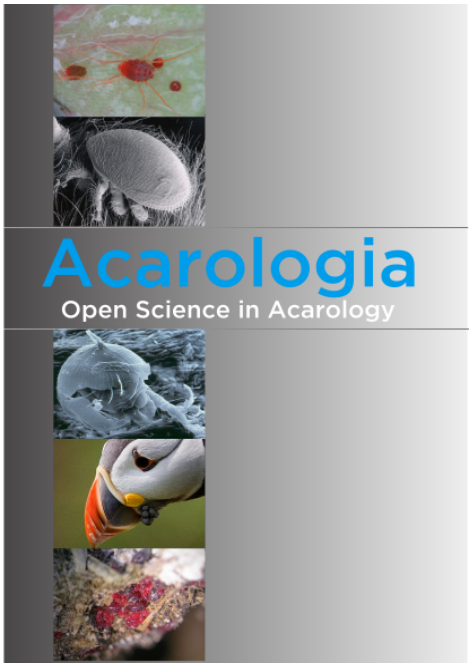

Acarologia

A quarterly journal of acarology, since 1959
Publishing on all aspects of the Acari

All information:

http://www1.montpellier.inra.fr/CBGP/acarologia/
acarologia-contact@supagro.fr

OPEN ACCESS

Acarologia is proudly non-profit,
with no page charges and free open access

Please help us maintain this system by
encouraging your institutes to subscribe to the print version of the journal
and by sending us your high quality research on the Acari.

Subscriptions: Year 2020 (Volume 60): 450 €
http://www1.montpellier.inra.fr/CBGP/acarologia/subscribe.php
Previous volumes (2010-2018): 250 € / year (4 issues)
Acarologia, CBGP, CS 30016, 34988 MONTFERRIER-sur-LEZ Cedex, France
ISSN 0044-586X (print), ISSN 2107-7207 (electronic)

The digitalization of Acarologia papers prior to 2000 was supported by Agropolis Fondation under the reference ID 1500-024 through the « Investissements d'avenir » programme (Labex Agro: ANR-10-LABX-0001-01)

Acarologia is under **free license** and distributed under the terms of the Creative Commons-BY-NC-ND which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original author and source are credited.

Acarologia
Open Science in Acarology

Mite fauna of a coffee agroecosystem (*Coffea arabica*L.) in the municipality of Monte Alegre do Sul, São Paulo State, Brazil. Part I.

Luiz Henrique Chorfi Berton[a] , Jeferson Luiz de Carvalho Mineiro[b] , Mário Eidi Sato[a] , Joaquim Adelino de Azevedo Filho[c] , Adalton Raga[d]

[a] APTA, Instituto Biológico, Centro Avançado de Pesquisa em Proteção de Plantas e Saúde Animal, Alameda dos Vidoeiros, n° 1097. CEP 13101-680. Gramado, Campinas, São Paulo. Brazil.
[b] APTA, Instituto Biológico, Centro Avançado de Pesquisa em Proteção de Plantas e Saúde Animal, Alameda dos Vidoeiros, nº 1097. CEP 13101-680. Gramado, Campinas, São Paulo. Brazil.
[c] APTA Regional, Polo Regional Leste Paulista, Estrada Vicinal Nelson Taufic Nacif Km 3, P.O. Box 01, CEP 13910-000, Monte Alegre do Sul, SP, Brazil.
[d] APTA, Instituto Biológico, Centro Avançado de Pesquisa em Proteção de Plantas e Saúde Animal, Alameda dos Vidoeiros, n° 1097. CEP 13101-680. Gramado, Campinas, São Paulo. Brazil.

Original research

ABSTRACT

This study aims to assess the mite fauna of coffee plants in the municipality of Monte Alegre do Sul, SP. The sample period was from April 2004 to February 2008. Each month, we sampled 480 leaves and 1,920 fruits from plants of the *Coffea arabica* L. cv. Mundo Novo. In total 16,062 adult individuals from 30 families representing 81 species of mite (and 1 incertae sedis). Among them, 95% were obtained from leaves, with the Mesostigmata contributing 23 species and 1,805 specimens. The phytoseiid mites were the most abundant, with 1,793 specimens. Seventeen families of Prostigmatid mites were recorded, represented by 48 species and 12,485 individuals. On fruits, the Mesostigmatid mites included three families and eight species. The Prostigmatid mites included nine families and 18 species, totalling 852 individuals. *Brevipalpus* sp. was the most abundant and frequent species, representing approximately 92% of the Prostigmatid mites. The present work reveals the occurrence of predator mites on coffee plants in the region: *Euseius alatus*, *Amblyseius herbicolus*, *Iphiseiodes matatlanticae*, *Armascirus* sp.1 and *Dactyloscirus* sp..

Keywords Phytoseiidae; Tenuipalpidae; *Oligonychus yothersi*; *Brevipalpus*

Received 10 June 2019
Accepted 22 November 2019
Published 06 December 2019

Corresponding author
Jeferson Luiz de Carvalho Mineiro:
jefmin@hotmail.com

Academic editor
Tixier, Marie-Stéphane

DOI
10.24349/acarologia/20194352

ISSN 0044-586X (print)
ISSN 2107-7207 (electronic)

Copyright
Berton L. H. C. *et al.*

Distributed under
Creative Commons CC-BY 4.0

OPEN ACCESS

Introduction

The coffee crop is important for Brazilian agribusiness, as the country is the world's greatest producer and exporter, as well as the world's second highest consumer of coffee (MAPA, 2017).

