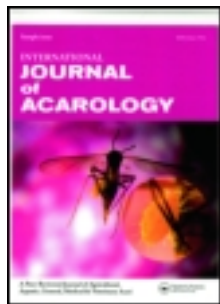


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Mites on grapevines in northeast Brazil: occurrence, population dynamics and within-plant distribution

Cleiton A. Domingos^a, José W.S. Melo^a, José E.M. Oliveira^b and Manoel G.C. Gondim Jr^a

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Mite pests are some of the major limiting factors affecting grape production in the world. Despite the economic importance of the grapevines and the damage to them caused by some of the phytophagous mites in northeast Brazil, little is known about the mite fauna associated with this crop. The present study aimed to identify the mite fauna associated with grapevine, to evaluate the fluctuation of the populations of the most frequent species of phytophagous mites and their associated predators over a 12-month period as well as their within-plant distribution. Considering all varieties sampled, *Tetranychus urticae* Koch and *Oligonychus mangiferus* (Rahman & Sapiro) comprised 74% of phytophagous mites. *Euseius citrifolius* Denmark & Muma and *Neoseiulus idaeus* Denmark & Muma comprised more than 80% of Phytoseiidae mites. The population dynamics study was conducted in a vineyard of Sagraone and a vineyard of Itália Muscat varieties. In these fields, *E. citrifolius* occurred at low population levels throughout the year, whereas *N. idaeus* was found only when high densities of *T. urticae* were observed. Tetranychidae and Phytoseiidae showed the same pattern of within-plant distribution, being found in higher densities on basal and median leaves and rarely they were found on apical leaves.

Keywords: *Tetranychus urticae*; *Oligonychus mangiferus*; *Euseius citrifolius*; *Neoseiulus idaeus*; natural enemy; Phytoseiidae; biological control

Introduction

Grapevine (*Vitis vinifera* L.) is cultivated in most of Brazil. In the last decade, the area cultivated to grapes in this country increased by about 16.5% (Pommer and Barbosa 2009). In the southern region of Brazil, more than 90% of the production of this crop are used for wine production, whereas in the southeastern region, more than 98% of the total production is destined for fresh consumption (Pommer 2003). In the northeastern region, more than 90% of the production is also for fresh consumption in the international market (Guimarães 2007). In this region, grapevines are cultivated mainly in the large municipalities of Petrolina and Juazeiro; 10,000 ha are dedicated to this crop in this region (Mello 2012).

Pests are considered to be among the most limiting factors of grapevine cultivation in northeastern Brazil by the local growers. Calendar-based prophylactic sprays are made routinely for mite control in most of the commercial vineyards of this region.

An alternative strategy for pest mite control is the use of predatory mites (McMurtry and Croft 1997; Moraes and Flechtman 2008). Phytoseiid predatory mites are extensively used for that purpose in different countries (Duso and De Lillo 1996; Kreiter et al. 2000; Papaioannou-Souliotis et al. 2000; Johann et al. 2009; Ferla et al. 2011; Johann and Ferla 2012).

Despite the economic importance of grapevines in northeast Brazil and the damage mites cause to them, little is known about the mite fauna associated with this crop in that region. The objective of the present work was to

identify the mite species found on this crop, to evaluate the fluctuation of the populations of the most frequent species of phytophagous mites and their associated predators over a 12-month period, and to evaluate their within-plant distribution, in northeastern Brazil.

Materials and methods

The work was conducted in commercial vineyards in the municipalities of Petrolina and Juazeiro, Pernambuco and Bahia states, respectively (Figure 1), from September 2008 to August 2009. This is an arid area where the rainy season is concentrated between January and April; according to the classification of Köppen (Kottek et al. 2006), the climate in this region is classified as BSwH type.

Population dynamics and within-plant distribution

The study was conducted in a vineyard of Sagraone and a vineyard of Itália Muscat varieties between September 2008 and August 2009. During the experiment, the fields were managed by growers, according to regular procedures, involving weekly applications of fungicides (thiofanate-methyl, difenoconazole and cyproconazole) and monthly applications of insecticides (imidacloprid, lambda-cyhalotrin and permethrin) and acaricides (abamectin, bifenthrin and carbosulfan) during the vegetative phase of the crop. No chemicals were applied in the reproductive phase (from flowering to harvesting).

