

Diversity and abundance of mites in citrus from Múgica and Gabriel Zamora, Michoacán

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Abstract

Considering the importance of both phytophagous and beneficial mites and the need to deepen the study of the species present in economically important crops such as citrus, this research aimed to know the diversity of mite species present in citrus (*Citrus* spp.) crops and to compare their abundance in open-field crops, nursery, and backyard in the municipalities of Gabriel Zamora and Múgica, Michoacán. Collections were carried out by the direct collection method from January to June 2022; a total of 25 collections were made in five localities and eight hosts; the mites present were counted and placed in semi-permanent preparations and were identified with different taxonomic keys. A total of 273 mites of nine species were collected and identified; *P. oleivora*, *B. yothersi*, *E. banksi*, *Eutetranychus* sp., *P. citri*, and *Tetranychus* sp. were identified in phytophages, and *E. ho*, *E. concordis*, and a morphospecies of the family Iolinidae in predators. Both municipalities had a similar number of specimens collected; however, Gabriel Zamora showed greater diversity, with eight species. *E. banksi* was the most abundant in Gabriel Zamora (63.97%) and *P. oleivora* was the most abundant in Múgica (67.89%). Regarding the type of production system, the open-field crop was the one that presented the greatest diversity and abundance, with six species and 48% of the specimens collected.

Keywords:

citrus, Michoacán, mites, phytophagous, predators.



Introduction

Mexico is one of the most important citrus producers in the world, ranking 4th in production volume only behind China, Brazil, and India. In the country, Michoacán stands out as the main producer of lemons and the second in grapefruit and pomelo, with a production of 798 252.03 and 77 435.82 t respectively, which generates revenues of around 10 million pesos (SIAP, 2022).

Various families of mites can cause damage to crops, which can be both direct and indirect. As for direct damage, some organisms break the cells of the plant when they feed and consequently decrease photosynthetic activity, as happens with species of the family Tetranychidae, while others have the ability to inject toxins and cause yellowing, galls or erineos, as do many species of the family Eriophyidae (Acuña-Soto, 2012). On the other hand, other species are characterized by the ability to transmit viruses to the plant during the feeding process, as is the case with several species of the family Tenuipalpidae, or they are only responsible for spreading fungal spores as some Eriophyidae do (De Moraes and Fletchman, 2008; Acuña-Soto, 2012).

Predatory mites also stand out since many species, mainly of the family Phytoseiidae, have the potential to be used as biological control agents on phytophagous mites of the families Tetranychidae, Tenuipalpidae, Eriophyidae or Tarsonemidae, as well as small insects, which provides another tool to transition to less polluting control methods (Ramos-Lima, 2012).

Considering the importance of both phytophagous and beneficial mites and the need to deepen the study of the species present in economically important crops such as citrus, the objective proposed is to know the diversity of mite species present in citrus (*Citrus* spp.) crops and to compare their abundance in crops, nursery, and backyard in the municipalities of Gabriel Zamora and Múgica, Michoacán.

Materials and methods

Fieldwork

The fieldwork was carried out from January to June 2022 in the municipalities of Gabriel Zamora and Múgica, under three production systems: open-field crop, nursery and backyard. A total of 25 collections were carried out in five localities, and the hosts sampled were mandarin, sweet orange, sour orange, grapefruit, sweet lime, Mexican lime, Persian lime and alemow.

In each of the sites, a directed collection was carried out using the direct collection method; leaves, flowers, and fruits were cut with scissors from each of the hosts under study and placed in bags with hermetic seals, then a label was placed with the collection data and they were placed in a polystyrene cooler to prevent the collected organs from perspiring excessively; finally, the samples were transported to the laboratory where they were stored in refrigeration at 4 °C.

Laboratory work

From each sample, ten leaves were randomly selected and placed one by one in a Petri dish, to later be reviewed with the stereo microscope both on the upper side and on the underside; when fruits were present, the pericarp was cut into small segments and the procedure performed with the leaves was repeated. The mites present in both the leaves and the fruits were counted and it was recorded in a logbook, and they were placed in 70% alcohol or in slide preparations.