The coffee trees host many species of mites and some of them are pests. Among the most important phytophagous families, the Tenuipalpidae (with the genus *Brevipalpus*) and Tetranychidae (with the genus *Oligonychus*) are the main pests of the coffee crops in Brazil (Pallini Filho *et al.*, 1992; Reis and Souza, 1986; Spongoski *et al.*, 2005; Mineiro *et al.*, 2006a, 2006b; Reis and Zacarias, 2007). *Brevipalpus* mites are the main vectors of viral diseases, such as Coffee Ringspot Virus. Other important pest species belong to the genus *Oligonychus* (*O. ilicis* and *O. yothersi*) causing intense defoliation (Reis and Zacarias, 2007).

One of the main way to regulate mite pests is the biological control using predatory mites (Pallini Filho *et al.*, 1992; Mineiro *et al.*, 2008). Mites of the family Phytoseiidae are the most

How to cite this article Berton L. H. C. *et al.* (2019), Mite fauna of a coffee agroecosystem (*Coffea arabica*L.) in the municipality of Monte Alegre do Sul, São Paulo State, Brazil. Part I.. **Acarologia 59(4): 542-550; DOI 10.24349/acarologia/20194352**

significant and well-studied predators of mite pests (McMurtry and Croft, 1997). Some species of this family are often found in association with phytophagous mites on coffee plants (Pallini Filho *et al.*, 1992; Reis *et al.*, 2000a; Mineiro *et al.*, 2006a, 2006b; Reis and Zacarias, 2007), and are effective in the control of pests (Moraes, 1991, 1992). *Iphiseiodes zuluagai* Denmark and Muma, *Amblyseius herbicolus* (Chant), *Euseius alatus* De Leon, *Euseius citrifolius* Denmark and Muma and *Euseius concordis* (Chant) are the most frequent Phytoseiidae mites on coffee trees (Reis *et al.*, 2000b; Mineiro *et al.*, 2006a, 2006b; Reis and Zacarias, 2007).

There are few studies focusing on mites of coffee trees in Brazil and most of them deal only with phytophagous species. Predatory mites, fungivores, and others that are part of the mite fauna in this crop are still poorly studied (Flechtmann, 1967; Pallini Filho *et al.*, 1992; Spongoski *et al.*, 2005; Mineiro *et al.*, 2006a, 2006b). Thus, it is necessary to assess the diversity of mites in the coffee agroecosystem and especially the species that can act as biological control agents, for improving the integrated pest management programs. This study aims to evaluate mite diversity on the leaves and fruits of coffee trees in Monte Alegre do Sul, eastern region of the State of São Paulo, Brazil.

Materials and Methods

The study was conducted in a plantation, *Coffea arabica* L. cv. Novo Mundo at São José farm, located in the municipality of Monte Alegre do Sul (Elev. 919 m, 22°40'734" S; 46°38'996" W), one of the main coffee-growing area of the state of São Paulo. This region is characterised by a high concentration of coffee plantations interspersed with forest fragments. The plants were 30 years old and spaced at 3.0 x 2.0 m. One side of the coffee plantation was bordered by the remains of Atlantic Forest in the Serra da Mantiqueira. The climate of Monte Alegre do Sul is classified as CWA (humid subtropical, with rains in summer and droughts in winter) (Setzer, 1966).

Surveys were conducted monthly from April 4, 2004 to February 11, 2008. For each date, 480 leaves were randomly sampled from 40 plants (12 leaves per plant), taken from the third or fourth pair of leaves from the distal end of a branch, in the middle third of the plant, according to the methodology described by Pallini Filho *et al.* (1992) and Mineiro *et al.* (2006a, 2006b).

From June 2006 to June 2007, six samples of coffee fruits were collected, from 40 plants, with 1,920 fruits obtained per sample. Due to variation in flowering, the collected fruits were those predominant in diameter and colour on the sampled date.

Samples of leaves and fruits were packed in separated paper bags. Each sample was immediately brought to the laboratory inside polystyrene boxes, containing Gelox® to reduce mite activity. For the extraction of mites from leaves and fruits, the collected material was immersed for five minutes in a 70% ethyl alcohol solution. Subsequently, the leaves and fruits were stirred to extract mites, and the solution was filtered through a sieve (with a 0.038 mm mesh). Mites collected on the sieve were stored in 70% alcohol, until analysis. Posteriorly, the mites were mounted on slides in Hoyer´s medium, and for eriophyids a modified Berlese liquid was used for mountings (Walter and Krantz, 2009).

To determine the relation between the mite densities and variables such as temperature and rainfall, a linear regression analyses was performed. The analyses were carried out using BioStat 5.0 program (Ayres *et al.*, 2007). Rarefaction curves were calculated using Past 3.0 program (Hammer *et al.*, 2006).

Results

A total of 16,062 mite specimens belonging to 30 families, 1 Incertae Sedis and 81 species was found. We observed 15,181 individuals and 76 species on leaves and 881 individuals and 29 species on fruits. The Jacknife rarefaction curve estimated 110 species for leaves and fruits (Figure 1A and 1B).

