New Hosts, Distribution, and Color Trap Preferences of the Invasive Thrips *Scirtothrips dorsalis* (Thysanoptera: Thripidae) in Mexico[1]

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Abstract *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae) is an insect of Asian origin and is currently distributed in several countries around the world. It has highly polyphagous habits and has been reported as a primary pest of different fruit, horticultural, and ornamental crops. This species was reported in Mexico in 2020, however, due to its invasive nature and its rapid adaptation to new ecosystems, it is probably present in other regions of the country. The lack of information on this pest has resulted in misidentifications and misdiagnosis at the field level by phytosanitary technicians. In the present work, we found that *S. dorsalis* is distributed in the states of Veracruz, Sinaloa, Jalisco, and Michoacán in Mexico occupying sites with different climates (warm and temperate) and elevations from 6 to 1,721 m above sea level. Plant reproductive hosts were blackberry (*Rubus* sp.), blueberry (*Vaccinium* sp.), Persian lime (*Citrus latifolia* Tanaka), mango (*Mangifera indica* L.), and pear (*Pyrus communis* L.). Through an evaluation of the response of adults toward chromatic traps, we found that this species greatly prefers yellow (×5.40) compared with blue color. More studies are needed on detection and control measures in order to reduce the distribution and economic impact caused by this insect pest in Mexico.

Key Words chili thrips, insect pest, behavioral response, fruit trees

Chilli thrips, *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae), is an invasive and highly polyphagous insect that feeds on plants belonging to several botanical families including species of horticultural, fruit, and ornamental importance, as well noncultivated species (Kumar et al. 2013). Due to its feeding habits, it consumes the cytoplasmic content of the mesophyll cells, which causes alterations in plant tissue in shoots, young leaves, flowers, and fruits (Kim et al. 2019, Rao et al. 2019, Rodríguez 2022, Seal and Kumar 2010). In addition, it can cause

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secondary damage in some hosts due to the transmission of phytopathogenic viruses of the Orthotospovirus genus (Mound et al. 2022). *Scirtothrips dorsalis* is native to Asia, however, it has spread to several countries in Oceania, Europe, Africa, and the Americas (European and Mediterranean Plant Protection Organization 2022, Kumar et al. 2013). In Mexico, *S. dorsalis* has been recorded in the southwestern region of the country and in commercial blueberry (*Vaccinium* sp.), raspberry (*Rubus* sp.), and blackberry (*Rubus* sp.) plantations in the Michoacan state (Ortiz et al. 2020). Later, it was detected severely affecting orchards of Mexican lemon (*Citrus aurantifolia* Swingle) in the Colima state (Murillo-Hernández et al. 2022).

Until now, *S. dorsalis* does not have an official phytosanitary status in Mexico and, therefore, does not have quarantine measures to mitigate its spread and damage. In addition, it is probably already distributed in other regions despite being a recently registered species in the country; therefore, its identity and damage can be confused with other organisms (e.g., other thrips species, mites, aphids, etc.) or physiological alterations in susceptible crops, making their management difficult.

One of the methods used for the detection and monitoring thrips populations are chromatic sticky traps. Some studies report the efficacy of these devices on *S. dorsalis*, however, the results may vary depending on the trap color and certain environmental conditions (Chu et al. 2006, Tsuchiya et al. 1995), and thus far, there are no reports of studies on the effectiveness of color traps in Mexico. The objective of this research was to gather more information about *S. dorsalis* in Mexico through an exploratory survey of economically important crops from different areas of the country, illustrate its main diagnostic characteristics and damage caused to plants, and establish their behavioral response to blue and yellow sticky traps.

Materials and Methods

Thrips sampling and identification. Sampling of avocado (*Persea americana* Mill.), blackberry, blueberry, mango (*Mangifera indica* L.), Persian lime (*Citrus latifolia* Tanaka), pear (*Pyrus communis* L.), and soursop (*Annona muricata* L.) plants was conducted in different localities in the Veracruz, Sinaloa, Jalisco, and Michoacan states. At each collection site, 10 samples composed of two infested leaves from the apical part of each plant species were collected and placed in 50-mL polypropylene tubes with 70% ethanol. Likewise, photographs were taken *in situ* to document the symptoms and damage caused to each host. Only plants inhabited by both larval and adult *S. dorsalis* were considered as reproductive hosts. The specimens were transferred to the laboratory of Parasitology and Biological Control of the Faculty of Agricultural Sciences of the Universidad Veracruzana, where the thrips in each sample were counted. Likewise, for their identification, 15 female adult specimens and five adult males from each host and locality were mounted on slides with Hoyer's solution according to the Mound and Kibby (1998) methodology. The specimens were observed under a microscope (Nikon, Alphaphot YS2, Nikon Corp., Tokyo, Japan) at 40, 100, and 400× for taxonomic identification using the taxonomic keys of Mound and Palmer (1981), Hoddle and Mound

(2003), and Kumar et al. (2011). Digital images of the main identification characters were obtained.

