Article

Tomato-associated phytophagous mites in northern Sinaloa, Mexico

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Abstract

Due to the great importance that Sinaloa has in the production of red tomato in Mexico, the need arose to carry out the present investigation whose objective was to determine the species of phytophagous mites associated with tomato cultivation in the north of Sinaloa and to know their population fluctuation. The work was carried out in the north of the state, in four sampling sites and two production systems (shade mesh and open field). Sampling was carried out on a biweekly basis during the period from December 2015 to May 2016, randomly 10 plants per plot were selected and 30 leaflets per plant, 10 per stratum (upper, middle and lower) were considered as the sampling unit. 1 548 mites in shade mesh and 1 314 in open field were collected, of the total mites collected, 71.5% corresponded to *Tetranychus urticae*, 13.2% to *Polyphagotarsonemus latus* and 15.3% to *Phytonemus pallidus*. The *T. urticae* species was present during all stages of crop development, its population fluctuation fluctuated according to temperature conditions, with lower presence records during January-February and higher incidence during April-May. The presence of the cyclamen mite, *Phytonemus pallidus* in the shade mesh production system during the reproductive stage of the crop represents the first record of the presence of this species on the crop in northern Sinaloa.

Keywords: *Phytonemus pallidus*, *Polyphagotarsonemus latus* and *Tetranychus urticae*, shadow mesh.

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Introduction

The Mexican red tomato *Solanum lycopersicum* L. (Solanaceae) is the vegetable that generates more currencies in Mexico, with a 21% share of the value of world exports (SAGARPA, 2014). Statistics provided by the Agrifood and Fisheries Information Service (SIAP, 2016), show that in Mexico 51 000 hectares are destined for tomato production, with a production of 2.8 million tons, of which 15 307 were established in Sinaloa , with an annual production of 867 164 tons, which is equivalent to 20% of the volume produced throughout the country: this places Sinaloa as the main producer of export tomatoes.

The 100% of the area of Sinaloa is sown for irrigation and is affected by insects, mites and diseases that reduce crop yields (Sánchez-Peña *et al*., 2006). In Mexico, farmers face serious phytosanitary problems that cause economic losses, including diseases caused by viruses, fungi and bacteria (Jaramillo *et al*., 2007), as well as insects and mites (Nuño-Moreno, 2007).

There is a great diversity of pests that affect tomato production such as whitefly (*Bemisia argentifolii* Bellows & Perring), leaf miner (*Liriomyza trifolii* Burgess), green peach aphid (*Myzus persicae* Sulzer), paratrioza (*Bactericera cockerelli* Sulc), the thrips of flowers (*Frankliniella occidentalis* Pergande), pinworm (*Keiferia lycopersicella* Walsingham), the red spider (Tetranychus urticae Koch), and the roasted tomato mite (*Aculops lycopersici* Massee), among others. *T. urticae* and *A. lycopersici* cause severe damage to many crops on the leaves and fruits, so that the injured areas discolor and the edges of the leaves show deformations as a result of the extraction of sap from the tissues that influences the growth, defoliation, discoloration, decrease in production and finally the death of the plant (Fasulo, 2000).

Damage by mites in all types of crops increased progressively, from secondary pests to primary pests in agriculture (Jeppson *et al*., 1975). Globally, these arthropods are represented 109 families (Zhang, 2011) and 54 617 species, of which 2 625 are present in Mexico, distributed in five orders, representing 4.8% of the world's wealth (Pérez *et al*. , 2013), located in the families Eriophyidae, Tetranychidae, Tenuipalpidae and Tarsonemidae, which include species of agricultural importance (Evans, 1992), in the particular case of Tetranychidae, this family is made up of 1 200 species grouped into 70 genera, within of which, the species belonging to *Tetranychus* are those that produce the greatest losses to agriculture (Zhang, 2003).

In Sinaloa 135 species of mites are registered, a very low number for the enormous quantity that must exist in the different terrestrial and aquatic habitats of the state; but, a systematic study of fauna mite in the entity is lacking, since there are only sporadic and casual data of certain species of medical and veterinary importance (Hoffmann *et al*., 2000). Therefore, the objective of this study was to determine the mite species associated with tomato cultivation in northern Sinaloa and to know their population fluctuation.

