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First record of the tomato red spider mite, *Tetranychus evansi* Baker & Pritchard (Acari: Tetranychidae) in Mexico, from cultivated and wild solanaceous plants

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Original research

ABSTRACT

The tomato red spider mite *Tetranychus evansi* Baker & Pritchard is a pest of primary importance on cultivated Solanaceae in some countries. Based on morphological characters and sequencing of a fragment of the cytochrome oxidase subunit I (COI) of mitochondrial DNA (mtDNA), the presence of *T. evansi* is reported for the first time in Mexico, from four municipalities (counties) in three states: Baja California, Nuevo León and Tamaulipas, on solanaceous plants, both cultivated (tomato, *Solanum lycopersicum* L., and potato *Solanum tuberosum* L.) and wild (nightshades, *Solanum* cf. *americanum* Mill. and *Solanum nigrescens* Mart. & Gal.). The molecular study confirms for the first time the presence of haplotype 4 (belonging to clade I) of *T. evansi* in North America (Nuevo Leon state). This clade includes most invasive *T. evansi* populations worldwide. Although no studies have been carried out on the economic impact of *T. evansi* in Mexico, it is of utmost importance to recognize the presence of this species to establish sound management strategies.

Keywords invasive pest; nightshade; phytophagous mite; potato; *Solanum*; tomato

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Introduction

Solanaceous plants include important crops worldwide. Tomato (*Solanum lycopersicum* L.) in its different varieties, and potato (*Solanum tuberosum* L.) are two of the most important crops in Mexico: for tomato, 49,287 ha were planted in 2022, with a value of 1,566,032 USD; for potato, 60,102 ha were planted in 2022, with a value of 803,805 USD (SIAP 2023). The states of Baja California, Nuevo Leon and Tamaulipas contributed 2.9% of total Mexican tomato production in 2022 (SIAP 2023); these areas include high-technology greenhouses with significant production output. For potato, the state of Nuevo Leon grew 5.4% of Mexico's production in 3,214 ha with a value of 78,523 USD in 2022 (SIAP 2023; Delgado-Luna *et al.* 2022).

Yield of solanaceous crops is affected by diseases and pests including mites (Ong *et al.* 2020; Ascencio-Alvarez *et al.* 2018; Lugo-Sánchez *et al.* 2019). Of these, the two-spotted spider mite, *Tetranychus urticae* Koch, the broad mite, *Polyphagotarsonemus latus* Banks and the cyclamen mite, *Phytonemus pallidus* Banks attack tomato in Sinaloa, the main producing state in Mexico (Lugo-Sánchez *et al.* 2019).

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One of the most important pest species of the genus *Tetranychus* worldwide on Solanaceae is the tomato red spider mite, *Tetranychus evansi* Baker & Pritchard (TRSM) (Navajas *et al.* 2013). This mite has been reported in 56 countries, associated with at least 147 plant species within 36 botanical families (Migeon and Dorkeld, 2023). In the American continent, TRSM is distributed in the Neotropical region in Argentina, Brazil, Dominican Republic, Puerto Rico and Virgin Islands; in the Nearctic region it is recorded from Florida, and the USA-Mexico border states of Arizona, Texas and California (Wene 1956 [as *Tetranychus marianae* McGregor]; de Moraes *et al.* 1987; Navajas *et al.* 2013; Migeon and Dorkeld 2023). Morphologically unclear samples resembling *T. evansi* were reported from the Pacific coast of Jalisco, Mexico (de Moraes *et al.* 1987).

Tetranychus evansi elicits some unique physiological responses in attacked plants, suppressing important defense pathways, therefore inflicting damage in a different way to some of its congeners (Sarmiento *et al.* 2011). TRSM is usually not considered a severe pest in its native host range (Brazil); however, in northern Argentina it is widespread and the most abundant tetranychid mite collected, with very high populations on tomato and other solanaceous plants (Guanilo *et al.* 2010; Furtado *et al.* 2007). It is a severe pest in sites of sub-Saharan Africa, where it can cause up to 90% crop loss of tomato (Migeon *et al.* 2009; Boubou *et al.* 2011; Savi *et al.* 2019) and it is considered a primary, invasive pest of solanaceous crops in Europe and the Mediterranean basin (EPPO 2022).