Evaluation of chromatic sticky traps. The experiment was conducted in a nursery of approximately 1 ha in area with mango plants (cv. 'Tommy Akins') and a natural occurrence of *S. dorsalis*, located in the town of Paso de la Milpa (19° 25′ 33.93″ N 96° 36′ 15.29″W, 267 masl), belonging to the Actopan municipality, Veracruz, Mexico. Yellow and blue sticky traps, 10 × 25.7 cm, were compared (Greentramp of Greenvass™, Murcia, Spain) for the attraction and capture of thrips. Four traps of each color were placed, distributed in a randomized complete block design, at 4 m in length and width within each plot. The traps were fixed to a wooden stake 80 cm above the ground. The experiment was initiated on 14 April 2022 and, 5 d later, the traps were removed and replaced with a re-randomization of the design to reduce any possible influence of capture by the location of the trap. The experiment concluded on 24 April 2022. The removed traps were wrapped in self-adhesive polyvinyl chloride plastic (Egapack™, E.G.A. Pack, Sommacampagna, Italy) for storage and transfer to the laboratory to quantify the number of thrips on each trap with the aid of a stereomicroscope (Velab VE-S5, Digikey, Thief River Falls, MN) at 40×. The data obtained were analyzed using a *t* test for two groups in the Statistica ver. 12 software (TIBCO Software, Inc., Palo Alto, CA).

Results and Discussion

***Scirtothrips dorsalis* distribution, hosts, and damage in Mexico.** Adults and larvae of *S. dorsalis* were detected on different hosts and locations in Mexico in the states of Veracruz, Sinaloa, Jalisco, and Michoacán (Table 1). According to our findings, this species can adapt to different environmental conditions, such as warm sub-humid to temperate climates and altitudes from 6 to 1,721 masl. Larvae can be aggregated in the young leaves, and the adults are generally dispersed over various parts of the plant; both larvae and adults remained active and exposed during the day. It is probable that the spread of this species in the country is due to anthropogenic causes such as the transport of cargo and goods, production marketing, movement of plant material for propagation, and naturally by wind action (Meissner et al. 2005) and prolonged periods of drought.

The association of *S. dorsalis* was antagonistic for each host due to its phytophagous feeding. The lesions caused by feeding activity showed variations according to the host species, its phenological stage, and the type of tissue damaged. Similarly, the severity of the damage visually corresponded to the numbers of thrips on the host.

Pear plant foliage (Fig. 1A–C) presented brownish-copper lesions on the sides of the leaf veins and slight curling at the ends, alterations in the leaflet, brittle texture, and wilting. The new leaves presented complete curling and growth deficiency. Numerous aggregations of larvae and adults were observed moving over infested leaves, mainly along the midrib. The presence of *S. dorsalis* in *Pyrus* was recorded by Chang (1991) and Ohkubo (1995) with *P. calleryana* Decne, *P. communis*, *P. pyrifolia* Nakai, and *P. serotina* Nakai in Asia; however, they do not document the damage or the role of these plants as primary hosts. Our report herein is the first record of *S. dorsalis* affecting pear plants in Mexico.

Table 1. Collection sites and hosts with the presence of larvae and adults of *Scirtothrips dorsalis* in Mexico.