Materials and methods

The study was carried out in four sampling sites: Agricola Los Reyes (25° 78' 34" north latitude, -108° 88' 42" west longitude), Agricola San José (25° 81' 54" north latitude, 108° 75' 58" west longitude), Agricola Moreno (25° 71' 23" north latitude, -108° 67' 39" west longitude) and Agricola Meza (25° 74' 10" north latitude, -108° 82' 83" longitude west), located in the Municipalities of Ahome and Guasave, in the north of Sinaloa. For the first two sites, the production system was in the open field, while in the other sites it was in shade mesh.

With a biweekly frequency, the sampling was carried out during the period from December 20, 2015 to May 25, 2016. In each plot diagonal linear transects were made, on which the samples of the mites were taken randomly (Bautista *et al*., 2004). With the purpose of specifying the location of the species, 10 plants per plot were randomly selected, 10 leaflets of each stratum of the plant (upper, middle and lower) (Rabinovich, 1980).

The leaflets were deposited in 30 x 25 cm polyethylene bags, labeled and placed in a cooler for conservation, they were transferred to the Entomology Laboratory of the Faculty of Agriculture of the Valle del Fuerte, of the Autonomous University of Sinaloa. The collected leaves were checked in a stereoscopic microscope brand LBM Luxeo 4Z. The mites of each sample were deposited in a vial with 70% alcohol with a brush; for assembly, the mites were clarified in lactic acid according to the methodology of Krantz and Walter (2009).

The dried lamellae were deposited in entomological cases and were identified according to the taxonomic keys of Tuttle *et al*. (1974), Jeppson *et al*. (1975) and Krantz (1978). The corraboration of species was carried out by Dr. Gabriel Otero Colina, of the Montecillo Campus Graduate College. The adult mite images were taken with a Carl Zeiss Tessovar microscope and subsequently treated with the Gimp software version 2.8.14, in order to make the drawings. The effect of factors such as precipitation and temperatures on the population density of mites was analyzed using Pearson's correlation coefficient.

Results and discussion

1 548 adult mites were collected under shade mesh conditions and 1 314 mites in open field conditions. Of the total mites collected, 71.5% correspond to the species *T. urticae* Koch, 15.3% to *P. pallidus* Banks and 13.2% to *P. latus* Banks. In the open field, the distribution of specimens in *T. urticae* for the upper, middle and lower strata was 528, 434 and 96, respectively, while for *P. latus* it was 282, 253 and 48 collected, respectively, under mesh conditions In the shade the distribution of *T. urticae* was 584, 348 and 56 specimens, respectively, for *P. latus* the distribution of specimens per stratum was 3, 81 and 37, respectively, in turn, the *P. pallidus* distribution was 57, 279 and 103 copies, respectively (Table 1).

Table 1. Mites associated with tomato cultivation in shade mesh and open field production systems in northern Sinaloa, Mexico.

Sampling sites	Family	Genus	Species	Individuals	Stratum
Agricola Meza	Tetranychidae	*Tetranychus*	*urticae*	368	upper
				125	middle
				37	lower
	Tarsonemidae	*Phytonemus*	*pallidus*	57	upper
				279	middle
				103	lower
Agricola Los Reyes	Tetranychidae	*Tetranychus*	*urticae*	282	upper
				253	middle
				48	lower
	Tarsonemidae	*Polyphagotarsonemus*	*latus*	62	upper
				104	middle
				90	lower
Agricola San Jose	Tetranychidae	*Tetranychus*	*urticae*	246	upper
				181	middle
				45	lower
Agricola Moreno	Tetranychidae	*Tetranychus*	*urticae*	216	upper
				223	middle
				19	lower
	Tarsonemidae	*Polyphagotarsonemus*	*latus*	3	upper
				81	middle
				37	lower

The results of the correlation analysis are shown in Table 2. It was observed that precipitation was only associated with the populations of *T. urticae* in two sites, Agricola Moreno and Agricola San Jose, while the population density of the observed species is found highly related to temperatures, in coincidence with Solano *et al*. (2008) in terms of population fluctuation of *Brevipalpus* spp., which is directly proportional to the increase in temperature, oscillating between 24 and 33 °C favors population development.