The mites were mounted between slides and coverslips in Hoyer's liquid. The taxonomic identification of the mites was carried out with the taxonomic keys of (Denmark *et al.*, 1999; Denmark and Evans, 2011) for Phytoseiidae, (NAPPO, 2014) for Tetranychidae and Tenuipalpidae (Beard *et al.*, 2015).

Results and discussion

A total of 273 mites from 9 species, five families and two orders were collected and identified. From the family Phytoseiidae, *Euseius ho* (De Leon, 1965) and *Euseius concordis* (Chant, 1959) were collected. From Eriophyidae, *Phyllocoptruta oleivora* (Ashmead, 1879) was collected. From Tenuipalpidae, *Brevipalpus yothersi* (Baker, 1949). For its part, from Tetranychidae, *Eutetranychus banksi* (McGregor, 1914), *Eutetranychus* sp., *Panonychus citri* (McGregor, 1916), and *Tetranychus* sp. were identified. Likewise, a morphospecies from the family Iolinidae was collected, which was not identified and only left at the family level (Table 1).

Table 1. Mites collected in citrus (*Citrus* spp.) from crops, nursery, and backyard in the municipalities of Gabriel Zamora and Múgica, Michoacán.

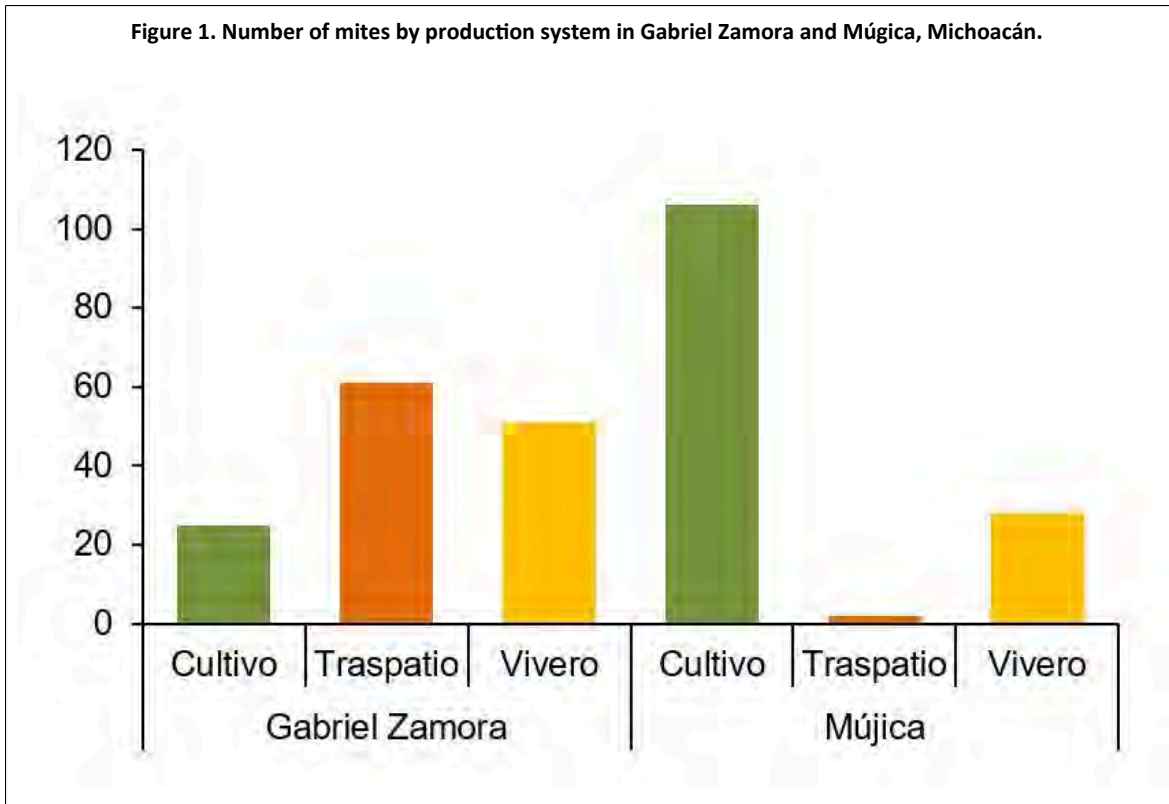
| Order | Family | Species | Habit | Host | Gabriel Zamora | | Múgica | | Total | |