State	Municipality	Location and Altitude	Collection Date	Host	Thrips Number by Sample			
					L*	F**	M†	Total
Veracruz	Actopan (nursery plants)	19°25′33.93″N 96°36′15.29″W 267 masl	3 March 2022	Pear (*Pyrus communis*)	419	17	21	457
			10 April 2022	Mango (*Mangifera indica*)	110	6	2	118
	Carrillo Puerto	18°48′22.65″N 96°34′52.55″W 187 masl	4 July 2022	Persian lime (*Citrus latifolia*)	276	19	15	310
Sinaloa	Ahome	25°50′49.70″N 108°54′4.08″W 21 masl	1 June 2022	Blueberry (*Vaccinium* sp.)	6	2	0	8
		25°46′32.88″N 109°07′17.86″W 6 masl	4 January 2023	Blueberry (*Vaccinium* sp.)	284	26	8	318
	El Fuerte	26°17′55.06″N 108°42′18.56″W 78 masl	2 June 2022	Blueberry (*Vaccinium* sp.)	11	2	4	17
Jalisco	Zapotlán el Grande	19°42′19.49″N 103°33′06.31″W 1,662 masl	12 May 2022	Blueberry (*Vaccinium* sp.)	42	10	4	56

Table 1. Continued.

State	Municipality	Location and Altitude	Collection Date	Host	Thrips Number by Sample			
					L*	F**	M†	Total
	Tuxpan	19°35′20.04″N 103°22′39.59″W 1,182 masl	5 November 2022	Blackberry (*Rubus* sp.)	173	35	11	219
Michoacán	Tangancicuaro	19°52′29.27″N 102°12′57.03″W 1,721 masl	16 June 2022	Blueberry (*Vaccinium* sp.)	28	5	3	36

* Larvae.
** Females.
† Males.

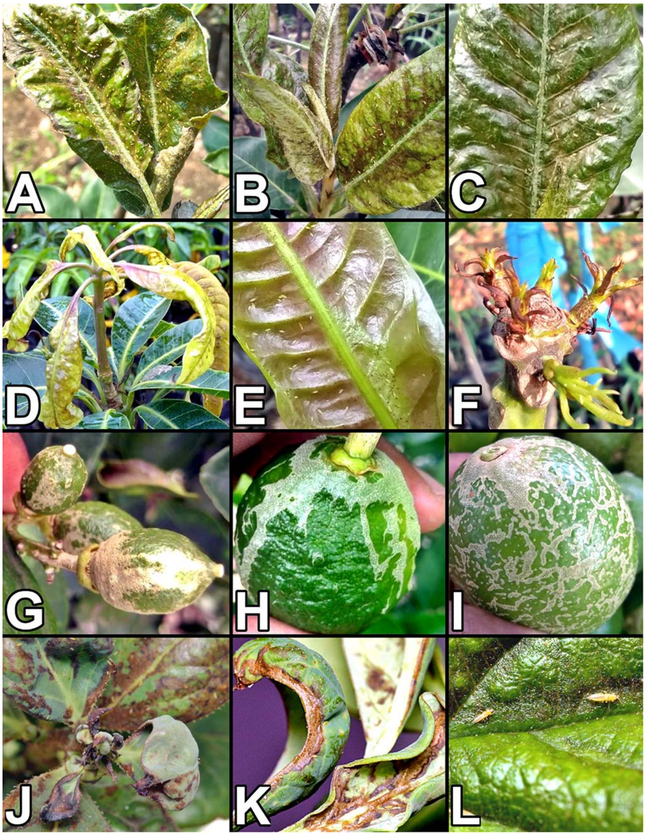

Fig. 1. Presence of *Scirtothrips dorsalis* and various manifestations of damage caused by its herbivory. (A–C) Spots and distortions of young leaves in pear plants with a high population of larvae and adults. (D) Mango shoot with changes in leaves. (E) Young mango leaf with presence of larvae on the underside. (F) Mango plant apex with distortion and malformation of shoots. (G–I) Lemon fruits in various stages of development with the presence of silvery-white scars on the epidermis. (J) Necrotized blueberry shoots and leaves with brown spots. (K) Presence of larvae and curved blueberry leaves with brown spots on the margins and veins. (L) Blackberry leaves with dark spots near the midrib and presence of male and female.

