El Colegio de la Frontera Sur

Atracción de trips (Thysanoptera) a trampas pegajosas de diversos colores en agroecosistemas de mango, y su impacto en insectos benéficos.

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Dedicatoria

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Resumen

Existen más de 1,000 cultivares de mango en el mundo y Ataulfo es el cultivar de origen mexicano más popular en los mercados nacionales e internacionales. Durante su floración, especies de trips fitófagos invaden las huertas para alimentarse y reproducirse sobre las inflorescencias, repercutiendo en la fructificación y rendimiento. El presente estudio evaluó la eficiencia de captura de seis trampas pegajosas de diferente color (amarillo, azul, blanco, morado, naranja y verde) con el propósito de: 1) conocer la diversidad de Thysanoptera; 2) determinar la atracción de los trips fitófagos; 3) evaluar el impacto de las trampas sobre los insectos benéficos; y 4) correlacionar las capturas de trips del género *Frankliniella* en las trampas, con aquellos presentes en las inflorescencias. Los resultados revelaron la presencia de 41 especies de trips recolectados tanto en las trampas pegajosas como en las inflorescencias. De estas, 32 especies son fitófagas, 4 depredadoras y 5 fungívoras. *Frankliniella cephalica*, *F. gardeniae* y *F. invasor* fueron las especies más abundantes. *Scirtothrips citri* y *S. manihoti* también fueron capturadas entre los trips fitófagos. Las trampas blancas capturaron significativamente más adultos de *Frankliniella* y una baja captura de enemigos naturales. Las trampas amarillas fueron las más atractivas para las especies de *Scirtothrips*, con bajo efecto detrimental sobre los insectos polinizadores del mango, pero un alto impacto en la captura de enemigos naturales. Las capturas de trips en las trampas pegajosas mostraron una correlación positiva pero no significativa con respecto a la densidad de trips recolectados en las inflorescencias. Como conclusión, el uso de las trampas pegajosas de colores es una buena opción para monitorear especies de trips en agroecosistemas de mango. Lo anterior, podría ser de utilidad para detectar trips en etapas tempranas de infestación, con el fin de implementar tácticas de manejo y evitar el incremento de las poblaciones.

Palabras clave:

Tisanópteros, mango Ataulfo, monitoreo, enemigos naturales, polinizadores.

Capítulo I

Introducción

El mango (*Mangifera indica* L.) es originario de la región Indo-Birmana, y es la especie de mayor importancia económica de la familia Anacardiaceae (Mukherjee & Litz 2009). El mango es una de las frutas tropicales de mayor consumo en el mercado internacional y es extensivamente cultivado en más de 100 países con agroecosistemas tropicales y subtropicales de Asia, África, Centro y Sur América (Téliz-Ortiz 2002; Mitra 2014). Aunque México ocupa el sexto lugar como país productor de mango, es el principal exportador mundial (FAO 2021; Kumar 2021). Los destinos del mango mexicano son principalmente Estados Unidos, Canadá, Japón y países europeos (Mitra 2014). Las exportaciones de México en 2020 fueron de aproximadamente 465,000 toneladas de mango, representando el 21 % de las exportaciones mundiales (FAO 2021).

El mango Ataulfo es un cultivar mexicano, que se originó en Tapachula, Chiapas, y su explotación comercial comenzó a inicios de 1960 (Infante et al. 2011). Desde entonces, la superficie cultivada se ha ido incrementando gradualmente en diferentes regiones del país, y en la actualidad se ha convertido en el cultivar predominante de México (SIAP 2020), desplazando a los tradicionales mangos floridanos (Haden, Keitt, Kent, Tommy Atkins, etc.).

En Chiapas, el mango es uno de los cultivos más importantes con una superficie aproximada de 39,000 ha cultivadas, de las cuales el 85 % son plantaciones de mango Ataulfo (SIAP 2020). Durante el período de floración, diversos insectos son atraídos hacia las huertas (Rocha et al. 2015). Entre ellos existen varias especies de trips que se alimentan y reproducen en las inflorescencias de mango (Ortiz et al. 2016). Rocha et al. (2012) reportaron la presencia de 15 especies de trips en Chiapas, siendo siete especies del género *Frankliniella* (Thripidae) las más abundantes. Algunas especies de *Frankliniella* son polífagas y se conocen como plagas de las inflorescencias de mango en otros países (Wysoky 1993; Aliakbarpour & Che Salmah 2010; Matos et al. 2019). Esas especies de trips son de hábitos oportunistas, y se alimentan de los nectarios florales y las anteras, ovipositando en los raquis de las inflorescencias y en las flores (Peña et al. 1998; Ortiz et al. 2016). Larvas y adultos de *Frankliniella* dañan las plantas al perforar y absorber los contenidos celulares (Hunter & Ullman 1989). Otros trips considerados como plaga son también frecuentemente recolectados en las flores de mango, por ejemplo, *Scirtothrips* spp. (Thripidae), aunque estas especies son más comunes en las hojas tiernas (López Guillén et al. 2014) y mangos pequeños (observación personal de Francisco Infante).

