeids. On leaflets, increases of the population level of phytoseiids corresponded to decreases of the level of stigmaeids, from September to November and from March to May. On twigs, the highest stigmaeid population level occurred when the level of phytoseiids was very low. On both leaves and twigs, whenever the population level of phytoseiids was high, the level of stigmaeids was low. Similar types of correlation between those predators have been observed on other crops (Clements & Harmsen 1992, Croft & MacRae 1992, MacRae & Croft 1996). Studies to clarify the exact type of interaction of mites of those families on rubber trees are desirable.

The relation of the tydeids with the phytoseiid and stigmaeid predators is not very clear, and should be experimentally studied in the future. Marked increases in tydeid levels on leaflets from October to February and on twigs from July to September corresponded to discrete increases or actually reductions in the population levels of those mites. The quick reduction in tydeid levels on twigs from September to October corresponded to very discrete decreases in phytoseiid and stigmaeid population levels. The pronounced increase in phytoseiid population level on twigs from February on did not correspond to any major change in the level of tydeids; only on leaflets the increase in phytoseiid population level in that period corresponded to a major reduction of tydeid level. These results suggest that phytoseiids and stigmaeids did not significantly affect the populations of the dominant tydeid species in this study. It is not clear what caused the quick and considerable reduction of the tydeid population level on twigs and its maintenance at much lower level after September on that substrate. One possibility would be the preference of those mites for the leaflets as substrate; in this sense, the tydeids would have moved from twigs to the new leaves, as soon as those started to be produced by the plants from October on.

It is of interest to notice that the fauna of predators in this study was quite different from that of the other studies mentioned previously. The most common species in the present study (*M. camelliae*) was totally absent or found in very low levels in those studies. Also not a single *A. compositus* was collected in such studies. *E. citrifolius*, the third most common phytoseiid in this study, was by far the dominant species found in the previous studies. Again, those differences could be due to the fact that in the previous studies mites were not evaluated on twigs, where the vast majority of *M. camelliae* and *A. compositus* was found in the present study.

The predators found in this and in the studies mentioned earlier were not able to maintain the population of *C. heveae* and *T. heveae* below damaging levels. It is possible that they may have avoided an earlier occurrence or the occurrence of still higher levels of those pest mites, but their actual effect on the latter needs to be further investigated.

Acknowledgments

To the Departamento de Ciências Exatas, ESALQ/USP, for providing the climatic data. To Prof. Dr. Marcos Silveira Bernardes of the Departamento de Produção Vegetal, ESALQ/USP for the logistic support and for allowing us to conduct this work in the rubber tree plantation. To Plantações E. Michelin Ltda. and Guaporé Pecuária S/A for partial financial support. To FAPESP (Fundação de Amparo à Pesquisa do Estado de São Paulo), for the post-doctoral fellowship awarded to the first author. This work was supported by FAPESP within the BIOTA/FAPESP – The Biodiversity Virtual Institute Program (www.biotasp.org.br).

References

Altieri, M.A., E.N. Silva & C.I. Nicholls. 2003. O papel da biodiversidade no manejo de pragas. Ribeirão Preto, Editora Holos, 226p.

Bellini, M.R. G.J. de Moraes & R.J.F. Feres. 2005. Ácaros (Acari) de dois sistemas de cultivo da seringueira no noroeste do estado de São Paulo. Neotrop. Entomol. 34: 475-484.

Bergmann, E.C., S. de L. Imenes, A.M. Tempest, L.E.F.R. Silva, C. Campaner & M. de F. Stradioto. 1994. Contribuição a conhecimento da entomofauna na cultura de seringueira (*Hevea brasiliensis* Muell. Arg.). Cult. Agron. 3: 33-46.

Chiavegato, L.G. 1968. Contribuição para o conhecimento de alguns ácaros que ocorrem na seringueira (*Hevea brasiliensis* Muell. Arg.). I Reunião Anual da Sociedade Brasileira de Entomologia, p.67.

Clements, D.R. & R. Harmsen. 1992. Stigmaeid-phytoseiid interactions and the impact of natural enemy complexes on plant-inhabiting mites. Exp. Appl. Acarol. 14: 327-341.

Croft, B.A. 1994. Biological control of apple mites by a phytoseiid mite complex and *Zetzellia mali* (Acari: Stigmaeidae): Long term effects and impact of azinphosmethyl on colonization by *Amblyseius andersoni* (Acari: Phytoseiidae). Environ. Entomol. 23: 1317-1325.

Croft, B.A. & I.V. MacRae. 1992. Persistence of *Typhlodromus pyri* and *Metaseiulus occidentalis* (Acari: Phytoseiidae) on apple after inoculative release and competition with *Zetzellia mali* (Acari: Stigmaeidae). Environ. Entomol. 21: 1168-1177.

