Mites associated with raspberry in Zamora and Los Reyes, Michoacán

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Abstract
Mexico ranks second in raspberry production and very little knowledge has been generated about the mites associated with this crop. In the present work, mites collected in the aerial part of raspberries produced in the municipalities of Zamora and Los Reyes de Salgado, Michoacán, Mexico from February 2018 to March 2019, were identified. In Los Reyes, 8 748 mites belonging to four families and nine species were recorded. The species found were Amblydromalus ca. congeae, Neoseiulus californicus, Phytoseiulus persimilis, Typhlodromips sp., Euseius mesembrinus, Euseius sp. (Phytoseiidae). Tetranychus ludeni (Tetranychidae), Tarsonemus sp. (Tarsonemidae), and Tyrophagus putrescentiae (Acaridae). A total of 4 253 adult specimens of two species were collected in Zamora, Neoseiulus fallacis with 235 (Phytoseiidae) and Tetranychus ludeni with 4 018 (Tetranychidae).

Keywords:
Acaridae, Phytoseiidae, Tarsonemidae, Tetranychidae.

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Introduction

Raspberries are berries from the family Rosaceae, characterized by their flavor, texture, and health benefits (Skrovankova et al., 2015). Mexico is the second largest producer of raspberries in the world, with an annual volume of 178,667 tonnes (SIAP, 2022). In Michoacán, it is grown in nine municipalities, Zamora is the first producer and Los Reyes de Salgado is the fourth most important (SIAP, 2022). Among all arthropods, mites are of utmost importance, tetranychids are important primary pests of the crop (Marié et al., 2018) and phytoseiids are natural enemies of mites and phytophagous insects (Amin et al., 2009).

In the world, the following has been reported in the aerial part of raspberry: 16 species of Phytoseiidae, 15 species of Tetranychidae, two of Tenuipalpidae, six of Eriophyidae and one species of the family Stigmaeidae, totaling 40 species. Nonetheless, in Mexico, only the presence of *Tetranychus urticae* in Chihuahua has been recorded (Parra-Quezada et al., 2002). Due to the relevance acquired by raspberries in Mexico and particularly in Michoacán and the little knowledge of these in the crop, the objective of this work was the taxonomic determination of the mite species in two of the most important municipalities for the production of this berry.

Materials and methods

Description of the orchards

The research was carried out in the municipality of Los Reyes, in an orchard of the Adelita variety located in the locality of San Sebastián (19° 33' 50.02" north latitude and 102° 29’ 18.33” west longitude) at 1,306 masl. The plant was a first-year plant, grown under a high tunnel, 5 months old at the start of the first sampling.

In the municipality of Zamora, an orchard with integrated management, the “El Ibge” orchard planted with the Evita variety was selected, which is located in the locality of Ojo de Agua (19° 59' 44.47” north latitude and 102° 11’ 46.04” west longitude) at 1,600 masl. The plant was a second-year plant, three months old at the start of the first sampling (primocane), grown under a high tunnel. Conventional management in the orchard.

Collection, preparation, and identification

Sampling was carried out monthly for six months, from October 2018 to March 2019 in Los Reyes and from February to May 2018 in Zamora. Forty samples were taken randomly, each sample consisting of leaflets, flowers, and fruits. They were placed individually in airtight plastic bags and transported to the laboratory in coolers with cooling gel bags. The preparation was done by assembling on slides (Walter and Krantz, 2009). A Leica® DM 1000 phase-contrast optical microscope and specialized keys were used to identify the specimens.

Information analysis

The relative abundance of the species found was estimated using the formula: $RA = n/N \times 100$. Where: $n$ is the i-th specimen and $N$ is the total number of mites counted (Ayala-Ortega et al., 2019).

To evaluate the population behavior in the Zamora orchard, the total population by sampling was calculated, considering the species, the data were plotted in a graph. On the basis of these same data, we calculated the exponential trend curve and the extrapolated potential curve, a line that includes for the latter the equation that fits it, for the phytophagous species.