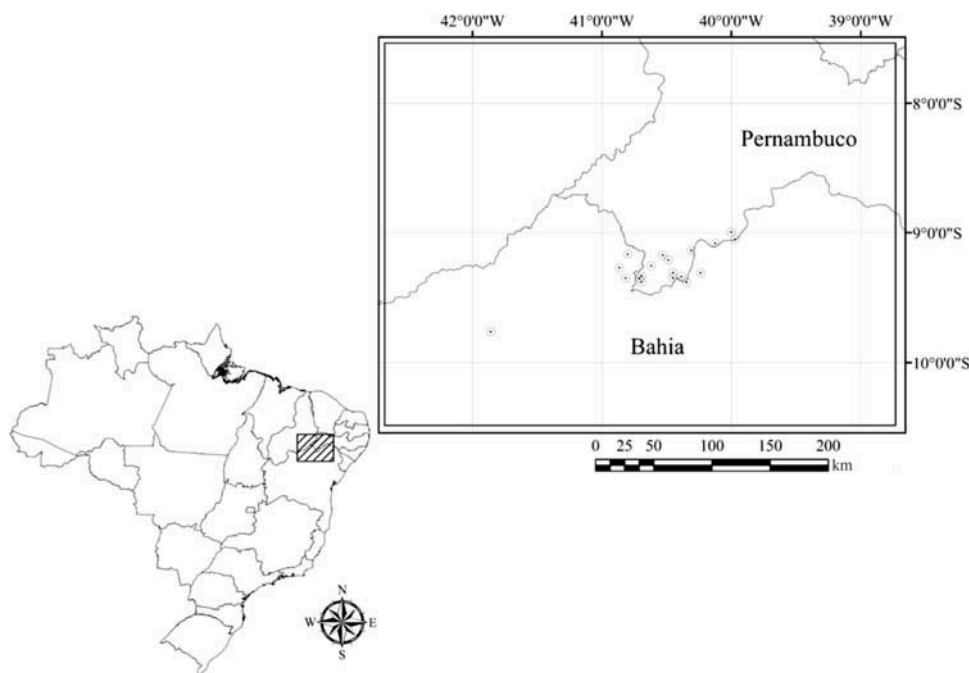


Figure 1. Sites where mites were collected on different hosts between September 2008 and August 2009, the sub-medium San Francisco Valley (Pernambuco and Bahia), Brazil.

Monthly leaf samples were taken from 12 grapevines randomly chosen from each vineyard. A leaf was taken from each section (apical, median and basal) of each branch of foliage strata (apical, median and basal) of each grapevine. Each leaf was placed in a plastic bag and transported in coolers to the laboratory, where the leaves were stored in a refrigerator (at approximately 10°C) for up to 5 days until inspected under a stereomicroscope. Mites preliminarily identified as *Tetranychus urticae* Koch or *Oligonychus mangiferus* (Rahman & Sapra), both Tetranychidae, were counted, and approximately 50 specimens of each of these were taken at random (including adults and immatures) and mounted in Hoyer's medium for later confirmation of the identification. All other phytophagous mites (Tarsonemidae and Tenuipalpidae), as well as all phytoseiid mites, were mounted in Hoyer's medium for identification and counting. Other predatory mites were not considered due to their low abundance. Only species of the most frequently observed phytophagous and predatory mite families were considered. Temperature, relative humidity and rainfall during the evaluation period were recorded at the weather station closest to each vineyard: Sagraone variety, 16 km from the station; Itália Muscat variety, 66 km from the station.

To investigate the possible variation in mite densities (tetranychid and phytoseiid) between leaves sampled from different parts of the branch, we used the PROC GLM of SAS (SAS Institute 2002), to test whether the density (mite/leaf) counted on a leaf (y) depended on the "site", "date", "branch" and "leaf" from which the observation originated. Site and branch were treated as fixed factors, whereas the remaining factors were random, with "sampling dates" nested within "sites" and "leaf" nested within "branch".

Given that the model assumes that the residuals are normally distributed with homogenous variance, we used a logarithmic transformation of the dependent variables done to meet these requirements [i.e. $y = \log(y + 1)$]. The Tukey–Kramer test was used to compare the levels within the "dates", "sites" and "leaf". P -values <5% were considered significant after protecting against experiment-wise error.