In mango nursery plants (Fig. 1D–F), the young leaves were deformed and slightly rolled, with a chlorotic appearance and numerous lesions in the form of coppery-brown spots. In some plants with damage to the apical meristems, malformed and reduced shoots developed which eventually desiccated. These alterations were similar to those manifested by the incidence of the witches broom disease in mango (Debnath et al. 2020) (Fig. 1F). Lesions with cracking of the bark were observed on the stem, probably caused by previous feeding damage and subsequent growth of the plant. No specimens of *S. dorsalis* were detected in mature mango trees close to infested nursery plants; however, low populations of other thrips species, such as *Frankliniella gardeniae* Moulton ($n = 8$), *F. insularis* Franklin ($n = 1$), *F. invasor* Sakimura ($n = 13$), and *F. schultzei* Trybom ($n = 1$), were collected. *Mangifera indica* is previously reported as a primary host for *S. dorsalis* in various parts of the world (Kumar et al. 2012, Lin et al. 2015), including several Asian countries where it is an important pest due to the damage caused to nursery plants and trees in production, such as scars on the leaves and roughness on the surface of the fruits. Under severe conditions, the shoots atrophy, preventing flowering and fruiting with the subsequent loss of yield (Karar et al. 2022, Lin et al. 2015).

In the Persian lime trees, different patterns of white-silver scars appeared on the epidermis of the fruits, generally around the calyx although in some cases the scars covered the entire fruit (Fig. 1G–I). Leaf and shoot alterations also were observed with high densities of larvae and adults. The damage observed in this work coincides with that reported by Murillo-Hernández et al. (2022) in Mexican lemon trees in the state of Colima. Likewise, *S. dorsalis* has been recorded causing serious damage to citrus crops in India (Rao et al. 2019), Iran (Minaei et al. 2015), Korea (Song et al. 2013), and Turkey (Atakan and Pehlivan 2021). Blueberry plants (Fig. 1J–K) showed brown to black lesions on the apices, blade, and veins. In the sites with the highest population density, the spots covered the entire leaf, including the petiole and part of the stem. Also, curling, deformation of the developed leaves, shoot atrophy, and defoliation were observed. The population density of *S. dorsalis* in blueberries varied at the different sites, probably due to the different cultural management tactics with the crop. The observed symptoms and the variation in population density are similar to those recorded in this crop in Mexico by Ortiz et al. (2020) and Leal et al. (2022) in the state of Michoacán. In the same way, there are reports of incidence and relevant damage of *S. dorsalis* in several countries including the United States (Liburd et al. 2020), so we can infer that blueberry is one of the most sensitive crops to attack by this thrips species. In blackberry, a slight dark coloration was observed near the veins, with a considerable number of larvae and adults; however, the sampled plants did not show major damage. *Scirtothrips dorsalis* has been recorded previously in blackberry crops in Mexico and Japan, with no relevant effects (Ohkubo 1995, Ortiz et al. 2020). The presence of juvenile stages indicates that the blackberry can be the main host, however, it is necessary to conduct more sampling to verify its status as a pest of this crop.

In avocado and soursop plants, only adults of *S. dorsalis* were found (on average one individual per sample); however, no significant damage was observed. Kumar et al. (2012) reported *S. dorsalis* in nursery avocado plants, without mentioning damage to the plants. According to our bibliographical review, there are no previous records of association of *S. dorsalis* with soursop plants. The presence of only adults may indicate that the avocado and soursop are not a reproductive host for *S. dorsalis*; however, even if these plants do not support all stages of development, they may contribute to the survival and success of the pest. It is necessary to conduct more sampling to corroborate this information. *Scirtothrips dorsalis* was detected for the first time in Mexico in commercial blueberry, raspberry, and

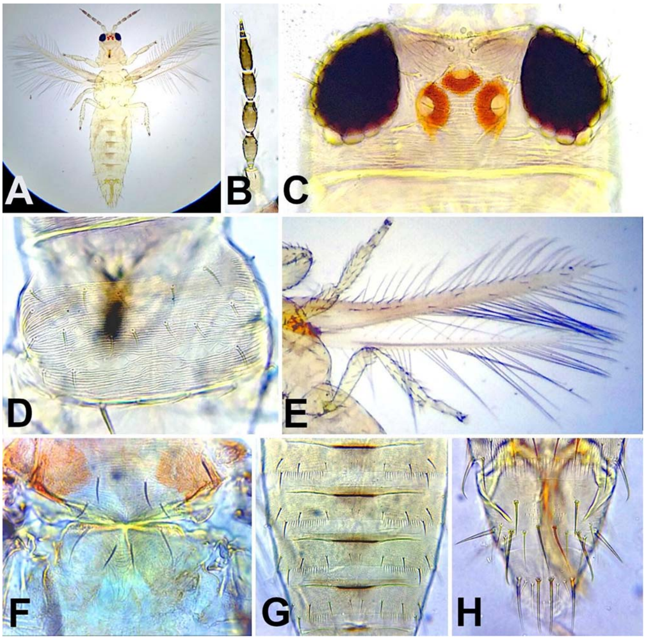

Fig. 2. ***Scirtothrips dorsalis*** **(A) Habitus of female, (B) 8-segmented antenna, (C) head with evident ocellar triangle and reddish crescent of ocelli, (D) pronotum, (E) forewing, (F) mesonotum and metanotum with slight reticulation, (G) lateral abdominal tergites with lines of microtrichiae, and (H) posteromarginal comb complete in tergite VIII.**