Croft, B.A. & I.V. MacRae. 1993. Biological control of apple mites: Impact of *Zetzellia mali* (Acari: Stigmaeidae) on *Typhlodromus pyri* and *Metaseiulus occidentalis* (Acari: Phytoseiidae). Environ. Entomol. 22: 865-873.

Daud, R.D. & R.J.F. Feres. 2004. O valor de *Mabea fistulifera* Mart. (Euphorbiaceae), planta nativa do Brasil, como reservatório para o predador *Euseius citrifolius* Denmark & Muma (Acari Phytoseiidae). Rev. Bras. Zool. 21: 453-458.

Feres, R.J.F. 1992. A new species of *Calacarus* Keifer (Acari, Eriophyidae) from *Hevea brasiliensis* Muell. Arg (Euphorbiaceae) from Brazil. Int. J. Acarol. 18: 61-65.

Feres, R.J.F. 1998. Two new Phyllocoptine mites (Acari: Eriophyidae) from *Hevea brasiliensis* Muell. Arg. (Euphorbiaceae) from Brasil. Int. J. Acarol. 24: 69-74.

Feres, R.J.F. 2000. Levantamento e observações naturalísticas da acarofauna (Acari, Arachnida) de seringueiras cultivadas (*Hevea* spp., Euphorbiaceae) no Brasil. Rev. Bras. Zool. 17: 157-173.

Feres, R.J.F. 2001. Ácaros eriofiídeos (Acari: Eriophyidae) em seringueira (*Hevea brasiliensis* Muell. Arg.: Euphorbiaceae) no Brasil, p.31-36. In L.A.N. de Sá & G.J. de Moraes. Ácaros de importância quarentenária. Jaguariúna, Embrapa Meio Ambiente, 40p.

Feres, R.J.F., D. de C. Rossa Feres, R.D. Daud & R.S. Santos. 2002. Diversidade de ácaros (Acari, Arachnida) em seringueiras (*Hevea brasiliensis* Muell. Arg., Euphorbiaceae) na Região Noroeste do estado of São Paulo, Brasil. Rev. Bras. Zool. 19: 137-144.

Ferla, N.J. & G.J. de. Moraes. 2002. Ácaros (Arachnida, Acari) da seringueira (*Hevea brasiliensis* Muell. Arg.) no estado do Mato Grosso, Brasil. Rev. Bras. Zool. 19: 867-888.

Ferla, N.J. & G.J. de. Moraes. 2003. Ciclo biológico de *Calacarus heveae* Feres 1992 (Acari, Eriophyidae). Rev. Brasil. Entomol. 47: 399-402.

Gerson, U., R.L. Smiley & R. Ochoa. 2003. Mites (Acari) in biological control. Boston, Blackwell Science, 539p.

Gonçalves, P. de S., O.C. Bataglia, A.A. Ortolani & F. da S. Fonseca. 2001. Manual de Heveicultura para o estado de São Paulo. Boletim Técnico do Instituto Agronômico de Campinas, 189, Campinas, 78p.

Jeppson, L.R., H.H. Keifer & E.W. Baker. 1975. Mites injurious to economic plants. University of California Press, Berkeley, 614p.

MacRae, I.V. & B.A. Croft. 1996. Differential impact of egg predation by *Zetzellia mali* (Acari: Stigmaeidae) on *Metaseiulus occidentalis* and *Typhlodromus pyri* (Acari: Phytoseiidae). Exp. Appl. Acarol. 20: 143-154.

McMurtry, J.A. & B.A. Croft. 1997. Life-styles of phytoseiid mites and their roles in biological control. Annu. Rev. Entomol. 42: 291-321.

Moraes, G.J & J.A. McMurtry. 1981. Biology of *Amblyseius citrifolius* (Denmark and Muma) (Acarina – Phytoseidae). Hilgardia 49: 1-29.

Onzo, A., R. Hanna, I. Zannou, M.W. Sabelis & J.S. Yaninek. 2003. Dynamics of refuge use: Diurnal, vertical migration by predatory and herbivorous mites within cassava plants. Oikos 101: 59-69.

Pontier, K.J.B., G.J. de Moraes & S. Kreiter. 2001. Biology of *Tenuipalpus heveae* (Acari, Tenuipalpidae) on rubber tree leaves. Acarologia 41: 423-427.

Sato, M.E., A. Raga, L.C., Cerávolo, A.C., Rossi & G.J. de Moraes. 2001. Effect of insecticides and fungicides on the interaction between members of the mite families Phytoseiidae and Stigmaeidae on citrus. Exp. Appl. Acarol. 25: 809-818.

Vieira, M.R. & E.C. Gomes. 1999. Sintomas, desfolhamento e controle de *Calacarus heveae* Feres, 1992 (Acari, Eriophyidae) em seringueira (*Hevea brasiliensis* Muell. Arg.). Cult. Agron. 8: 39-52.

Received 22/XI/04. Accepted 27/VI/05.