Table 2. Correlation coefficient (Pearson) between precipitation and temperatures with population density of *T. urticae*, *P. latus* and *P. pallidus* in northern Sinaloa, Mexico.

Sites	Species	Precipitation	Maximum temperature	Minimum temperature	Average temperature
A. Los Reyes	*T. urticae*	0.13737	0.7144	0.64055	0.70875
		0.6871	0.0135	0.0337	0.0146
	P. latus	0.10315	0.87177	0.71804	0.84535
		0.7628	0.0005	0.0128	0.001

Sites	Species	Precipitation	Maximum temperature	Minimum temperature	Average temperature
A. Moreno	*T. urticae*	-0.67077	0.82448	0.77311	0.80933
		0.0239	0.0018	0.0053	0.0025
	P. latus	0.46193	0.64427	0.63595	0.64694
		0.1526	0.0324	0.0354	0.0314
A. San Jose	*T. urticae*	-0.63687	0.93362	0.90595	0.93099
		0.0351	<0.0001	0.0001	<0.0001
A. Meza	*T. urticae*	-0.23932	0.76043	0.78211	0.78605
		0.4785	0.0066	0.0044	0.0041
	P. pallidus	-0.18814	0.77319	0.64699	0.74097
		0.5796	0.0053	0.0314	0.0091

Correlation coefficient (CC) Prob > lRl; *= the variables are correlated (α= 0.05).

In Agricola Meza, under shade mesh conditions, 530 individuals of *T. urticae* and 439 of *P. pallidus* were collected. The presence of *T. urticae* was recorded in the middle and upper strata of the plants; the highest population densities occurred in April and May, because they coincided with the ideal conditions (Aucejo-Romero, 2005), which caused the leaves to be completely covered with cobweb, because the farmer did not carry out the phytosanitary measures given the low prices of tomato in the market.

The species *P. pallidus* (Figure 1 and 2), preferred the middle layer of the plant, preferring dark and humid habitats (DGSV-CNRF, 2014) and its fluctuation varied within the crop, with different population peaks with presence during the months from February to May, with favorable temperature conditions (Cloyd, 2010).

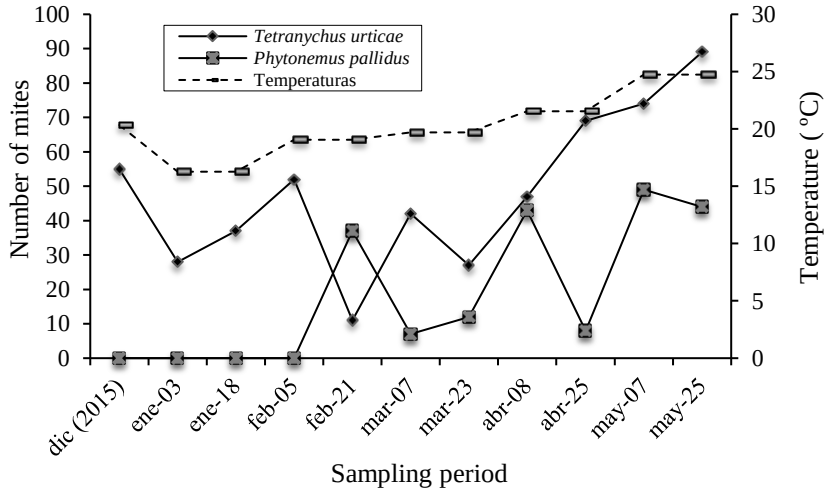

Figure 1. Population fluctuation of tomato mites under shade mesh conditions Agricola Meza.