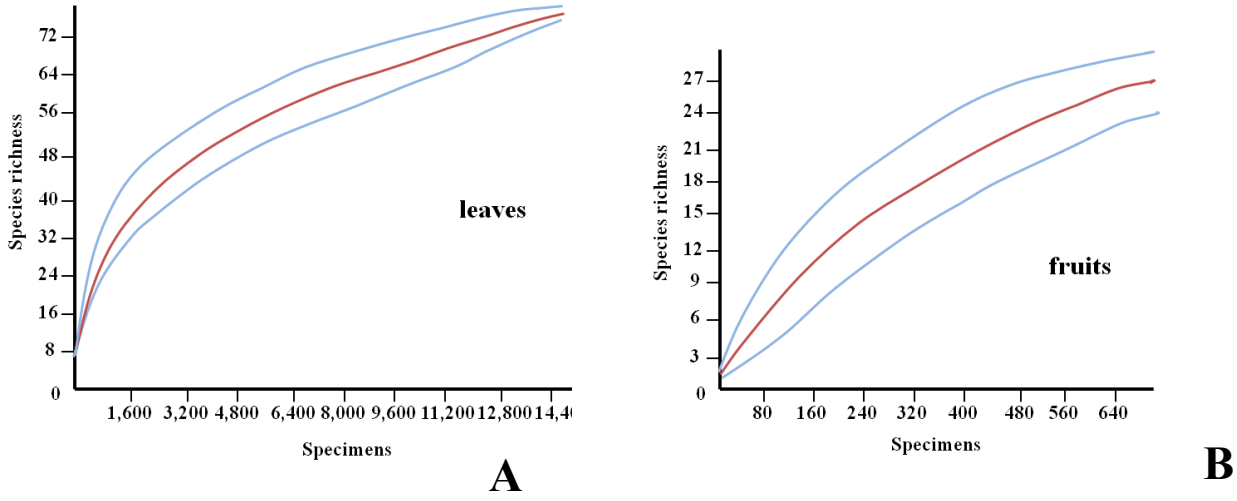

Figure 1 Accumulation curves of species of mites collected on leaves and fruits of *Coffea arabica* cv. Mundo Novo in Monte Alegre do Sul, São Paulo State, Brazil.

Leaves

A total of 1,805 Mesostigmata specimens was observed, belonging to 30 families, 1 Incertae Sedis and 23 species. The phytoseiids mites were the most abundant, with 1,793 specimens. The most abundant and frequent species were *E. alatus*, *A. herbicolus*, *Iphiseiodes matatlanticae* Mineiro, Castro and Moraes and *I. zuluagai* (Table 1).

The Prostigmatid mites contributed to 12,485 individuals, belonging to 17 families and 48 species (approximately 82% of the mites on leaves). The families Tarsonemidae, Tenuipalpidae, and Tetranychidae were the most abundant, together representing 91% of the Prostigmatid mites. *Fungitarsonemus sp*., *Brevipalpus* sp. and *Oligonychus yothersi* (McGregor) were the most abundant and frequent species (Table 2). *Brevipalpus* mites could not be identified to species level, because a recent review (Beard *et al.*, 2015) shows a complex species within *Brevipalpus phoenicis*. Thus, we cannot be sure that 3,983 *Brevipalpus* individuals belong to the same species.

The predatory mites *Zetzellia* sp., *Agistemus brasiliensis* Matioli, Ueckermann and Oliveira, *Armascirus sp.1*, and *Dactyloscirus* sp. were the most frequent and abundant (Table 1). The present work reveals new occurrence of predator mites for coffee plants for the region: *E. alatus*, *A. herbicolus*, *I. matatlanticae*, *Armascirus sp.1* and *Dactyloscirussp.*.

The specimens of four families of Oribatid mites were also observed (35 individuals, 0.2% of mites in leaves). *Oripoda* sp. was the most abundant species of oribatid (Table 1). Within the Astigmatina mites (856 individuals), three families and five species were recorded. *Czenspinskia* sp. and *Tyrophagus* sp. were the most abundant mites. *Czenspinskia* sp. alone represented 63% of the cohort Astigmatina (Table 1).

Fruits

Twenty-one specimens belonging to three families and eight species of Mesostigmatid were observed (2% of mites on fruits). The phytoseiid mites were the most abundant, with 15 specimens (71% of the Mesostigmatid mites individuals recovered on fruits).

Specimens of Prostigmatid mites (852) belonging to nine families and 18 species were observed (97% of the mites on fruits). *Brevipalpus* sp. was the most abundant and frequent

species, representing approximately 92% of Prostigmatid mites. *Exothorhis* sp. was the most abundant and frequent species among the predators (Table 1).

The mites of the suborder Oribatida (*Oripoda* sp.) and cohort Astigmatina (*Tyrophagus* sp. and *Czenspinskia* sp.) were rarely found, with only eight individuals recovered on fruits (Table 1).

Population dynamics on leaf

Euseius alatus was the most abundant and frequent Phytoseiidae species (Table 1), especially in September 2005 and October 2007 (Figure 2). There was a positive correlation between temperature and *E. alatus* densities, but there was a negative correlation with precipitation (Table 2, Figures 2 and 3). *Amblyseius herbicolus* was the second most abundant and frequent species (Table 1), with peaks in April 2004 and April 2006 (Figures 2 and 3). There was a negative correlation between temperature and precipitation and *A. herbicolus* densities (Table 2, Figures 2 and 3). *Iphiseiodes matatlanticae* was frequent (66%) and reached 1.2% of phytoseiid mites (Table 1). However, this species was practically absent in September 2006 (Figure 2). There was a negative correlation between temperature and precipitation and the *I. matatlanticae* population (Table 2, Figures 2, 3).

Table 1 Faunistic analysis of mites recovered on leaves and fruits of coffee *Coffea arabica* L. cv. Mundo Novo, at Municipality of Monte Alegre do Sul, São Paulo State, Brazil, from April 2004 to February 2008.