Invasive populations of *T. evansi* represent a threat to solanaceous crop production worldwide. Timely detection of invasive pests and diseases is of utmost importance to establish proper control measures (Migeon *et al.* 2009). In this study we report for the first time the presence of *T. evansi* in Mexico, from cultivated (tomato and potato) and wild (nightshade) solanaceous hosts.

Material and methods

Sample collection

Leaves of wild and cultivated solanaceous plants infested by suspect TRSM were collected at four sites from three states in Mexico (Table 1).

Table 1 *Tetranychus evansi* samples and plant hosts from Mexico.

Locality			Host plant		Date collected
State	Town, Municipality	Coordinates	Scientific name	Common name	
Baja California (BC)	San Carlos, Ensenada	31°47'06"N, 116°26'53"W	<i>Solanum nigrescens</i>	slender nightshade	10-oct-23
Nuevo León (NL)	García	25°44'36"N 100°26'13"W	<i>Solanum</i> cf. <i>americanum</i>	black nightshade	15-juin-20
			<i>Solanum lycopersicum</i> (saladette)	saladette tomato	12-juil-23 30-juil-20
	Monterrey	25°42'46"N, 100°21'12"W	<i>Solanum tuberosum</i> cv. Fiana	white potato	25-juil-23
			<i>Solanum tuberosum</i> cv. Fiana	white potato	10-juil-23
			<i>Solanum lycopersicum</i> var. <i>cerasiforme</i>	cultivated cherry tomato	10-juil-23
Tamaulipas (TAM)	Ciudad Victoria	23°46'08"N, 99°09'43"W	wild <i>Solanum lycopersicum</i> var. <i>cerasiforme</i>	cherry tomato	3 June 2020

Morphological identification

Samples were examined using a stereomicroscope, placing mites in Hoyer's medium on slides (EPPO 2022). A sample of 170 females were examined from García (Nuevo Leon state). For Ciudad Victoria (Tamaulipas state) and Ensenada (Baja California state), 10 males and 10 females were examined from each population. Mites on slides were examined under an Olympus Vanox phase contrast microscope at Laboratorio Nacional de Microscopía Avanzada (National Laboratory of Advanced Microscopy), Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE) and identified according to Baker and Pritchard (1960), de Moraes *et al.* (1987), Seeman and Beard (2011) and EPPO (2022); characteristics observed included aedeagus, tarsus I and empodium, and pregenital striae.

Females from García, Nuevo León, and females and males from Baja California and Tamaulipas were deposited (as slides) at "Colección Nacional de Ácaros" (CNAC), Instituto de Biología, Universidad Nacional Autónoma de México (UNAM), Mexico City, Mexico.

Molecular analysis

Molecular methods for DNA sequencing of a fragment of the mitochondrial cytochrome oxidase I (COI) region were performed at Biociencia, Monterrey, Nuevo Leon, Mexico (<http://www.biociencia.com.mx>). DNA was extracted from 30 females and nymphs from Garcia, Nuevo Leon, following the cetrimonium bromide (CTAB) procedure in Doyle and Doyle (1987) modified by SENASICA (2017). Primers used LCO1490: 5'-GGTCAACAAATCATAAAGATATTGG-3' and HC02198: 5'-GGTCAACAAATCATAAAGATATTGG-3' were as in Folmer *et al.* (1994). Amplification conditions are described in SENASICA (2017). Sequencing of PCR products was provided by Biociencia. Sequences were compared (BLAST) in the NCBI database to determine percent species identity.