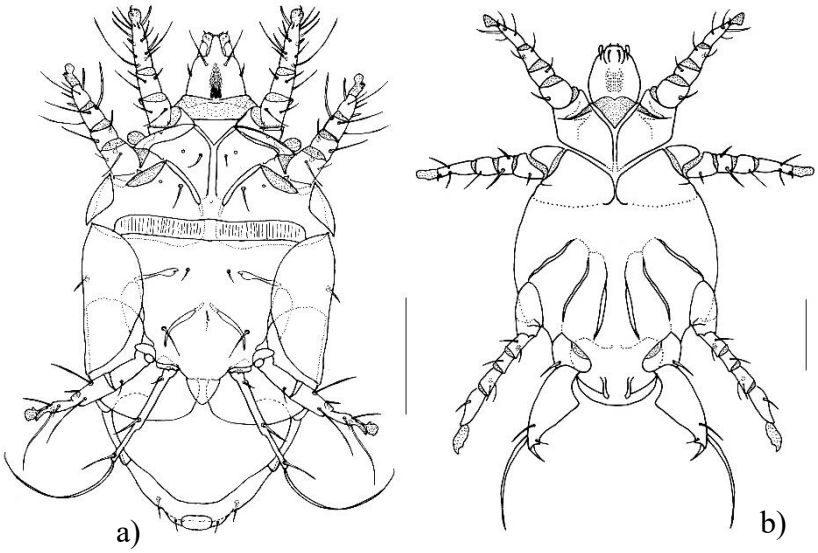

Figure 2. Ventral view of adult *Phytonemus pallidus*. a) female; and b) male. 100 µm scale.

For the open field system at Agricola Los Reyes (Figure 3), a total of 839 mites were collected, of which 583 correspond to *T. urticae* and 256 to *P. latus*. The highest populations of *T. urticae* occurred in May, coinciding with the temperature increases; this species prefers the middle and upper strata of the plant.

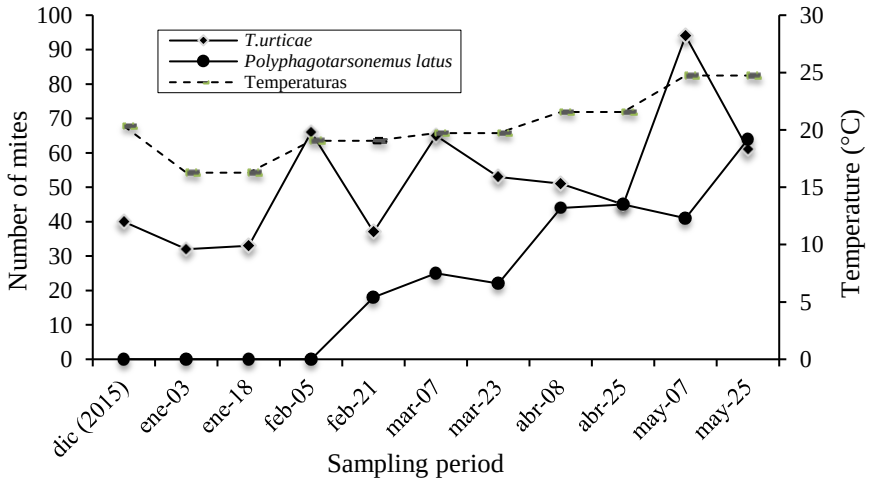

Figure 3. Population fluctuation of *T. urticae* and *P. latus* in open field tomatoes in Agricola Los Reyes.

The results obtained indicate that there is a relationship between temperature and mite population, which coincides with Da Silva (2002) and Praslička and Huszar (2004), who argue that hot and dry summers favor the reproduction of mites. The *P. latus* species was collected in February and increased its population in April and May, where it showed preference for the middle and lower strata of the plants, since they are humid, shady places and these mites feed on the lower surface of the leaf (Peña and Bullock, 1994).

In Agricola San Jose (Figure 4), 475 individuals of *T. urticae* were collected in tomato, an open-field production system established, whose presence was located in the middle and upper strata of the plant, being the only species found in this site; likewise, its presence was recorded from the first sampling, which maintained its population from February to May and fluctuated according to the high temperatures that ranged from 20 ºC to 30 ºC, favorable for its development and biological cycle, as well as low relative humidity and presence of some predatory insects such as *Stethorus* sp. (Coleoptera: Coccinallidae), registered in the study.