|----------------|---------------|--------------------------------|----------------|---|----------------|-------|--------|-------|-------|-------|
| | | | | | No. | (%) | No. | (%) | No. | (%) |
| Mesostigmata | Phytoseiidae | <i>Euseius concordis</i> | Predatory | Persian lime | 4 | 2.9 | 0 | 0 | 4 | 1.47 |
| | | <i>Euseius ho</i> | Predatory | Mexican lime | 6 | 4.41 | 6 | 4.38 | 12 | 4.4 |
| Trombidiformes | Eriophyidae | <i>Phyllocoptruta oleivora</i> | Phytophagous | Grapefruit | 0 | 0 | 93 | 67.88 | 93 | 34.07 |
| | Tenuipalpidae | <i>Brevipalpus yothersi</i> | Phytophagous | Mandarin, sour orange, sweet lime, Persian lime, Mexican lime, grapefruit | 27 | 19.85 | 14 | 10.22 | 41 | 15.01 |
| | Tetranychidae | <i>Eutetranychus banksi</i> | Phytophagous | Sweet lime, Persian lime, Mexican lime, alemow, mandarin, sour orange, sweet orange, grapefruit | 87 | 63.97 | 23 | 16.79 | 110 | 40.29 |
| | | <i>Eutetranychus</i> sp. | Phytophagous | Persian lime | 1 | 0.7 | 0 | 0 | 1 | 0.3 |
| | | <i>Panonychus citri</i> | Phytophagous | Mexican lime | 1 | 0.74 | 0 | 0 | 1 | 0.37 |
| | | <i>Tetranychus</i> sp. | Phytophagous | Alemow, mandarin | 7 | 5.15 | 1 | 0.73 | 8 | 2.93 |
| | Iolinidae | Morphospecies 1 | Diverse habits | Persian lime, sour orange | 3 | 2.2 | 0 | 0 | 3 | 1.1 |
| Total | | | | | 136 | 100 | 137 | 100 | 273 | 100 |