Complementary determination of the mite fauna

To complement the evaluation of the mite fauna, leaf samples were also taken in January and July 2009 from a vineyard of each of the following varieties: Benitaka, Chenin Blanc, Sagraone, Itália, Shiraz and Thompson (Figure 1). The procedure adopted was exactly the same mentioned for the evaluation of the population dynamics and within plant distribution. To facilitate interpretation, data obtained in the vineyards considered in the population dynamics study were pooled with data obtained in the additional vineyards for the analyses.

Results

Population dynamics and within-plant distribution

Tetranychus urticae, *O. mangiferus* and *Polyphagotarsonemus latus* (Banks) comprised 95% of the phytophagous mites found on Sagraone variety. The highest densities of *T. urticae* and *O. mangiferus* were 87.8 and 7.9 mites/leaf, respectively, on the second sampling date (October 2008) (Figures 2A and C), when rainfall and relative humidity levels were low, temperatures were relatively high and pesticide application was not done.

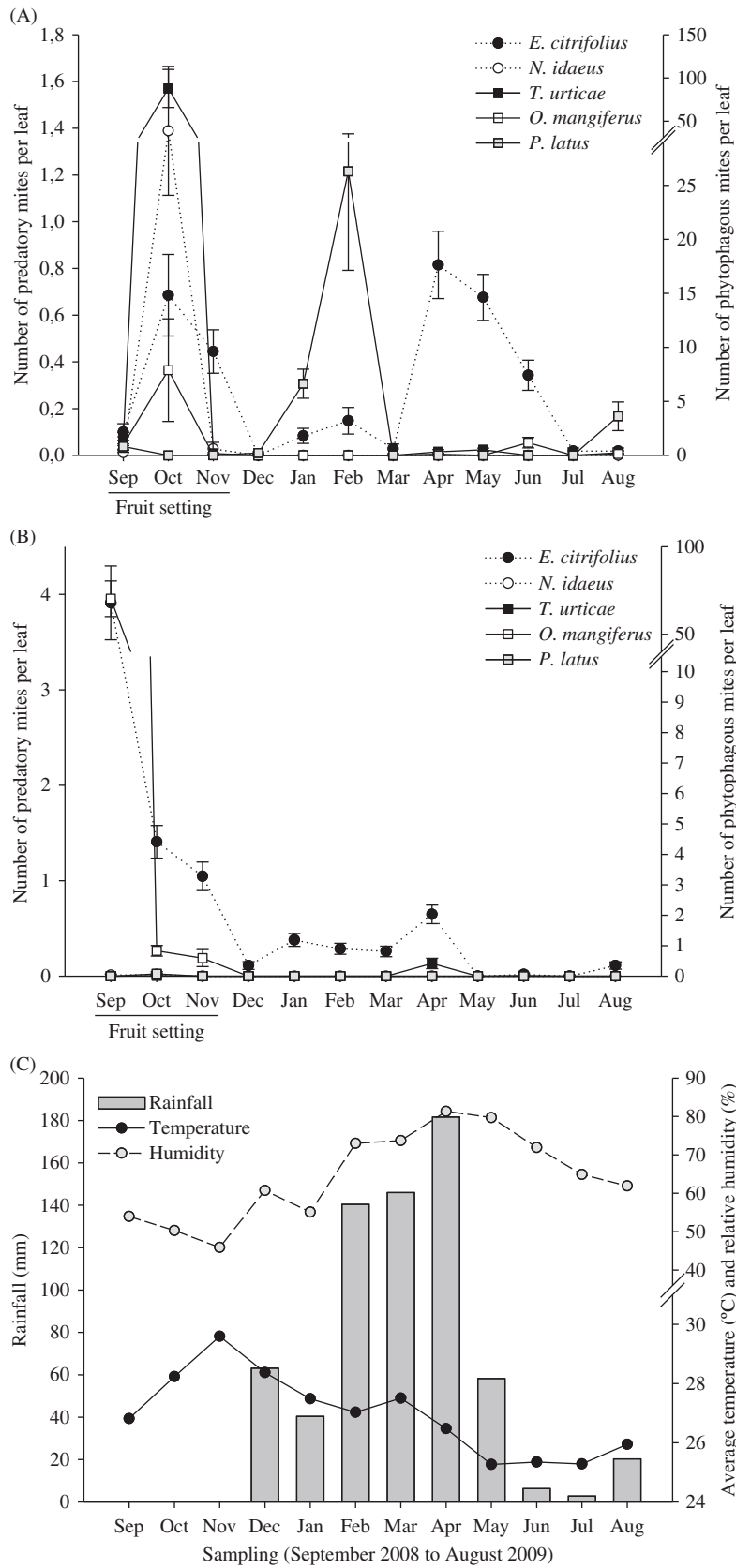


Figure 2. Mean numbers (and corresponding standard errors) of Phytophagous and predaceous Phytoseiidae mites per leaf in Sugraone (A) and Itália varieties (B), as well as monthly rainfall (mm), average temperature (°C) and average humidity (%) (C), between September 2008 and August 2009. Fruit setting correspond to the period inflorescence and fruit-ripening when pesticides were not applied.

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Their densities then decreased quickly to levels of less than 1 mite/leaf, with the concurrent increased levels of rainfall and humidity and decreased levels of temperature (December–August). *Neoseiulus idaeus* Denmark & Muma was found only in October 2008, when the peak population density of the tetranychid mites occurred. However, it was found only on leaves infested by *T. urticae*.

The highest density of *P. latus* was 26.3 mites/leaf; it occurred much later than the period when the peak population of the tetranychids was observed; densities then decreased quickly to levels of less than 1 mite/leaf, with a small new increase in the last sampling date (August 2009), when 3.6 mites/leaf were found. *Euseius citrifolius* Denmark & Muma comprised 90% of the phytoseiid found on these plants. *Euseius citrifolius* was found in sampling dates, reaching a maximum of 0.8 mites/leaf in April, coinciding with the peak rainfall.