Family	Species	leaves		fruits	
		Ab	Fr	Ab	Fr
Mesostigmata					
Ascidae	*Asca* sp.	1	1.4	2	33.33
Blattisociidae	*Lasioseius* sp.	3	4.23		
Laelapidae	sp.1	1	1.4		
Melicharidae	*Proctolaelaps bickley*	1	1.4		
Parasitidae	sp.1	2	2.82		
Phytoseiidae	*Amblyseius herbicolus*	397	81.69	3	16.67
	Euseius alatus	1.018	92.95	2	33.33
	Euseius citrifolius	5	5.63		
	Euseius concordis	10	8.45		
	Euseius sp.	1	1.4		
	Iphiseiodes matatlanticae	195	66.2	1	16.67
	Iphiseiodes zuluagai	120	59.15	4	16.67
	Metaseiullus camelliae	2	2.82		
	Neoseiulus sp.	1	1.4		
	Phytoseius woodburyi	1	1.4		
	Phytoseius sp.1	1	1.4		
	Phytoseius sp.2	1	1.4		
	Proprioseiopsis cannaensis	1	1.4		
	Proprioseiopsis dominigos	29	26.76	3	33.33
	Proprioseiopsis sp.	1	1.4		
	Typhlodromalus sp.	1	1.4		
	Typhlodromus transvaalensis	9	11.27	2	16.67
Incertae Sedis	*Africoseius* sp.	4	5.63	4	
Prostigmata					
Bdellidae	*Hexabdella cinquaginta*	8	8.45	2	33.33
	Spinibdella denheyeri	3	4.23		
	Spinibdella sp.	4	4.23		
Cheyletidae	*Cheletogenes* sp.			1	16.67
	Cheletomimus sp.			1	16.67
	Cheyletus sp.	2	1.4		
	Prosocheyla sp.			2	33.33
Cunaxidae	*Armascirus* sp.1	86	45.07		
	Armascirus sp.2	1	1.4		
	Armascirus sp.3	11	7.04		
	Armascirus sp.4	4	5.63		
	Dactyloscirus sp.	33	14.08		
Diptilomiopidae	*Catarhinus* sp.	9	11.27		
Eriophyidae	*Aceria* sp.	8	8.45		
	Phyllocoptruta sp.	3	4.23		
	Tetra sp.	1	1.4		
Erythreioidea	sp.1	1	1.4		
Eupalopsellidae	*Exothorhis* sp.	4	4.23	11	100.0
Eupodidae	*Eupodes* sp.	3	4.23		
Iolinidae	*Homeopronematus* sp.	66	22.54	1	16.67
	Parapronematus acaciae	13	15.49	3	16.67
	Parapronematus sp.	5	2.82		
Pygmephoridae	sp.1	1	1.4		
Raphignathidae	*Raphignathus* sp.	1	1.4		
Stigmaeidae	*Agistemus brasiliensis*	146	43.66	1	16.67
	Agistemus floridanus	8	7.04		
	Agistemus sp.			1	16.67
	Zetzellia malvinae	26	9.86		
	Zetzellia sp.	218	66.2	3	33.33
Tarsonemidae	*Daidalotarsonemus* sp.			1	16.67
	Fungitarsonemus sp.	4.266	91.55	4	16.67
	Polyphagotarsonemus latus	12	12.68	1	16.67
	Tarsonemus confusus	1	1.4	1	16.67
	Tarsonemus sp.	11	12.68		
Tenuipalpidae	*Brevipalpus* sp.	3.983	98.59	810	100.0
	Tenuipalpus sp.	1	1.4		
Tetranychidae	*Aponychus* sp.	1	1.4		
	Eutetranychus sp.	1	1.4		
	Oligonychus yothersi	3.118	1.4	3	
	Oligonychus sp.	1	98.59		33.33
	Tetranychus sp.	60	25.35		
Tuckerellidae	*Tuckerella pavoniformis*	1	1.4		
Tydeidae	*Brachytydeus formosa*	63	43.66	2	16.67
	Brachytydeus sp.1	291	43.66	4	50.0
	Brachytydeus sp.2	5	1.4		
	Brachytydeus sp.3	3	4.23		
	Brachytydeus sp.4	1	1.4		
	Tydeus sp.	1	1.4		
Oribatida					
Cymbaeremaeidae	*Scapheremaeus* sp.	5	5.63		
Epilohmanniidae	*Epilohmannia* sp.	2	2.82		
Haplochtoniidae	*Haplochthonius* sp.	7	9.86		
Oripodidae	*Oripoda* sp.	20	11.27	3	50.0
	Oripodidae new gen.	1	1.4		
Cohort Astigmatina					
Acaridae	*Neotropacarus* sp.	8	1.4		
	Tyrophagus sp.	192	57.75	2	33.33
Histiostomatidae	*Histiostoma* sp.	1	1.4		
Winterschmidtiidae	*Czenspinskia* sp.	626	46.48	3	33.33
	Winterschmidtiidae sp.1	29	9.86		

Ab = Abundance; Fr = Frequency

Table 2 Relationship between *Brevipalpus* sp., *Oligonychus yothersi*, *Euseius alatus*, *Amblyseius herbicolus*, *Iphiseiodes matatlanticae* and *Agistemus brasiliensis* and the variables: temperature and precipitation. From April 2004 to February 2008.

variable	linear regression	*r*	F	d,f,	*p*
Oligonychus yothersi x temperature	y = 20.6501 + 0.0382x	-0.015	0.3223	46	0.5798
Oligonychus yothersi x precipitation	y = 139.1536 - 2.6033x	-0.0036	0.8372	46	0.6319
Amblyseius herbicolus x temperature	y = 21.1755 - 0.3857x	0.0408	29 543	46	0.0888
Amblyseius herbicolus x precipitation	y = 140.8809 - 12.4836x	0.0143	16 654	46	0.2008
Euseius alatus x temperature	y = 20.6598 + 0.0939x	-0.0188	0.1518	46	0.7005
Euseius alatus x precipitation	y = 139.844 - 7.288x	-0.0108	0.5097	46	0.5142
Agistemus brasiliensis x temperature	y = 20.6502 + 0.9524x	0.0078	13 634	46	0.2477
Agistemus brasiliensis x precipitation	y = 128.8636 - 0.4252x	-0.0222	0.0001	46	0.9871
Iphiseiodes matatlanticae x temperature	y = 21.4864 - 1.6354x	0.1131	68 645	46	0.0115
Iphiseiodes matatlanticae x precipitation	y = 148.6595 - 47.4711x	0.0408	29 574	46	0.0887
Brevipalpus sp. *x temperature*	y = 20.0901 + 0.1272x	0.0566	3 762	46	0.0557
Brevipalpus sp. *x precipitation*	y = 118.0006 + 1.9292x	-0.0122	0.4457	46	0.5147

The tenuipalpid *Brevipalpus* sp. was the most abundant phytophagous species (25% of all mites) and the most frequently observed (99%) (Table 1). The highest peaks were observed in April 2004, February 2005, March and October 2006 (Figure 2). There was a positive correlation between temperature and precipitation and the densities of *Brevipalpus* sp. (Table 2, Figures 2, 3). *Oligonychus yothersi* represented 19% of the total mites and was the most frequent phytophagous species (99%) (Table 1). There was a positive correlation between temperature and *O. yothersi* densities and a negative correlation with precipitation (Table 2, Figures 2, 3).