Of the total number of mites, 136 correspond to the municipality of Gabriel Zamora and 137 to Múgica; however, although both municipalities presented similar numbers in terms of the number of specimens collected, Gabriel Zamora was the one that had a greater diversity, with nine species, while Múgica only had five. Of the species collected, *E. banksi* was the most abundant in the municipality of Gabriel Zamora (63.97%) and *P. oleivora* in Múgica (67.89%).

Diversity and abundance by type of production system

In the open-field crop (C), it had the highest number of specimens collected, with 131 (48%), followed by nursery (N) with 79 (29%), and backyard (B) with 63 (23%) (Figure 1). In Gabriel Zamora, the three production systems ranged between 20 and 60 mites, of which (B) was the one with the highest number of specimens, followed by (N) and (C), but none of them clearly stood out. Something opposite happened in Múgica, where the highest number of specimens was found in (C) and was much higher than (N) with 28, while in (B) the presence of mites was very limited (Figure 1).

Figure 1. Number of mites by production system in Gabriel Zamora and Múgica, Michoacán.



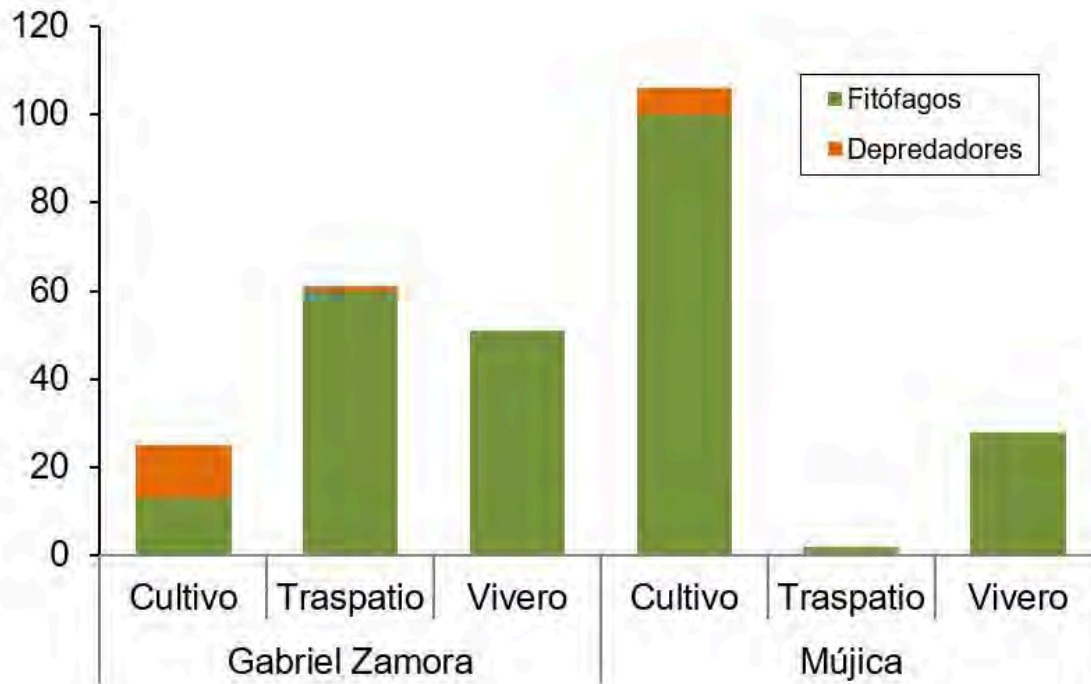
In terms of diversity, six species were collected in (C), five in (B) and three in (N). In (C), *E. concordis*, *E. ho*, *B. yothersi*, *P. oleivora*, *E. banksi* and morphospecies 1 were identified; in (B), *B. yothersi*, *E. banksi*, *Eutetranychus* sp., *P. citri* and morphospecies 1; and in (N), *Tetranychus* sp., *B. yothersi* and *E. banksi*.

Number of specimens by eating habit

Of the total number of mites collected, 254 are phytophagous and 19 are predatory. *P. oleivora*, *B. yothersi*, *E. banksi*, *Eutetranychus* sp., *P. citri* and *Tetranychus* sp. were identified in phytophages, while *E. ho*, *Euseius concordis* and morphospecies 1 (Iolinidae) were identified in predators. Regarding the diversity of phytophagous mites, five species were collected in Gabriel Zamora and four in Múgica, and in the case of predators, five species in Gabriel Zamora and only two in Múgica.

There was no tendency to find a greater number of specimens of phytophagous mites in any particular type of management, but all types of management had different behaviors in each of the collection sites, an example of this is that the largest number of phytophagous mites was collected in crops (C) in the municipality of Múgica, with 100 specimens, followed by backyard (B) and nursery (N) in Gabriel Zamora with 60 and 51 specimens, respectively. This is different from what happened with predatory mites, since they were mainly present in crops (C), and their presence in nursery (N) and backyard (B) was practically non-existent (Figure 2).

Figure 2. Number of phytophagous and predatory mites collected by each production system in Gabriel Zamora and Mújica, Michoacán.