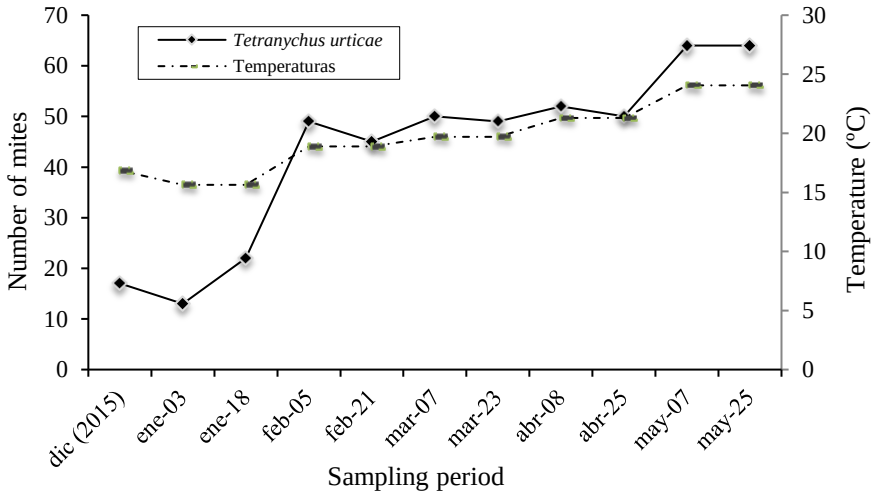

Figure 4. Population fluctuation of *T. urticae* in open field tomatoes in Agricola San Jose.

In Agricola Moreno under conditions of shade mesh, a total of 579 specimens were obtained, of which 458 corresponded to *T. urticae* and 121 to *P. latus* (Figure 5). The species *T. urticae* was presented from the first sampling in December 2015 with low populations during the first months, with the highest population peaks in April and May 2016, this species was located feeding more preferably in the middle and upper parts of the plants. The *P. latus* species was found in the lower part of the plant in February and raised its populations in April and May, until the end of the crop where it presented the largest number of individuals in the middle part of the plant.

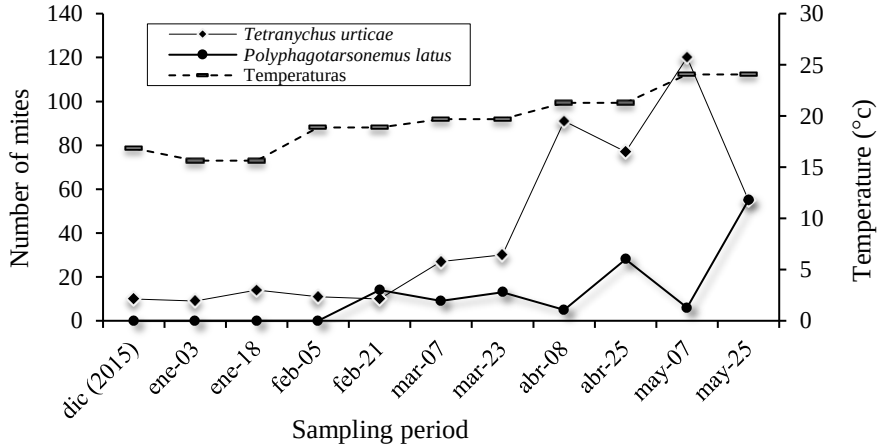

Figure 5. Population fluctuation of *T. urticae* and *P. latus* in tomato under shade conditions in Agricola Moreno.

It should be noted that the percentage of phytophagous mites associated with tomato cultivation in northern Sinaloa (Figure 6) is much higher compared to the number of predatory and commensalistic mites, some result that coincides with that obtained indicates that (*Oligonychus punicae* Tutle) and (*Olygonychus perseae* Hirst) (Tetranychidae), are the most representative and harmful species of phytophagous mites in the avocado crop (*Persea americana* Mill, 1768) in Michoacan also depend on the agronomic management of the crop, is decisive in the number of mites present in each batch and in each sampling.