Discussion

The numbers of specimens and species collected in this study are similar to those reported by Mineiro *et al.* (2006b) in the municipalities of Garça and Jeriquara, SP, in the central-western and northeast regions of the state of São Paulo, respectively. However, the mite populations were much higher than that observed in state of Minas Gerais by Pallini Filho *et al.* (1992) and Marchetti (2008). The mite diversity on leaves was higher than on fruits, probably due to the higher sampling effort for leaves. Furthermore, the leaves exhibit a greater surface area and they are present for more months than fruits.

Oligonychus yothersi was the most abundant and frequent pest mite, similarly to the studies of Mineiro *et al.* (2008) in the municipality of Atibaia (Sao Paulo), and of Marchetti (2008) in Machado, Patrocínio and Viçosa (Minas Gerais). The species most commonly found in coffee in Brazil is *O. ilicis* (Flechtmann, 1967; Heinrich, 1972; Pallini Filho *et al.*, 1992; Mineiro *et al.*, 2006a, 2006b). In Costa Rica and Colombia, *O. yothersi* infestations are reported on coffee trees, with leaf tanning identified as a symptom (Orozco-Hoyos *et al.*, 1990; Ochoa *et al.*, 1991). In a survey conducted by Mineiro *et al.* (2008) in Atibaia, there were no symptoms found of tanning on coffee plants. In the present study, no symptoms of leaf tanning were observed.

Phytoseiid mites presented the highest richness of species among predatory mites. Some studies have shown that phytoseiid mites are associated with phytophagous species (Moraes, 1991, 1992; Pallini Filho *et al.*, 1992; McMurtry and Croft, 1997; Reis *et al.*, 2000a; Mineiro *et al.*, 2006a, 2006b, 2008), which may contribute to mite pest control. In the present study, *E. alatus* was the most abundant and frequent phytoseiid mite. This differs from the observations of Mineiro *et al.* (2006a, 2006b), who found no individual of this species in these surveys.

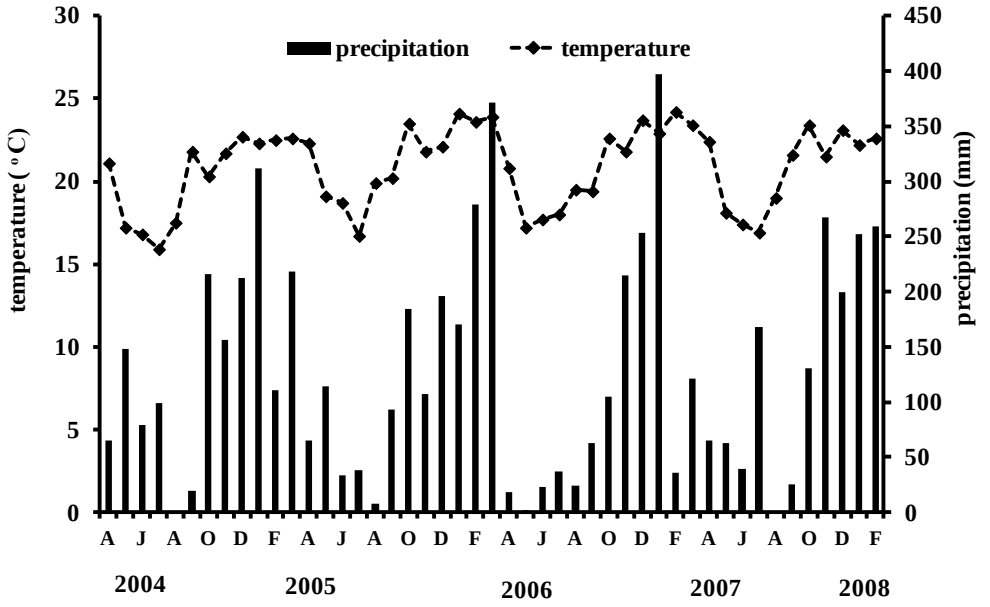

Figure 2 Population fluctuation of *Brevipalpus* sp., *Oligonychus yothersi*, *Euseius alatus*, *Amblyseius herbicolus*, *Iphiseiodes matatlanticae* and *Agistemus brasiliensis* in *Coffea arabica* cv. Mundo Novo plantation, in Monte Alegre do Sul municipality, São Paulo State, Brazil. Period from April 2004 to February 2008.