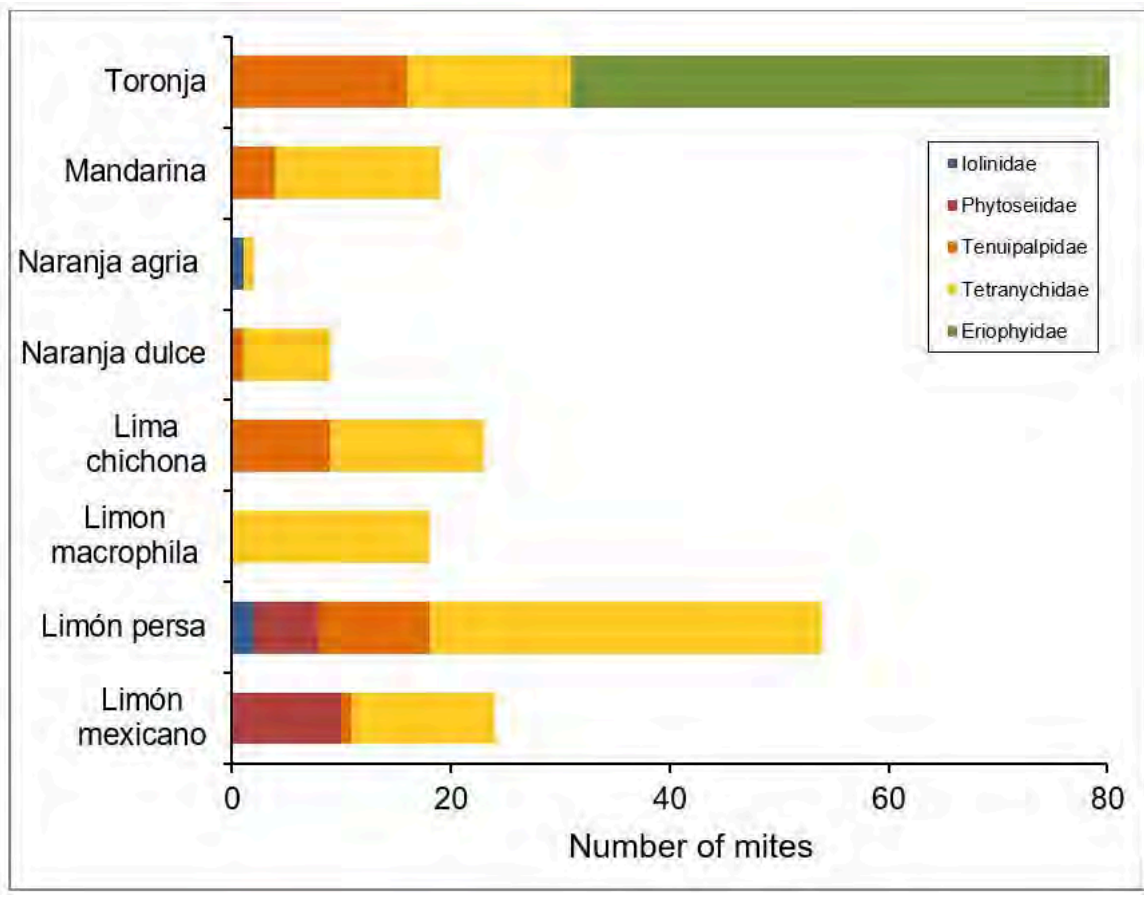
Diversity and abundance of mites by crop

The crops with the highest number of specimens collected were grapefruit (*C. x paradisi*) with 124 and Persian lime (*C. x latifolia*) with 54, while the least abundant were sour orange (*C. x aurantium*) and sweet orange (*C. x sinensis*) with 2 and 9 specimens, respectively.

Regarding the diversity of families collected by crop, the Persian lime was the one that presented the highest number with five, followed by the grapefruit and the Mexican lime (*C. x aurantifolia*), which had three, while the sour orange, sweet orange (*C. x sinensis*), sweet lime (*C. x limetta*) and mandarin (*C. reticulata*) presented two families and alemow a single family (Figure 3).



Figure 3. Number of mites and families present by crop in Gabriel Zamora and Múgica, Michoacán.