Results and discussion

Morphological observations

The mite was confirmed as *T. evansi* from morphological examination of females (populations from all three states) and males in the Tamaulipas and Baja California populations. No males were found in the Garcia, Nuevo Leon sample ($n = 170$). Populations of *T. evansi* can be strongly female-biased (de Moraes and McMurtry 1987). The size and shape of the aedeagus (Figure 1A, B) closely match descriptions in Baker and Pritchard (1960), de Moraes *et al.* (1987), Seeman and Beard (2011) and EPPO (2022). For females, differences between tarsus I of *T. evansi* and *T. marianae* were used (de Moraes *et al.* 1987). The pregenital striae are entire; dorsal striae are longitudinal (not transverse) between setae e_1-e_1 , forming a diamond or rhomboid shape between setae e_1-f_1 in females (Seeman and Beard 2011).

Molecular analysis

A COI sequence 471 bp long (GenBank accession PP060370) was obtained from Garcia (Nuevo Leon state) samples. A BLAST analysis resulted in 97.21-100% identity and 98% query cover with *T. evansi* sequences in Genbank (for example, Boubou *et al.* 2011). The next more similar species was *Tetranychus truncatus* Ehara with a distant 89.5% identity (11.5% divergence). These values indicate that samples are not conspecific with *T. truncatus*, but are conspecific with TRSM. Within the Tetranychidae, Ben-David *et al.* (2007) suggested a minimum of 98% identity for species separation using COI and ITS2 markers. They emphasize that solid morphological characterization is essential for designation of correct reference sequences.

Ten COI haplotypes have been reported in *T. evansi*; these cluster into two lineages or clades (Boubou *et al.* 2011; Knecht *et al.* 2020). Clade I is present in Africa, Asia, the Mediterranean

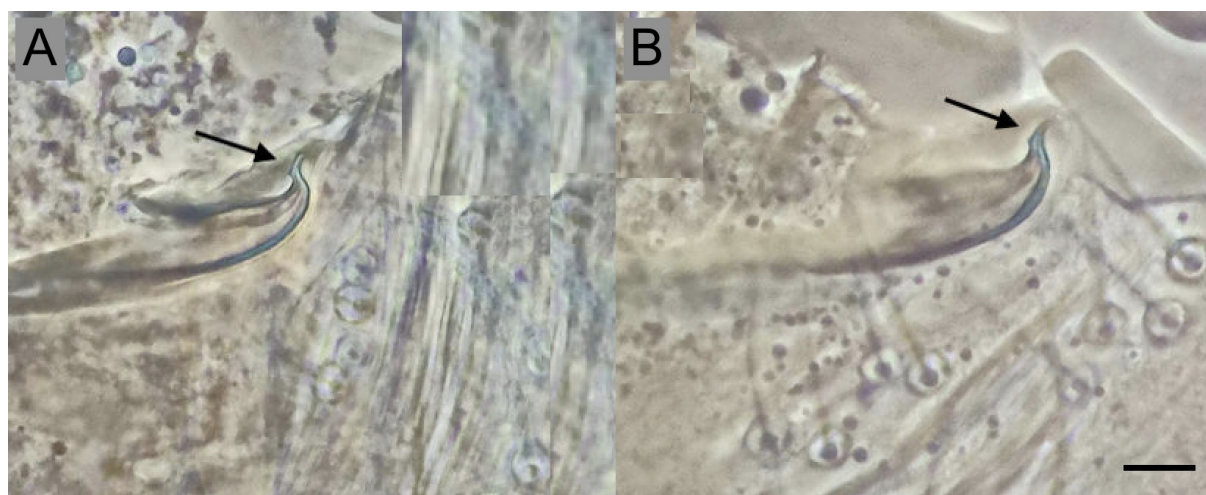


Figure 1 Aedeagi of Mexican *T. evansi*: A – from Ensenada, Baja California; B – from Ciudad Victoria, Tamaulipas. Bar = 6 μ m. Notice characteristic horse head-shape of aedeagus (arrows).