Euseius species have been reported as effective predators of various species of phytophagous mites in several crops. *Euseius alatus* is mainly reported in citrus orchards (Moraesand McMurtry, 1983; Sato *et al.*, 1994), coffee (Moraes and McMurtry, 1983; Pallini Filho *et al.*, 1992) in the Southeast, and many other plants in the Brazilian Northeast region (Moraes *et al.*, 1993). *Amblyseius herbicolus* was also frequent and abundant predatory mite, as also reported by Reis *et al.* (2007) and Marchetti (2008), in coffee regions of Minas Gerais, and São Paulo (Mineiro *et al.*, 2019). Pallini Filho *et al.* (1992) concluded that this species is found in association with pest mites, and that result is promising in terms of biological control. The predation and oviposition rates of *A. herbicolus* increase as the population density of *Brevipalpus* increases (Reis *et al.*, 2007). *Iphiseiodes zuluagai* was also reported in coffee trees in Minas Gerais (Marchetti, 2008; Silva *et al.*, 2010). Mineiro *et al.* (2006b) did not record *I. zuluagai* in the Garça or Jeriquara regions (Sao Paulo state), although this species is frequently encountered in coffee trees in Brazil (Flechtmann, 1967; Pallini Filho *et al.*, 1992; Matos *et al.*, 2004; Spongoski *et al.*, 2005; Mineiro and Sato, 2008; Mineiro *et al.*, 2008; Silva *et al.*, 2010). The presence of *I. zuluagai* in coffee crops might be relevant for mite pest management, as predation of Tenuipalpid and Eriophyid pests on citrus has already been proven (Gravena, 1993; Gravena *et al.*, 1994; Sato *et al.*, 1994; Yamamoto and Gravena, 1996). According to Reis *et al.* (2000b), *I. zuluagai* can be an important predator of mite species in coffee crops.

Stigmaeid mites are biological control agents in various crops, and are considered the second most important predatory mites, after the phytoseiid mites (Matioli *et al.*, 2002). Studies have shown that stigmaeid mites can control mite pests, as *Brevipalpus*, *Phyllocoptruta oleivora* (Ashmead), *Panonychus citri* (McGregor), and *O. ilicis* (Matioli *et al.*, 1998; Reis *et al.*, 2000a; Sato *et al.*, 2002). The Stigmaeid species reported in this study were similar to those reported by Mineiro *et al.* (2006a) in coffee trees in the Garça region. In Jeriquara, Mineiro *et al.* (2006b) reported *Zetzellia malvinae* Matioli, Ueckermann and Oliveira as one of the most frequent predators. Furthermore, Matioli *et al.* (2002) observed higher oviposition of *A. brasiliensis* when supplied with *Brevipalpus* in comparison with other preys. According

to Matioli and Oliveira (2007), *A. brasiliensis* has a prey preference for *Brevipalpus*. However, it also feeds on *O. ilicis,* and thus can be used as a natural biological control agent in coffee plantations in the South and Southeast of the state of São Paulo.

The results of the present study indicated a high richness of mite species on coffee plants in the municipality of Monte Alegre do Sul. However, when compared to other surveys performed in the states of São Paulo and Minas Gerais (Pallini Filho *et al.*, 1992; Spongoski *et al.*, 2005; Mineiro *et al.*, 2006a, 2006b; Marchetti, 2008), some differences in mite diversity were observed. These differences might be due to biotic and abiotic factors such as the surrounding vegetation, soil type, geographical conditions, and precipitation. Further studies are necessary