The species most frequently found on plants of the Italia Muscat variety were the phytophagous mite *O. mangiferus* and the predatory mite *E. citrifolius*. The peak population densities of both species (70.3 and 3.9 mites/leaf, respectively) occurred on the first sampling date (September 2008). The densities then decreased rapidly afterward, to levels of less than 1 mite/leaf, remaining so until the end of the study. *Tetranychus urticae*, *N. idaeus* and *P. latus* were each found in less than three sampling dates, always at densities of less than 1 mite/leaf.

The general linear model fitted to the data for tetranychid mites in both of the sampling sites explained 67% of the total variation in the data ($F_{31,184} = 12.00$; $P < 0.0001$). The nesting of “sampling dates” within “sites” and “leaf” within “branch” were significant ($P < 0.0496$), whereas neither “sites” nor “branch” contributed significantly to the total variation in the data (Table 1). Post hoc tests showed that for plants of both the Sagraone and Itália Muscat varieties, more tetranychid mites were found during the reproductive phase (the period when pesticides were not applied); that leaves of the apical branch section of the branch carried significantly fewer tetranychid mites than leaves of the other sections independently of the foliage stratum; and that tetranychid mite populations on leaves of the median and basal branch sections were not significantly different.

Independently of the variety *P. latus* occurred at a low frequency. In addition, these mites were found only on apical leaves, regardless of the branch from which the leaves were collected. Because of the low frequency with which they were found, these mites were not subjected to statistical analysis.

The general linear model fitted to the phytoseiid data in both sampling sites explained 74% of the total variation in the data ($F_{31,184} = 17.33$; $P < 0.0001$). “sites”, “sampling dates” nested within “sites”, and “leaf” nested within “branch” were highly significant ($P < 0.0008$), whereas “branch” did not contribute significantly to the total variation in the data (Table 2). Post hoc tests showed that plants of the Sagraone variety hosted significantly more

Table 1. Total number and percentage (%) of mites found between September 2008 and August 2009 in *Vitis vinifera*, the sub-medium San Francisco Valley (Pernambuco and Bahia), Brazil.