Family Eriophyidae

Phyllocoptruta oleivora

Common names: citrus rust mite, citrus sooty mold, citrus bronzing mite, mold mite, rust mite, citrus scab (CABI, 2022; SINAVIMO, 2022).

Material examined: Coróndiro, Múgica (18° 59' 25.4" north latitude, 102° 7' 33.8" west longitude), 15/II/2022, grapefruit (*C. x paradisi*) in crops, (6 ♀).

Notes: it is a common species of the genus *Citrus* and has been recorded in lemon (*C. x limon*), orange (*C. x sinensis*), grapefruit (*C. x paradisi*), tangerine (*C. x tangerine*), Persian lime (*C. x latifolia*), sour orange (*C. x aurantium*), citron (*C. medica*) and mandarin (*C. reticulata*) in countries such as Mexico, Cuba, Malta, Brazil, Iran, the United States of America, Kenya and Spain (De la Torre and Martínez, 2004; De Moraes and Fletchmann, 2008; Xue *et al.*, 2009). During the research, *P. oleivora* was collected only on the pericarp of grapefruit fruits in crops in the municipality of Múgica and in general it was the only species of mite that was collected on fruits.



Family Phytoseiidae

Euseius concordis

Material examined: Lombardía, Gabriel Zamora (19°10' 40.68" north latitude, 102° 03' 54.05" west longitude), 09/II/2022, Persian lime (*C. x latifolia*) in crops (1 larva, 1 ♀, 3 ♂).

Notes: *E. concordis* is a species on which several studies have been carried out to evaluate its capacity as a biological control agent; it has been evaluated as a potential predator of economically important phytophagous mites such as *Tetranychus evansi* (Baker and Pritchard, 1960), *Oligonychus yothersi* (McGregor, 1914), *O. ilicis* (McGregor, 1917) (Acari: Tetranychidae) and *Polyphagotarsonemus latus* (Banks, 1904) (Acari: Tarsonemidae) (Silveira *et al.*, 2020); it has also been evaluated as a predator of eggs of some insects such as *Aleurodicus cocois* (Quaintance and Baker, 1913) (Hemiptera: Aleyrodidae) (Pacheco *et al.*, 2018). During the research, *E. concordis* was collected in Persian lime (*C. x latifolia*) in crops in Gabriel Zamora and although there is already a record of its presence in Mexico, this is the first time that it is associated with species of the genus *Citrus*.

Euseius ho

Material examined: El Capire, Gabriel Zamora (19° 07' 59.12" north latitude, 102° 01' 21.91" west longitude), 24/I/2022, Mexican lime (*C. x aurantifolia*) in crops, (6 ♀). Nueva Italia, Múgica (18° 59' 32.52" north latitude, 102° 07' 43.63" west longitude), 15/II/ 2022, Mexican lime (*C. x aurantifolia*) in crops (1 ♀, 5 ♂).

Notes: this is the first time it has been associated with Mexican lime (*C. x aurantifolia*), so it is a new record for the crop.

Family Tenuipalpidae

Brevipalpus yothersi

Common name: mites of the family Tenuipalpidae are generally known as false spider mites.

Material examined: Lombardía, Gabriel Zamora (19° 09' 43.22" north latitude, 102° 02' 56.98" west longitude), 02/VI/2022, mandarin (*C. reticulata*) in backyard, (1 ♀). Lombardía, Gabriel Zamora (19°09' 11.84" north latitude, 102° 03' 16.28" west longitude), 24/VI/ 2022, sour orange (*C. x aurantium*) in backyard, (7 ♀). Lombardía, Gabriel Zamora (19° 09' 28.86" north latitude, 102° 03' 04.91" west longitude), 07/VI/2022, sweet lime (*C. x limetta*) in backyard, (3 ♀). Nueva Italia, Múgica (19° 02' 52.05" north latitude, 102° 05' 08.04" west longitude), 13/IV/ 2022, Persian lime (*C. x latifolia*) in nursery, (3 ♀). Nueva Italia, Múgica (18° 59' 25.43" north latitude, 102° 07' 33.84" west longitude), 15/II/ 2022, grapefruit (*C. x paradisi*) in open field, (2 ♀). Nueva Italia, Múgica (19° 02' 06.62" north latitude, 102° 05' 18.90" west longitude), 09/VI/ 2022, Mexican lime (*C. x aurantifolia*) in backyard (1 ♀).