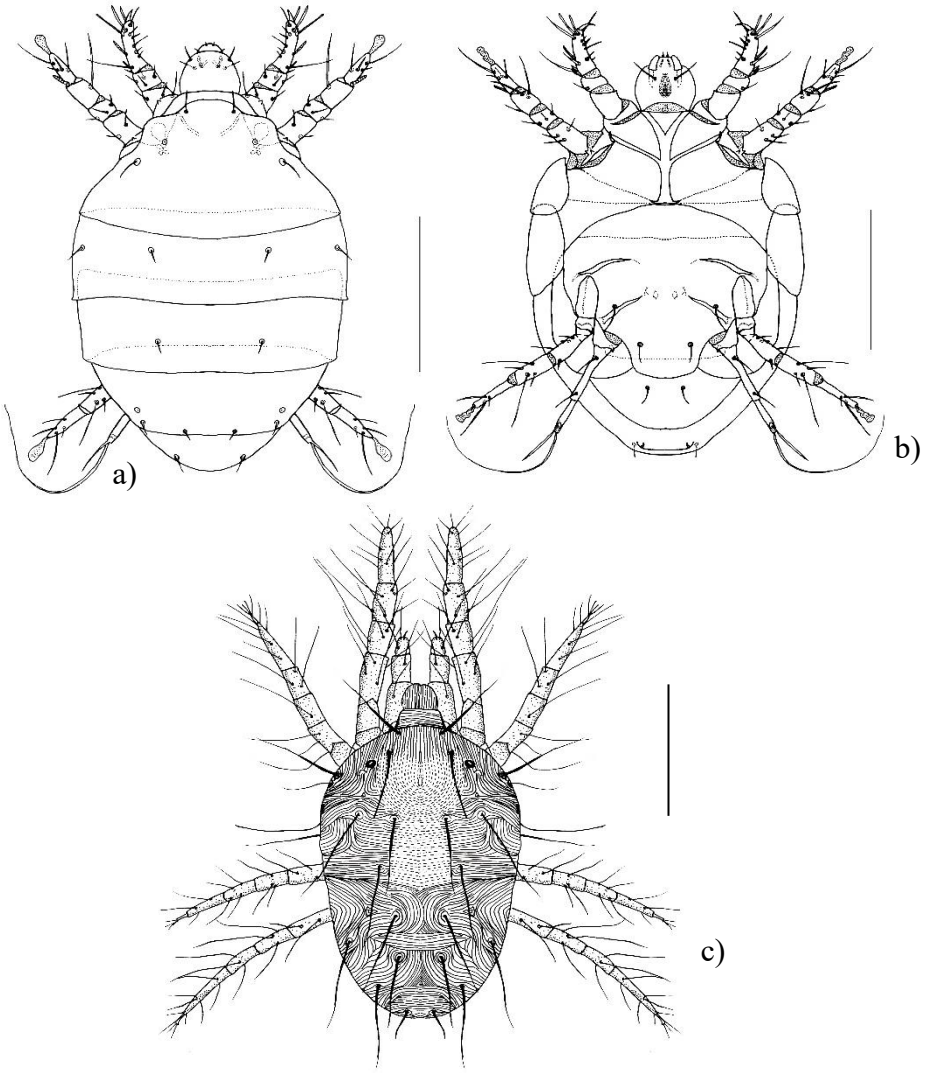

Figure 6. a) Dorsal view of *Polyphagotarsonemus latus* male. b) ventral view of female *P. latus*; and c) dorsal view of male *Tetranichus urticae*. 100 µm scale

Which coincides with the results obtained in this investigation, since the lots that showed greater deficiency in the agronomic management of the tomato presented greater abundance of mites and therefore, greater damage (Chow *et al*., 2009; Flores *et al*., 2011). It is important to note that at the end of the crop cycle the species that presented the lowest percentage of population incidence was *P*. *pallidus* (84%) and the agricultural ones Meza and Moreno presented intermediate values with (57 and 60%), respectively.

In Agricola Los Reyes and Agricola San José showed the incidence of mites in the open field, from 22 to 37%, in contrast under shade mesh conditions that show the incidence of mites in the two production systems, the presence of higher incidence is presented as the temperatures were favorable for the development of the mite.

Conclusions

T. urticae Koch, *P. latus* Banks and *P. pallidus* Banks were determined as the species of phytophagous mites associated with tomato cultivation in the different production systems in northern Sinaloa, which have great potential for impact of the damage on the tender leaves and the fruits. During the development of the crop *T. urticae* was present during all stages presented its lowest population in January, February and its highest incidence in April and May respectively, which is related to temperature.

The *P. latus* Banks species was found in tomato cultivation in the flowering and fruiting stages and *P. pallidus* Banks was present in shade mesh during the reproductive stage of the crop.

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