Finally, and in order to explain the population trend of phytophages, we calculated the age class structure for eggs, immature stages, and adults, based on the proportion of each of these phases, by sampling.
Results and discussion

Zamora

We collected a total of 4,253 adult individuals, two species, one belonging to the order Mesostigmata (*Neoseiulus fallacis* Garman from Phytoseiidae with 235 mites) and the other belonging to Trombidiformes, suborder Prostigmata (*Tetranychus ludeni* from Tetranychidae with 4,018). *N. fallacis* is a mite widely marketed for being useful in Integrated Pest Management (IPM) programs, especially in the northern and southern United States of America (Pratt *et al.*, 2002). The record of *N. fallacis* is of great importance for raspberry crops and for the control of pest mites present in the crop. This is the first time it has been reported for Mexico and its relevance lies in the fact that the species is classified as an excellent generalist predatory mite of different types of mites in warm and moderately humid environments (Bounfour and Tanigoshi, 2002).

In general, *Tetranychus urticae* Koch has been identified as the most common spider mite species in berries (INTAGRI, 2017). In the morphotaxonomy analysis carried out, it is verified that this is not the mite that is present in the samples analyzed. In a taxonomic survey of tetranychids in New Zealand, Zhang (2002) reported that many specimens previously identified as *T. urticae* and *T. cinnabarinus* Boisduval were in fact *T. ludeni*, coinciding with the fact that this mite has been confused with other species of the family.

It was observed that *T. ludeni* causes chlorotic spots on the underside of the leaves, where high populations and death of the leaves are recorded, with a notorious leaf loss; the mites concentrate in the lower parts of the plants where the web becomes very abundant and when the populations increase, it can cover the entire plant.

Figure 1 shows the populations of *T. ludeni* and *N. fallacis*, by sampling, as mentioned above, one day before the second sampling, an application of an acaricide was made. It can be seen that there was a low prey-predator ratio since the levels of the pest are high and those of the phytoseiid do not correspond to the increases of the phytophage, it could seem that they behave like unrelated organisms.

![Figure 1. Total population of *Tetranychus ludeni* and *Neoseiulus fallacis*. Sampling 2 after pesticide application) by sampling, exponential trend curve (blue), and linear extrapolated potential curve (dashed blue-black).](https://doi.org/10.29312/remexca.v15i3.3660)
it has been reported that they can consume up to 20 prey/day, so the prey-predator ratio should always be based on their predatory capacity, which in the case of *N. fallacis* is high (Argüelles et al., 2013). However, the prey levels observed here appear to be so high that *N. fallacis* is not able to efficiently decrease *T. ludeni*.

Figure 1 shows the total population of *T. ludeni* by sampling, the exponential trend, and the linear extrapolated potential curve of two subsequent samples if they could have been carried out (indicated in a dashed line).

The exponential curve has a notable tendency to increase and the linear extrapolated potential curve is of the type $y = ax + b$, which is nothing more than a first-degree equation representing a straight line (Escobar, 2015). They show how high the population levels of the tetranychid could have been and explain why it was not possible to continue the study.

The application of the chemical treatment carried out can greatly influence the mite populations (Gillott, 2005); even though it decreased the population of the pest in the second sampling (although it recovers very significantly), it also decreased the levels of the predator, which, apparently, did not have the same capacity to increase its population. The age class structure is shown in Figure 2. The analysis of this graph explains the increase in *T. ludeni* populations observed in raspberry.

In all the samples, the highest proportion was eggs, which is a clear indication that the population is increasing and the trend will be to increase, as was proven in practice. González (2012) recorded that the age class distribution of a population determines its future growth, if adult individuals predominate, in the future there will be a strong mortality, while if the majority are juveniles, the population will soon grow.

In the case of tetranychid mites in raspberries, the best option would be to apply an ovicidal product, which is harmless to predators, in order to reverse the age class structure observed and perhaps encourage the phytoseiids present in the agroecosystem to prey more efficiently. Therefore, it is important to know all the interactions generated in a plant-pest-predator system, in order to improve the effectiveness of biological control and management in general, by knowing the biology and ecology of each of the individuals that interact in this system.
Los Reyes

A total of 8,749 mites belonging to four families and nine species were collected (Table 1), of which *Tetranychus ludeni* was the one that predominated with 92.76% and the family Phytoseiidae was the one with the highest number of species.