and South America; Clade II includes Mediterranean and South American populations only. Our sequence from Mexico belongs in clade I and it is identical to haplotype TW (GenBank FJ440677) reported by Gotoh *et al.* (2009) from Wufeng, Taiwan and designated as haplotype H4 (Boubou *et al.* 2011); it is also identical to later reports: MT0196779.1 and MT019789.1 (Mo'atza Azorit Emeq Hamaayanot, Israel); MT019707.1 (Tokyo, Japan); MT019694.1 (Andalucía, Spain); and MT0196732.1 and MT019792.1 (Canary Islands, Spain) (Knecht *et al.* 2020). This haplotype is widespread in Africa (Niger), Europe (the Mediterranean: Algeria, Greece, Israel, southern and southeastern Spain, and Tunisia), also, from the Canary Islands (Spain) and Asia (Japan, Taiwan) (Boubou *et al.* 2011; Knecht *et al.* 2020).

This is the first report of clade I from North America. In general, clade I mites have a higher invasive potential than mites from clade II (Meynard *et al.* 2013; Santamaría *et al.* 2018; Knecht *et al.* 2020).

Field observations

TRSM populations reported in this work are listed in Table 1. All life stages including eggs and overlapping generations were observed on these plants. Mites were initially observed on nightshades or “hierba mora” (*Solanum nigrescens* Mart. & Gal. and *Solanum cf. americanum* Mill.) at Ensenada (Baja California) (on *S. nigrescens*) and in García (Nuevo León) respectively (Figure 2A). These non-cultivated plants were in vacant lots of residential areas, along urban and rural roads and other weedy disturbed areas. Severe infestations of TRSM leading to leaf necrosis or plant death were observed on nightshades. These and very similar nightshades appear to be worldwide frequent hosts for TRSM (Qureshi *et al.* 1969; Tsagkarakou *et al.* 2007; Santamaría *et al.* 2018). The capacity to manipulate plant defenses and a high intrinsic growth rate might contribute to observed high populations (Sarmiento *et al.* 2011; Navajas *et al.* 2013). Clade I mites can attain very high population levels on both nightshades and tomato (Santamaría *et al.* 2018).

TRSM was also observed in high levels on tomato and potato plants grown in home gardens in 2020 and 2023, in the urban area of Monterrey and García, Nuevo León state. In 2023, mixed infestations of TRSM and very low numbers of much darker unidentified spider mites, were observed on the same tomato plants. The darker unidentified mite was observed only on newer tomato growth, while older growth was more heavily infested by TRSM. This could result from an initial infestation by TRSM (see Sarmiento *et al.* 2011; Navajas *et al.* 2013); in the



Figure 2 Damage by *T. evansi* on Solanaceae: A – Infested leaves of wild nightshade, *Solanum* cf. *americanum*, García, Nuevo León; B – Discolored lesions on tomato fruit (*Solanum lycopersicum*). García, NL, Mexico.

field this species is usually dominant over other spider mites, reducing the absolute and relative abundance of other *Tetranychus* species, including the widespread, darker-colored *T. urticae* (Ferragut *et al.* 2013; Azandémè-Hounmalon *et al.* 2015); as mentioned, this can result from manipulation of plant defenses and a high intrinsic growth rate (Sarmiento *et al.* 2011; Navajas *et al.* 2013). In Nuevo Leon state (García and Monterrey sites) the mites infested saladette tomato plants late in the season, after flowering. Fruits were damaged, showing numerous tiny pale spots or blotches from feeding by hundreds of mites (Figure 2B). Eventually most foliage was killed and the plants died prematurely, before fruit production was complete. Both varieties of tomatoes (saladette and cherry) at Nuevo Leon were severely impacted. We lack quantitative data, but damage on potato was also particularly intense and rapid, perhaps worse than on tomato; in time, all potato plants were completely wilted and died.

Considering this apparent geographical expansion of *T. evansi* into Mexico, it is pertinent to comment on its host plant range. The mite is considered oligophagous (Guanilo *et al.* 2010; Ferragut *et al.* 2013). In our observations, the mites infested only solanaceous plants, and the mite masses thus produced (Figure 3) did not colonize or damage other plants (from at least 8 families) in physical contact with infested plants. Reports of host plants should verify full completion of the arthropod's life cycle on these plants (i.e. true “host plants”) and distinguish these from “food plants” (those where the arthropod can feed, but not reproduce; food plants temporarily support arthropod survival in the absence of true hosts) and from overwintering, shelter and incidental plants (Mendonça *et al.* 2011; Reyes-Corral *et al.* 2021; Delgado-Luna *et al.* 2022).