Notes: *B. yothersi* was recorded in *C. x sinensis* in Argentina, India, Nigeria, Spain, and Mexico (Beard *et al.*, 2015), in *C. x aurantifolia* in Brazil and Colombia, in *C. reticulata* in Ethiopia and India, as well as in *C. x latifolia* and *C. x medica* in Colombia and India, respectively (Beard *et al.*, 2015).

Brevipalpus yothersi is part of the complex of species of the group *Brevipalpus phoenicis*, which, together with *B. californicus* (Banks, 1904) and *B. obovatus* (Donnadieu, 1875) (Acari: Tenuipalpidae), are known to be the transmitters of 'citrus leprosis', a disease that affects a large number of citrus species in various places such as the Americas (Méndez-Méndez *et al.*, 2012). During the research, *B. yothersi* was collected both in Múgica and in Gabriel Zamora and in various hosts, such as *C. reticulata*, *C. x limetta*, *C. x latifolia*, *C. x paradisi* and *C. x aurantifolia*; however, at no time was the characteristic symptomatology of CLV observed.

Family Tetranychidae

Eutetranychus banksi

Common name: Texas citrus mite.

Material examined: Lombardía, Gabriel Zamora (19°10' 05.52" north latitude, 102° 03' 39.18" west longitude), 28/II/2022, Persian lime (*C. x latifolia*) in nursery (6♀, 5♂, 1 L, 8 N). Lombardía, Gabriel Zamora (19° 10' 05.52" north latitude, 102° 03' 39.18" west longitude), 28/II/ 2022, sweet lime (*C. x limetta*) in nursery (3♀, 4 L, 7 N). Lombardía, Gabriel Zamora (19° 10' 05.52" north latitude, 102°03' 39.18" west longitude), 28/II/ 2022, mandarin (*C. reticulata*) in nursery (3♀, 4♂, 1 N). Lombardía, Gabriel Zamora (19° 10' 05.52" north latitude, 102° 03' 39.18" west longitude), 28/ II/ 2022, grapefruit (*C. x paradisi*) in nursery (2♀, 2 L). Lombardía, Gabriel Zamora (19° 10' 40.68" north latitude, 102°03' 54.05" west longitude), 09/II/ 2022, Persian lime (*C. x latifolia*) in open field (9♀, 4 N, 1 L). Lombardía, Gabriel Zamora (19° 09' 11.84" north latitude, 102° 03' 16.28" west longitude), 24/VI/ 2022, alemow (*C. macrophylla*) in backyard (8♀). Lombardía, Gabriel Zamora (19° 05' 15.74" north latitude, 102° 03' 26.46" west longitude), 24/VI/ 2022, Mexican lime (*C. x aurantifolia*) in backyard (1♀, 1♂, 7 L, 1 N). Lombardía, Gabriel Zamora (19° 09' 19.61" north latitude, 102° 03' 02.40" west longitude), 04/VI/ 2022, grapefruit (*C. x paradisi*) in backyard (4♀, 1.4♂ N, 2 L). Lombardía, Gabriel Zamora (19° 09' 11.84" north latitude, 102° 03' 16.28" west longitude), 04/VI/ 2022, sour orange (*Citrus aurantium*) in backyard (1♀). Lombardía, Gabriel Zamora (19° 05' 20.85" north latitude, 102°03' 23.61" west longitude), 04/VI/ 2022, sweet orange (*Citrus x sinensis*) in backyard (8♀). Nueva Italia, Múgica (19° 02' 52.05" north latitude, 102° 05' 08.04" west longitude), 13/IV/ 2022, Persian lime (*C. x latifolia*) in nursery (2♀). Nueva Italia, Múgica (19° 02' 52.05" north latitude, 102° 05' 08.04" west longitude), 13/IV/ 2022, alemow (*C. macrophylla*) in nursery (2♀, 1♂, 4 N, 1 L). Nueva Italia, Múgica (19° 02' 52.05" north latitude, 102° 05' 08.04" west longitude), 13/IV/ 2022, Mexican lime (*C. x aurantifolia*) in nursery (2♀).