![Table 1](https://doi.org/10.29312/remexca.v15i3.3660)

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<th>Order</th>
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<th>No.</th>
<th>RA (%)</th>
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<td>Mesostigmata</td>
<td>Phytoseiidae</td>
<td><em>Amblydromalus</em> congeae</td>
<td>336</td>
<td>3.84</td>
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<td></td>
<td></td>
<td><em>Neoseiulus californicus</em></td>
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<td>1.58</td>
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<tr>
<td></td>
<td></td>
<td><em>Phytoseiulus persimilis</em></td>
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<tr>
<td></td>
<td></td>
<td><em>Typhlodromips</em> sp.</td>
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<td>0.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Euseius</em> sp.</td>
<td>2</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Euseius mesembrinus</em></td>
<td>1</td>
<td>0.01</td>
</tr>
<tr>
<td>Trombidiformes</td>
<td>Tetranychidae</td>
<td><em>Tetranychus ludeni</em></td>
<td>8,115</td>
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<tr>
<td></td>
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<td>Total</td>
<td></td>
<td></td>
<td>8,748</td>
<td>100</td>
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</table>

Family Phytoseiidae

*Amblydromalus congeae*. It was found in greater abundance between October 2018 and January 2019, mainly located on the underside of mature leaves, although some were among the flower structures. *A. congeae* had the highest proportion in the family.

*Neoseiulus californicus* was present from December 2018, with a higher proportion in January and February; they were found on mature leaves, as well as on the sepals of flowers. Even though applications are made for biological control in the orchard, its incidence is low (Table 1). *N. californicus* is a widely distributed species used for control in the world (Demite et al., 2020). In Mexico, it has been reported in Michoacán (Ayala-Ortega et al., 2019) and Jalisco (Denmark and Evans, 2011).

*Phytoseiulus persimilis* was found from January 2019, with higher numbers in January and February 2019; they were numerous in mature and senescent leaves, with a high presence of *Tetranychus ludeni*. This species was also used by the producer and although continuous releases were made, its incidence was low (Table 1). *P. persimilis* is present in 41 countries (Moraes et al., 2004; Demite et al., 2020).

For *Typhlodromips* sp., its abundance was low, only present in December 2018 and February 2019, located on the underside of the leaves (Table 1). Two species of the genus *Euseius* were found, one that could not be determined to species, which was present in a small proportion, with one specimen in December 2018 and another in February 2019. And another determined as *Euseius mesembrinus*, only one specimen was collected in March 2019 (Table 1).

Of the phytoseiid species that were released as part of the biological pest control tactic, only *P. persimilis* and *N. californicus* were recovered, but not *A. swirskii*. This could have been due to the fact that the latter was not established in the crop or to other factors related to the quality of the product and its way of release.

On the other hand, the low number of *Typhlodromips* sp., *Euseius* sp., and *Euseius mesembrinus* may have been caused by competition and predation of the species that were released (Müller
and Brodeur, 2002), mainly by generalist predators (Schausberger and Croft, 2000) such as *N. californicus* or by the dominance of the other generalist phytoseiid *A. congeae* (McMurtry et al., 2013), which was found on the underside of leaves, a region full of trichomes (Chwil and Kostryco, 2020), unlike *Amblydromalus limonicus*, which inhabits plants that possess glabrous (without trichomes) leaves (McMurtry et al., 2013). The genera *Typhlodromips* and *Amblydromalus* constitute a new report for *R. idaeus*, while *E. mesembrinus* for the genus *Rubus*.

**Family Tetranychidae**

*Tetranychus ludeni* was the only species of this family that was collected, present during all months. The highest proportion was recorded in December 2018 and January 2019, with a non-uniform distribution in the orchard. Defoliation was observed in the patches where there was a greater number of individuals by sample. It is commonly confused with *Tetranychus urticae* (Ayala-Ortega et al., 2019) but differs from this and other *Tetranychus* species by the shape of the male’s aedeagus, among other characteristics.