blackberry plantations in the state of Michoacán (Ortiz et al. 2020) and in orchards of Mexican lemon in the municipalities of Armería and Tecomán in the state of Colima (Murillo-Hernández et al. 2022). Our results show that its distribution has spread to several areas of the country with different environments and hosts.

Diagnosis of mounted adults. The examined specimens presented the typical characteristics of the species as a mostly yellow body with a small brown area in the middle part of the tergites (Fig. 2A), antenna eight-segment, segment I light, II lightly shaded, III-IV shaded (Fig. 2B) each with a forked sensory cone and V–VIII brown; major setae light coloration. Broad head (Fig. 2C); three pairs of interocellar setae present, pair III arising between posterior ocelli; two pairs of well-developed postocular setae, ocellar triangle, postocular region and pronotum with closely spaced striation and four pairs of posteromarginal setae (Fig. 1D). Forewings shaded with three setae on distal half of first vein, and two widely spaced setae on second vein (Fig. 2E); posteromarginal cilia straight. Posterior half of metanotum with slight longitudinal reticulation without campaniform sensilla (Fig. 2F). Laterals of abdominal tergites II–VIII covered with microtrichiae and posterior margin with fine comb (Fig. 2G); tergite VIII with complete comb (Fig. 2H), posterior half of abdominal sternites IV–VI covered with microtrichia. Males smaller than females; tergite IX without drepanae.

Table 2. Mean number of *Scirtothrips dorsalis* captured in sticky chromatic traps in mango nursery.

Sticky Trap Color	Females	Males	Total Individuals
Blue	77 a	22 a	99 a
Yellow	350 b	282 b	637 b
t test	$t = 2.85$	$t = 2.62$	$t = 2.84$
	$P = 0.0216$	$P = 0.0343$	$P = 0.0250$

Means within columns followed by different lowercase letters are significantly different (*t* test; $P \leq 0.05$).

The specimens examined in this study are morphologically similar to those reported in Brazil by Dias-Pini et al. (2018) which, according to these authors, lack conspicuous reticulation in the posterior half of the metanotum and have the presence of complete lines of microtrichia in the posterior part of the abdominal sternites.

Behavioral response to yellow and blue sticky traps. A total of 5,891 flying adults were captured in the traps. Trap color affected the attractiveness of *S. dorsalis* ($P = 0.0250$). Yellow traps were significantly more effective compared to blue traps for both sexes (Table 2) capturing 5.4 times more adults than the blue traps. The captured sex ratio varied according to the color of the trap. In yellow traps, the sex ratio was 1.24 females to 1 male, and in blue traps this proportion was 3.56 females for each male.

Our results agree with Chu et al. (2006) and Schrader et al. (2019), who report that this thrips species is more attracted to yellow traps compared to other trap colors. Likewise, yellow sticky traps are commonly used at the experimental level in research related to population dynamics, observation of biological parameters (Derksen et al. 2016, Seal et al. 2010), or as a cultural practice for the management of *S. dorsalis* in Asian countries (Deka et al. 2020). In contrast, other authors, such as Sridhar and Onkara-Naik (2015) and Hossain et al. (2020), mention that the most efficient trap color for *S. dorsalis* is blue, obtaining 2 to 2.6 more captures than yellow traps. Although the attraction to colors (mainly white, yellow, blue, and green) in thrips is well documented, the number of specimens captured is highly variable and is influenced by environmental conditions, the type of crop, the presence of other attracted insects by the colors, and the conditions of placement of the traps (Gharekhani et al. 2014, Lopez-Reyes et al. 2022).

Considering the economic importance of crops affected by *S. dorsalis* in Mexico, studies should be conducted to establish detection and control measures, with the aim of reducing the spread and damage caused by this insect pest to other agricultural areas of the country. Based on our results, yellow sticky traps are a viable option to detect and monitor *S. dorsalis* and to implement management strategies.

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