At García and Monterrey, plants not colonized by TRSM, grown in heavily infested unsprayed home gardens included aloe or sábila (*Aloe vera* L.), avocado (*Persea americana* cv. “Hass”), cacti (*Opuntia ficus-indica* (L.) Mill and *Nopalea cochenillifera* (L.) Salm-Dyck), Mexican lime (*Citrus aurantiifolia* (Christm.) Swingle), seedlings of oaks (*Quercus polymorpha* Schlecht. & Cham. and *Q. fusiformis* Small), orange (*Citrus × aurantium* L.), papaya (*Carica papaya* L.), peace lily (*Spathiphyllum wallisii* Regel) and peppermint (*Mentha × piperita* L.). Therefore, at least in these gardens, the mite appeared to be quite oligophagous on Solanaceae (Guanilo *et al.* 2010; Migeon and Dorkeld 2022; Da-Costa *et al.* 2022). On papaya, there were orange-colored masses of mites, apparently engaging in wind dispersal behavior (ballooning) (Figure 3). Notwithstanding mite masses, no mite reproduction was observed, and papayas were not damaged; suggesting that the mites came from adjacent, heavily infested tomato plants. Interestingly, no noticeable populations were observed on chili pepper plants (Solanaceae) growing within 1 m of tomato plants infested with very high



Figure 3 Webbing and orange masses of *T. evansi* individuals on papaya leaf (*Carica papaya*), engaging apparently in wind dispersal behavior (ballooning). García, Nuevo León, Mexico.

densities of TRSM. These unharmed pepper plants were six mature plants of a cultivar (jalapeño, *Capsicum annuum* var. *annuum* L.) and two plants of wild (piquín) chili pepper (*C. annuum* var. *glabriusculum* [Dunal]). Chili pepper is listed as severely impacted in Benin, Africa (Azandeme-Hounmalon 2022). This could be compared to the fact that wild chili pepper has resistance traits against *Tetranychus merganser* Boudreaux (Chacón-Hernandez *et al.* 2020).

The presence of *T. evansi* represents an additional challenge for production of solanaceous crops in Mexico. Ecological studies of the mite are required, both in agricultural and non-agricultural settings. Its pest status has been variable over time and space, in both native and invaded areas (Navajas *et al.* 2013; Azandémè-Hounmalon *et al.* 2022; F. Ferragut, personal communication). Its presence in Arizona, California and Texas (see de Moraes *et al.* 1987 and references therein; Ferragut & Escudero, 1999; Migeon *et al.* 2009), states bordering Mexico, can explain its detection in widely separated locations of this country. Containment in Mexico thus would prove difficult. It was recorded decades ago right at the Mexican border: outbreaks on tomato at unspecified sites of the lower Rio Grande Valley of Texas (Weslaco?) (Wene 1956) and in 1957 at Donna, Texas (de Moraes *et al.* 1987), both sites adjacent to Tamaulipas state and close to Nuevo Leon state (Migeon *et al.* 2009; Navajas *et al.* 2013; Migeon and Dorkeld 2023). In the climatic analysis and modelling by Migeon *et al.* (2009) and Meynard *et al.* (2013), extensive areas of these states appear as highly suitable for TRSM; parts of Baja California state are moderately suitable. Thus, TRSM is likely to be present in additional localities in the country. On the other hand, sampling effort in solanaceous crops is limited, making it difficult to detect and identify mite species. Similarly, it is important to continue exploring native and invaded areas for natural enemies (de Moraes and McMurtry 1985; Navajas *et al.* 2013; Guanilo *et al.* 2010; Furtado *et al.* 2014; Dayoub *et al.* 2022) towards the inclusion of biological control among other sustainable management strategies of TRSM in Mexico.

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