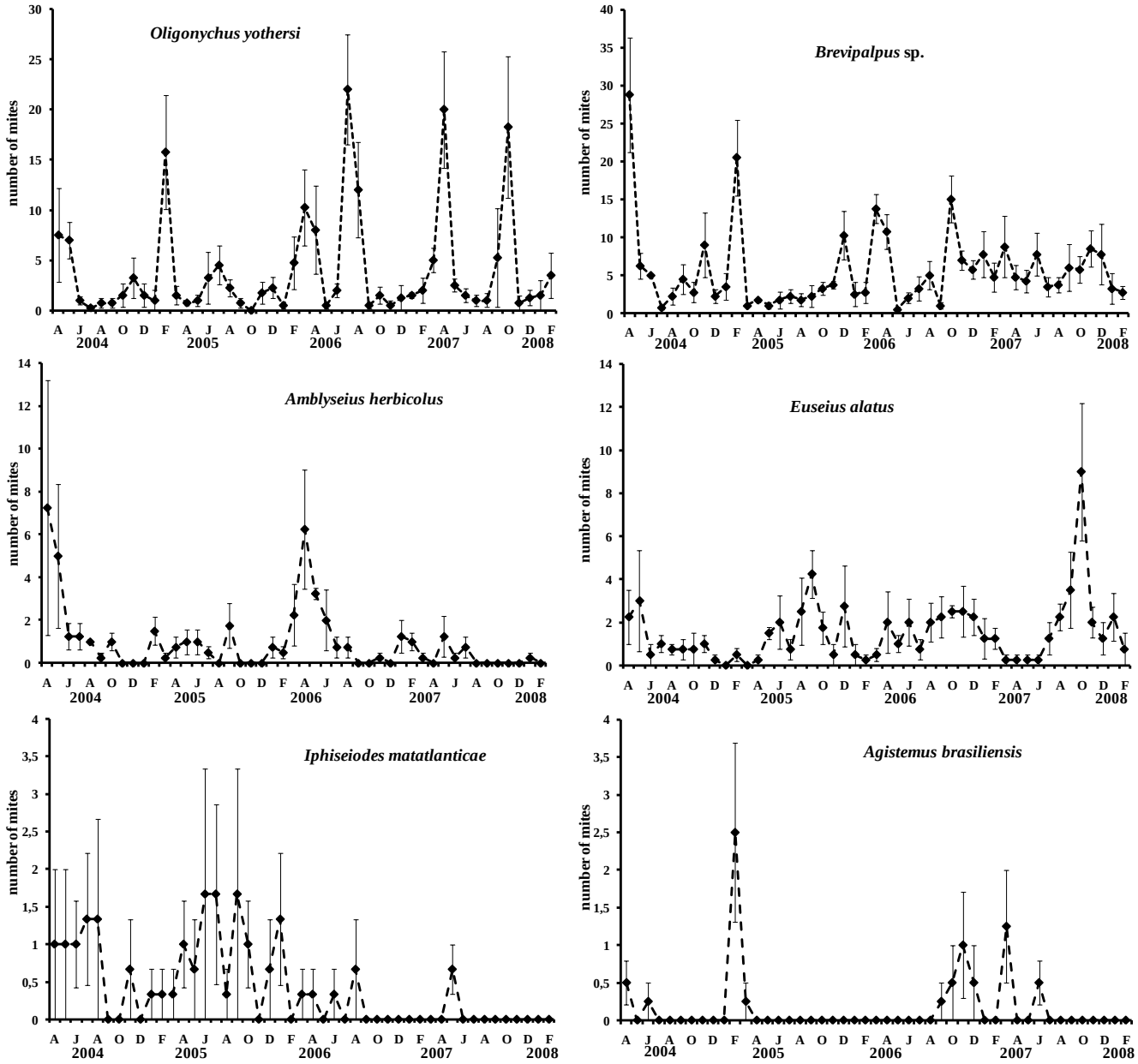

Figure 3 Temperature (°C) and precipitation (mm) in *Coffea arabica* cv. Mundo Novo plantation, in Monte Alegre do Sul municipality, São Paulo State, Brazil. Period from April 2004 to February 2008.

to better understand these interactions and to propose adequate management for an effective biological control.

Acknowledgements

Thanks are offered to the APTA Leste Paulista (Monte Alegre do Sul, SP), for operational support of this study; and to Sr. Valdir Rossi, owner of São José farm, for allowing access to the area for this research; and to Embrapa-Café (Consórcio Pesquisa Café) for the scholarship to the second author; also, thanks go to CNPq-Brazil (The National Council for Scientific and Technological Development) for the research fellowship provided to the third and fourth authors.

References

Ayres M., Ayres Jr. M., Ayres D.L., Santos A.S. 2007. BioEstat 5.0. Aplicações estatísiticas nas áreas das ciências biomédicas. Belém. Sociedade Civil Mamirauá. CNPq. 324pp.

Beard J.J., Ochoa R., Braswell W.E., Bauchan G. 2015. *Brevipalpus phoenicis* (Geijskes) species complex (Acari: Tenuipalpidae), a closer look. Zootaxa, 3944(1): 1-67. doi:10.11646/zootaxa.3944.1.1

Flechtmann C.H.W. 1967. Ácaros do cafeeiro. Anais da Escola Superior de Agricultura Luiz de Queiroz, 24: 91-95. doi:10.1590/S0071-12761967000100009

Gravena S. 1993. Manejo integrado de pragas dos citros: adequação para o manejo integrado do solo. Laranja, 14: 401-419.

Gravena S., Benetoli I., Moreira P.H.R., Yamamoto, P.T. 1994. *Euseius citrifolius* Denmark and Muma predationon citrus leprosis mite *Brevipalpus phoenicis* (Geijskes) (Acari: Phytoseiidae: Tenuipalpidae). Anais da Sociedade Entomológica do Brasil, 23: 209-218.

Heinrich W.O. 1972.Contribuição ao estudo da biologia do *Oligonychus* (*Oligonychus*) *ilicis* (Acarina: Tetranychidae). Tese de Doutoramento. Universidade de São Paulo, Escola Superior de Agricultura "Luiz de Queiroz". 116pp.

MAPA. 2017. Ministério da Agricultura, Pecuária e Abastecimento. Café no Brasil. (http://www.agricultura.gov.br/assuntos/politica-agricola/cafe/cafeicultura-brasileira accessed on 31st July 2018).

Marchetti M.M. 2008. Ácaros do cafeeiro em Minas Gerais com chave de identificação. Dissertação de Mestrado. Universidade Federal de Viçosa. Viçosa, MG. 159pp.

Matioli A.L., Leite G.L.D., Pallini Filho A., Picanço M. 1998. Distribuição espacial e temporal e efeitos de diferentes tratos culturais em ácaros associados à laranja Pêra-Rio. Agro-Ciência, 14: 395-405.

Matioli A.L., Ueckermann E.A., Oliveira, C.A.L. 2002. Some stigmaeid and eupalopsellid mites from citrus orchards in Brazil (Acari: Stigmaeidae and Eupalopsellidae). International Journal of Acarology, 28: 99-120. doi:10.1080/01647950208684287

Matioli A.L., Oliveira C.A.L. 2007. Biologia de *Agistemus brasiliensis* Matioli, Ueckermann and Oliveira (Acari: Stigmaeidae) e sua potencialidade de predação sobre *Brevipalpus phoenicis* (Geijskes) (Acari: Tenuipalpidae). Neotropical Entomology, 36: 577-582. doi:10.1590/S1519-566X2007000400016

Matos C.H.C., Pallini A., Chaves F.F., Galbiati C. 2004. Domácias do cafeeiro beneficiam o ácaro predador *Iphiseiodes zuluagai* Denmark and Muma (Acari: Phytoseiidae)?. Neotropical Entomology, 33: 57-63. doi:10.1590/S1519-566X2004000100011

McMurtry J.A., Croft B.A. 1997. Life-styles of phytoseiid mites and their roles in biological control. Annual Review of Entomology, 42:291-321. doi:10.1146/annurev.ento.42.1.291

Mineiro J.L.C., Sato M.E. 2008. Ácaros plantícolas e edáficos em agroecossistema cafeeiro. O Biológico, 70: 25-28.

Mineiro J.L.C., Sato M.E., Berton L.H.C., Raga A. 2019. Mites (Arachnida: Acari) on coffee plants in forest fragment and conventional plantation in Monte Alegre do Sul, State of São Paulo, Brazil. O Biológico, 81(1): 1-30. doi:10.31368/1980-6221v81a10004

Mineiro J.L.C., Sato M.E., Raga A., Arthur V., Cangani K.G., Barbosa F.V. 2006a. Diversidade de ácaros (Arachnida: Acari) em cinco cultivares de duas espécies de cafeeiros (*Coffea* spp.) em Garça, Estado de São Paulo. Arquivos do Instituto Biológico, 73: 333-341.