A total of 12 species of *Tetranychus* feed on *Rubus* species, among others; *Tetranychus turkestani* and *T. urticae* (Marié et al., 2018) feed on *Rubus idaeus*.

In the study, the highest relative proportion was for *T. ludeni*, the only species that represented the family Tetranychidae. This differs from what was found by Ayala-Ortega et al. (2019) on blackberry, where, in addition to *T. ludeni*, they found *T. urticae*, although the latter in low proportions. In the present study, *R. idaeus* is recorded as a new host of *T. ludeni*, although it had already been reported on *Rubus pinnatus* (Migeon and Dorkeld, 2019).

**Family Tarsonemidae**

Only two individuals belonging to a species of the genus *Tarsonemus* were recorded during October 2018. These were found on the undersides of recently mature leaves. Although some species of the genus *Tarsonemus* have been reported as phytophagous (Karmakar, 2016), they are not present as pests. This genus has been recorded in Brazil (*Rubus* sp. vars. *Caigangue* and *Tupy*) and Mexico (*Rubus* sp. var *Tupy*) by Marchetti and Juarez-Ferla (2011); Ayala-Ortega et al. (2019), respectively, but without causing apparent damage to the host.

**Family Acaridae**

*Tyrophagus putrescentiae* was identified on the upper side and underside of the leaves throughout the collection period, with the highest proportion in February and March 2019. *Tyrophagus putrescentiae* has a cosmopolitan distribution (Sánchez-Ramos, 1987). It is one of the most common species of Acaridae found in human homes (Ree et al., 1997). They have a high food spectrum as they can feed on fungi, grains and stored products, bulbs, plants, immature stages of coleopterans, nematodes, etc. (Dhooria, 2016).

Despite being known as a dust mite, *T. putrescentiae* has been reported feeding on soybean stems under field conditions (Oliveira et al., 2007). Marchetti and Juárez-Ferla (2011) reported this species on *Rubus fruticosus* in Brazil, but without causing any harm. A similar situation was observed in raspberry as no damage caused by these mites was associated.

Nevertheless, *T. putrescentiae* has been shown to be an alternative food source for generalist phytoseiids under laboratory conditions (Zou et al., 2016), a role it could play in crop foliage.

**Other remarks**

The number of species identified in the orchard was low if compared to what was reported in blackberry by Marchetti and Juárez-Ferla (2011); Ayala-Ortega et al. (2019), who found 26 and 18 species, respectively. However, the results of these authors agree that Phytoseiidae presented a number of species greater than other families. Phytoseiids are a diverse group in the aerial part of plants (Walter and Proctor, 2013), which explains the number of species found.
Unlike blackberries, members of the family Diptilomiopidae were not found in raspberries, where they were the most abundant (Marchetti and Juárez, 2011; Ayala-Ortega et al., 2019), this is possibly due to variations in the number of trichomes present in leaves (Karley et al., 2016) and excretions secreted by glandular trichomes (Chwil and Kostryco, 2020), which could benefit or hinder the establishment of phytophagous species.

Conclusions

*Tetranychus ludeni* was identified by its taxonomic characters as the phytophagous species present in raspberry, as well as by the damage it caused, chlorotic spots on the underside of the leaves; when there are high populations, the web covers the entire plant and there is leaf loss. *T. ludeni* is the first report for raspberry crops in Mexico; it has been documented in different host plants; in Mexico it has been recorded on blackberry, confirming once again that the taxonomic determination of the “red spider mite” is necessary because not all of them are *Tetranychus urticae*.

The record of *Neoseiulus fallacis*, in the orchard that did not apply biological control with mites, is of great importance for raspberry crops as a native predator, which can be propagated for the control of pest mites present. This is the first time it has been reported for Mexico and the relevance of this record lies in the fact that the species is classified as an excellent generalist predatory mite, to control different types of mites in warm and moderately humid environments.

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Bibliography


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