Notes: *E. banksi* has been recorded associated with citrus such as *C. x aurantifolia* in Argentina and Venezuela, *C. x aurantium* in Argentina, *C. x limon* in the United States of America, Argentina, Costa Rica, El Salvador and Nicaragua, *C. x paradisi* in Costa Rica, El Salvador and Nicaragua, *C. reticulata* in Argentina, Brazil and Peru and *C. x sinensis* in Mexico, Argentina, Spain, Cuba, and Brazil (Migeon and Dorkeld, 2022).

During the research, *E. banksi* was collected in most of the collection sites and in all production systems (crops, nursery, and backyard), and it was also collected in many of the hosts with which we worked, such as Persian lime (*C. x latifolia*), sweet lime (*C. x limetta*), mandarin (*C. reticulata*), grapefruit (*C. x paradisi*), alemow (*C. macrophylla*), Mexican lime (*C. x aurantifolia*) and sour orange (*Citrus aurantium*), sweet orange (*Citrus x sinensis*). This is the first time that this species has been associated with citrus crops in the state of Michoacán.

Panonychus citri

Common name: citrus red mite.

Material examined: Lombardía, Gabriel Zamora (19° 07' 59.12" north latitude, 102° 01' 21.91" west longitude), 24/VI/2022, Mexican lime (*C. x aurantifolia*) in open field, (1♀).

Notes: *P. citri* is a pest that has a large number of hosts, but mainly attacks species of the genus *Citrus* worldwide (NAPPO, 2014); it has been recorded attacking lemon (*C. x limon*) in the United States of America, Taiwan, Japan, Costa Rica, Spain and China (Migeon and Dorkeld, 2022), grapefruit (*C. x paradisi*) in the United States of America, Hawaii, and Peru (Migeon and Dorkeld, 2022), mandarin (*C. reticulata*) in India (Gupta and Grupta, 1994), and orange (*C. x sinensis*) in Hawaii (Lee, 1986). In Mexico, it was recorded in lemon trees in the state of Michoacán for the first time in 2018 (Ayala-Ortega *et al.*, 2018).

Despite being a common pest of citrus, during the research only one specimen of this species was collected on Mexican lime (*C. x aurantifolia*) in open field and it was the least abundant of all the species collected.

Conclusions

A total of nine species of mites associated with citrus were collected and identified, *P. oleivora*, *B. yothersi*, *E. banksi*, *Eutetranychus* sp., *P. citri* and *Tetranychus* sp. in phytophages, and *E. ho*, *E. concordis* and morphospecies 1 (Iolinidae) in predators. Both municipalities had a similar number of specimens collected, with 136 and 137 specimens; however, Gabriel Zamora showed greater diversity, with eight species. Of the species collected, *E. banksi* was the most abundant in Gabriel Zamora (63.97%) and *P. oleivora* was the most abundant in Múgica (67.89%).

Regarding the type of production system, the open-field crop (C) was the one with the greatest diversity and abundance, with six species and 131 specimens collected (48%). There was no tendency to find a greater number of phytophagous mite specimens in any particular type of management, but rather all types of management had different behaviors in each of the collection sites, so the hypothesis proposed is rejected.

The crops with the highest number of specimens collected were grapefruit (*C. x paradisi*) and Persian lime (*C. x latifolia*) with 124 and 54 mites respectively, while the Persian lime was the most diverse with five species. Of the mites collected, *E. concordis* is a new record for Mexico, while *E. ho* is a new record for the Mexican lime (*C. x aurantifolia*).

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