Mineiro J.L.C., Sato M.E., Raga A., Arthur V., Moraes G.J., Sarreta F.O., Carrijo, A. 2006b. Diversidade de ácaros (Arachinda: Acari) em *Coffea arabica* L.cv. Mundo Novo, nos municípios de Jeriquara e Garça, Estado de São Paulo. Biota Neotropica, 6: 1-15. doi:10.1590/S1676-06032006000200012

Mineiro J.L.C., Sato M.E., Raga A., Souza Filho M.F., Spongoski S. 2008. Incidência de ácaros em cafeeiro cv. Catuaí Amarelo. Bragantia, 67: 197-201. doi:10.1590/S0006-87052008000100024

Moraes G.J. 1991. Controle biológico de ácaros fitófagos. Informe Agropecuário, 15: 56-62.

Moraes G. J. 1992. Perspectivas para o uso de predadores no controle de ácaros fitófagos no Brasil. Pesquisa Agropecuária Brasileira, 27: 263-270.

Moraes G.J., Alencar J.A., Lima J.L.S.,Yaninek J.S., Delalibera Jr. I. 1993. Alternative plant habits for common phytoseiid predators of the cassava green mite (Acari: Phytoseiidade, Tetranychidae) in Northeast Brazil. Experimental and Applied Acarology, 17: 77-90. doi:10.1007/BF00156945

Moraes G.J. de, McMurtry J.A.1983. Phytoseiid mites (Acarina) of northeastern Brazil with descriptions of four new species. International Journal of Acarology, 9: 131-148. doi:10.1080/01647958308683326

Ochoa R., Aguilar H., Vargas C. 1991. Ácaros fitofagos de America Central: Guia ilustrada.Turrialba: CATIE, 251pp.

Orozco-Hoyos J., Duque-Echeverry M.C., Meso-Cobo N.C. 1990. Efecto de la temperatura sobre la tabla de vida de *Oligonychus yothersi* em *Coffea arabica*. Cenicafé, 41: 5-18.

Pallini Filho A., Moraes G.J., Bueno V.H.P. 1992. Ácaros associados ao cafeeiro (*Coffea arabica* L.) no Sul de Minas Gerais. Lavras, MG. Ciência and Prática, 16: 303-307.

Reis P.R., Altoé B.F., Franco R.A. 2007. Controle de Ácaros-praga em Cafeeiro com Produto de Efeito Fisiológico e o Impacto Sobre Ácaros Benéficos. Coffee Science, 2:123-134.

Reis P.R., Souza J.C. 1986. Pragas do cafeeiro. In: RENA, A. B. et al. (Eds.). Cultura do cafeeiro: fatores que afetam a produtividade. Piracicaba: POTAFOS, p. 323-378.

Reis, P.R. and Souza, J.C. and Pedro Neto, M. (2000a) Flutuação populacional do ácaro da mancha-anular do cafeeiro e seus inimigos naturais. In: Simpósio de pesquisa dos cafés do Brasil. EMBRAPA/CAFÉ 2:1490.

Reis, P.R., Teodoro A.V., Pedro Neto M. 2000b. Predatory activity of Phytoseiidae mites on the developmental stages of coffee ringspot mite (Acari: Phytoseiidae: Tenuipalpidae). Anais da Sociedade Entomológica do Brasil, 29: 547-553. doi:10.1590/S0301-80592000000300017

Reis P.R., Zacarias M.S. 2007. Ácaros em cafeeiro. Belo Horizonte. EPAMIG. Boletim Técnico, 81. 76pp.

Sato M.E., Mineiro J.LC., Raga A., Mendonça M.J.C., Barbosa F.V. 2002. Ácaros fitófagos e predadores em diferentes cultivares de *Coffea* spp., em Garça, SP. In: Congresso Brasileiro de Pesquisas Cafeeiras, Caxambu, MG. Trabalhos apresentados... Rio de Janeiro: MAPA/PROCAFÉ. p.283-284.

Sato M.E., Raga A.,Cerávolo L.C., Rossi A.C.,Potenza M.R. 1994.Ácaros predadores em pomar cítrico de Presidente Prudente, Estado de São Paulo. Anais da Sociedade Entomológica do Brasil, 23: 435-441.

Setzer J. 1966. Atlas climático e ecológico do Estado de São Paulo. Comissão Interestadual da Bacia Paraná-Uruguai e Centrais Elétricas de São Paulo, São Paulo. 186pp.

Silva E.A., Reis P.R., Zacarias M.S., Marafeli P.P. 2010. Fitoseídeos (Acari: Phytoseiidae) associados a cafezais e fragmentos florestais vizinhos. Ciência e Agrotecnologia, 34: 1146-1153. doi:10.1590/S1413-70542010000500010

Spongoski S., Reis P.R., Zacarias M.S. 2005. Acarofauna da cafeicultura de cerrado em Patrocínio, Minas Gerais. Ciência e Agrotecnologia, 29: 9-17. doi:10.1590/S1413-70542005000100001

Walter D.E., Krantz G.W. 2009. Collecting, rearing and preparing specimens. In: Krantz, G.W. and Walter, D.E. (Eds.). A manual of acarology. 3rd edition. Texas Tech University Press. USA. 807pp.

Yamamoto P.T.,Gravena S. 1996. Influência da temperatura e fontes de alimento no desenvolvimento e oviposição de *Iphiseiodes zuluagai* Denmark and Muma (Acari: Phytoseiidae). Anais da Sociedade Entomológica do Brasil, 25: 109-115.