Family/species	Total	Prevalence
Phytophagous species	23,128	93.5 ¹
Tarsonemidae	5589	24.2 ¹
<i>Polyphagotarsonemus latus</i> (Banks)	5589	
Tenuipalpidae	440	
<i>Brevipalpus phoenicis</i> (Geijskes)	440	1.9
Tetranychidae	17,099	73.9
<i>Oligonychus mangiferus</i> (Rahman & Sapro)	7235	42.3 ²
<i>Tetranychus urticae</i> Koch	9864	57.7
Predaceous species (Phytoseiidae)	1598	6.5
<i>Amblyseius tamatavensis</i> Blommers	6	0.4
<i>Euseius citrifolius</i> Denmark & Muma	1264	79.1
<i>Euseius concordis</i> (Chant)	3	0.2
<i>Neoseiulus idaeus</i> Denmark & Muma	164	10.3
<i>Neoseiulus transversus</i> Denmark & Muma	4	0.3
Imaturos	157	9.8
Total	24,726	

Notes: ¹For each feeding habit (phytophagous or predator), each value refers to the proportion of specimens in relation to the total number of specimens collected; for each family, each value refers to proportion in relation to the total number of specimens of the same feeding habit collected.

²For species, each value refers to proportion in relation to the total number of mite of the same family.

predators than the Italia variety; that in both varieties, more phytoseiid mites were found during the reproductive phase of the plants; that leaves of the apical branch had significantly fewer phytoseiid mites than leaves of others sections; and that phytoseiid mite populations on leaves of the median and basal branch sections were not significantly different.

Complementary determination of the mite fauna

In total, 24,726 mites (including specimens collected in the population dynamics study) were collected, approximately 93.5% phytophagous and 6.5% predators (Table 1). Tetranychid mites comprised 73.9% of the mites, but this family was represented by only two species: *T. urticae* (57.7% of the specimens in the family) and *O. mangiferus* (42.3%). Only one species each of Tarsonemidae (*P. latus*) and Tenuipalpidae [*Brevipalpus phoenicis* (Geijskes)] was found. Among the predatory mites, the most abundant was *E. citrifolius* (79% of the specimens of the phytoseiids), followed by *N. idaeus* (10.3%); each of the other 6 species corresponded to less than 1% of the predatory mites.

Discussion

Population dynamics and within-plant distribution

Among other factors, the observed densities of *T. urticae* and *O. mangiferus* were influenced by pesticide applications. Growers were reluctant to accept the inclusion in

Table 2. Results of a generalized linear model fitted to data of mite densities from Sugraone and Itália varieties between sites and among sampling dates, branch and leaf.

Source	SS	Df	MS	F	P
Predaceous species (Phytoseiidae)					
Sites	422.24	1	422.24	11.69	0.0008
Date (sites)	17,503.96	22	795.63	22.02	<0.0001
Branch	79.15	2	39.57	1.10	0.3367
Leaf (branch)	1409.97	6	234.99	6.50	<0.0001
Error	6648.88	184	36.13		
Phytophagous species (Tetranychidae)					
Sites	109,935.78	1	109,935.78	2.86	0.0926
Date (sites)	13,646,900.88	22	620,313.68	16.13	<0.0001
Branch	49,443.59	3	24,721.80	0.64	0.5270
Leaf (branch)	496,649.58	6	82,774.93	2.15	0.0496
Error	7,077,405.71	184	38,464.16		

this work of a control treatment (with no pesticide application). The occurrence of the predator *N. idaeus* at relatively high numbers at the peak occurrence of *T. urticae* and *O. mangiferus* on the Sugraone variety is not surprising, given that this predator has been reported to have a close association with tetranychid mites in northeast Brazil (Moraes and McMurtry 1983; Domingos 2010). The major reduction in the population level of those phytophagous mites could be a function of the effect of that predator, whose population also reduced drastically afterward, apparently due to the reduction of the population of those possible prey. However, the very low number of *N. idaeus* on the Italia Muscat variety suggested *N. idaeus* to be mostly related to *T. urticae*, given the very low numbers on the latter species on this variety.

The peak population densities of *P. latus* occurred about 2 months after plants were drastically pruned, when rainfall and humidity were near their maxima, and when new shoots were developing. Higher population densities could be observed, had the samples been composed only of young leaves, which are preferred for this mite group (Alagarmalai et al. 2009), or had spraying not been done. The coincident increase in the population of *E. citrifolius* with the increasing population of *P. latus* between December and February suggests a possible predation of the former on the latter; the decrease of the population levels of those species could be due to the pesticide application in this period. However, the available information could not account for the major increase in the population of *E. citrifolius* between March and April. *Euseius* species are known to use pollen of different plants as a food source (McMurtry et al. 2013). This behaviour has been demonstrated also for *E. citrifolius* (Moraes and McMurtry 1981). However, extensive flowering was not observed in the experimental fields between March and April.

The population dynamics observed in the Italia Muscat variety suggested a positive relation between the populations of *O. mangiferus* and *E. citrifolius* in the period when pesticides were not sprayed. This could be expected, given that *E. citrifolius* has been reported to feed, develop and reproduce on eggs of tetranychid mites (Moraes and

McMurtry 1981). Webbing has been reported to be detrimental to *Euseius* species (McMurtry et al. 1970), but similarly to most *Oligonychus* species (Jeppson et al. 1975), *O. mangiferus* produce little webbing.

Our data demonstrated that Tetranychidae mites were found in higher densities on basal and median leaves. As stated by Walzer et al. (2009), the distribution of *T. urticae* over time was characterized by an initial occupation of the basal and middle strata, followed by a slow migration to the top stratum, with the progressive deterioration of basal and median leaves. The patterns of spatial distribution of mites can be affected by competition, predation and other behavioural traits of a particular species (Zalom et al. 1985; Peña and Baranowski 1990; Walzer et al. 2009), as reported by other authors (Jeppson et al. 1975; Bassett 1981; Gerson 1992; Grinberg et al. 2005; Johann et al. 2009; Johann and Ferla 2012).

Complementary determination of the mite fauna

Most studies conducted in Brazil (Haji et al. 2001; Johann et al. 2009; Valadão 2010; Klock et al. 2011; Johann and Ferla 2012) reported *T. urticae* as a secondary grape pest with very low levels of occurrence while *O. mangiferus* just was reported once on grapes in southern of Brazil by Soria et al. (1993). Since that first report, the importance of this mite on grapes has not changed (Johann et al. 2009). However, according to the findings of the current study, *O. mangiferus* appears to be an important pest of grapes for both varieties in the northeast of Brazil. *Polyphagotarsonemus latus* was not frequent, even on young leaves; the relatively low importance of this mite to grapevines in northeastern and southern Brazil had already been reported (Haji et al. 2001; Johann et al. 2009; Johann and Ferla 2012).

Four notable absences were *Panonychus ulmi* (Koch) (Tetranychidae), *Calepitrimerus vitis* (Nalepa) and *Colomerus vitis* (Pagenstecher) (Eriophyidae) and the predatory mite *Neoseiulus californicus* (McGregor) (Phytoseiidae). The first three species are the most abundant phytophagous mites on the leaves of grapevines in

the southern region of Brazil (Soria and Dal Conte 2005; Ferla and Botton 2008; Johann et al. 2009; Siqueira et al. 2011; Johann and Ferla 2012) and other countries (Attiah 1967; James and Whitney 1993; James et al. 1995; Duso and de Lillo 1996; Bernard et al. 2005; Walton et al. 2010). The latter is one of the most abundant and frequent predators associated with the main mite pest species on grapevines in the southern and southeastern regions of Brazil (Monteiro et al. 2008; Johann et al. 2009; Johann and Ferla 2012) and several other countries (Fraulo and Liburd 2007; Klock et al. 2011). The absence of these species are most likely related to the climate in the field in northeastern Brazil, which is very dry and hot. Eriophyid mites have been intercepted in plant material introduced in northeastern Brazil, but apparently these mites have not been established in that area (Personal Communication G. J. de Moraes). This study clearly shows that the fauna of mites associated with grapes in the northeast of Brazil is quite different from that found in the southern and southeastern regions of Brazil. This difference, coupled with the fact that the use of pesticides in grapes in the northeast is much more intense (Monteiro 2014) than in others regions, implies the need of different managements due to both intense use of pesticides and different composition of phytophagous and predatory mites. This is the first study reporting the mite fauna associated with grapevine in northeast Brazil. In this region, *T. urticae* and *O. mangiferus* were the most common phytophagous, whereas the most common predators were *E. citrifolius* and *N. idaeus*. These phytophagous and predators mites showed the same pattern of within-plant distribution, indicating that basal and median leaves should be observed to monitoring these mites. The same pattern of distribution also suggests that these predators mites might contribute to control phytophagous mite populations. This study offers important information to those interested in studying the ecology of mites in vines. Further studies to assess the capacity of *E. citrifolius* and *N. idaeus* to control populations of *T. urticae* and *O. mangiferus* are needed as well as to assess the effect of pesticides on these species.

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