Los daños por trips en las flores de mango han sido asociados con la baja productividad de las huertas (Gehrke-Vélez 2008). Inflorescencias de mango altamente infestadas con trips se desecan, las flores caen prematuramente y conllevan a una baja fructificación y bajos rendimientos del cultivo. En huertas de Chiapas se han reportado en promedio 867 *Frankliniella* spp. (larvas y adultos) por inflorescencia a lo largo del ciclo de la floración (Rocha et al. 2012). Aunque el umbral de daño económico por trips no ha sido establecido con precisión, estudios preliminares mencionan que una inflorescencia de mango Ataulfo tiene alrededor de 3,500 flores (Rocha et al. 2012); cuando el 95 % de esas flores ya están abiertas, pueden tolerar hasta 1,109 trips sin que haya pérdidas en el rendimiento del cultivo (Lucero et al. 2019). Sin embargo, por el tamaño diminuto de los trips son muy difíciles de muestrear y de contar. En ese sentido, su manejo es llevado a cabo mediante la aspersión de insecticidas sintéticos independientemente de su densidad poblacional (Lucero et al. 2019). En otros agroecosistemas el uso de trampas pegajosas de color se ha sugerido como método de monitoreo para estimar las poblaciones de trips, debido a su bajo costo y rápida implementación (Jacobson 1997; Tang et al. 2016; Silva et al. 2020).

Existen algunos estudios que han reportado la atracción de trips a trampas pegajosas de diferentes colores en plantaciones de mango (Grové et al. 2000; Xia et al. 2019). De igual manera, las capturas de trips en trampas pegajosas se han utilizado para estimar la densidad poblacional en las inflorescencias (Peña 1993; Aliakbarpour & Che Salmah 2011), y también como alertas tempranas de las infestaciones de trips (Reddy et al. 2018). Sin embargo, estos estudios se han realizado en agroecosistemas de mango donde existen diferentes especies de trips a las presentes en México. El único estudio que ha evaluado las trampas pegajosas en huertas de mango de México fue realizado por Virgen-Sánchez et al. (2011). En este estudio se reportó que la trampa morada fue la más atractiva para los trips, en comparación con las trampas de color azul y amarillo.

Aunque los datos aportados son valiosos, este estudio únicamente evaluó tres colores y no identificó las especies de trips capturadas. El impacto de las trampas sobre la captura de los insectos no blanco tampoco fue evaluado.

Con base en lo anterior, los planes para el manejo de los trips del mango implican el desarrollo de una herramienta de muestreo para monitorear la densidad de estos organismos, y posteriormente implementar medidas de control de manera oportuna. En ese sentido, el presente estudio tuvo como objetivos: 1) conocer la diversidad de tisanópteros durante la floración del cultivo de mango, 2) determinar la atracción de los trips fitófagos, como las especies de *Frankliniella* y *Scirtothrips*, hacia las trampas pegajosas de diferentes colores; 3) evaluar el impacto de estas trampas sobre la captura de insectos benéficos, con especial énfasis en enemigos naturales y polinizadores; y 4) correlacionar las capturas de *Frankliniella* en las trampas pegajosas, con los *Frankliniella* presentes en las inflorescencias de mango.

Capítulo II

Colored sticky traps for monitoring phytophagous thrips (Thysanoptera) in mango agroecosystems, and their impact on beneficial insects

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Abstract

The capture efficiency of colored sticky traps (blue, green, orange, purple, white, and yellow) was tested in mango agroecosystems with the purpose to: (i) document the diversity of Thysanoptera; (ii) determine the attractiveness of phytophagous thrips; (iii) assess the impact of these traps on beneficial insects; and (iv) assess the relationship between the density of *Frankliniella* thrips captured on traps and those found in the inflorescences. Forty-one species of thrips were collected either from sticky traps or from inflorescences. Of these, 32 species feed either on leaves or flowers. *Frankliniella cephalica*, *F. gardeniae* and *F. invasor*, were the most abundant species. *Scirtothrips citri* and *S. manihoti* were also captured among other phytophagous thrips. The white trap captured significantly more *Frankliniella* species and also had the smallest capture of beneficial insects. Yellow traps were the most attractive for *Scirtothrips* species, with low detrimental effects on insect pollinators, although high capture of natural enemies. Thrips species captured on sticky traps showed a positive but non-significantly correlation with respect to the density of thrips in mango inflorescences. Our results indicate that colored sticky traps could be a good option for monitoring thrips in earlier stages of infestation to implement management tactics.

Mango (*Mangifera indica* L.) is one of the most important tropical fruits and is cultivated in more than one hundred countries[1]. First introduced into Mexico from The Philippines before 1779[2], this crop flourished throughout the country, resulting in an important cash crop. Mexico is the largest exporter of mango worldwide. In 2020, approximately 465,000 tons were exported, representing 21% of the global export trading[3].

Ataulfo is a Mexican mango of great popularity in the international markets and one of the finest cultivars exported by this country[4, 5]. This cultivar originated in southern Mexico by the middle of the last century[6,7], and since then, it has gradually become the predominant cultivar around the country[8], displacing the traditional Floridian mango cultivars (Haden, Keitt, Kent, Tommy Atkins, etc.).

In the State of Chiapas, Mexico, mango is one of the most important crops with approximately 39,000 ha, from which 85% are planted with Ataulfo[8]. During mango flowering, numerous species of insects invade orchards to feed and reproduce on inflorescences. Thrips are highly attracted to the cultivar Ataulfo. Rocha et al.[9] reported 15 thrips species in Chiapas, with seven *Frankliniella* spp. among the most abundant. Some *Frankliniella* species are polyphagous and well-known as pests of mango inflorescences[10,11,12]. Due to their opportunistic habits, they feed on the floral nectaries and anthers, ovipositing on the rachis of panicles and flowers[13,14]. *Frankliniella* larvae and adults damage plants by puncturing and then sucking the cellular contents[15]. Other pestiferous thrips are also frequently collected in mango flowers (i.e., *Scirtothrips* spp., although species in this genus are most common on young leaves[16] and small mango fruits).

Damage by thrips has been associated with the decline of mango yields in Chiapas[17]. Inflorescences heavily infested with thrips dry up, flowers drop off prematurely and fail to set fruit. Earlier studies have recorded a mean of 867 *Frankliniella* thrips (larvae and adults) per inflorescence throughout the flowering period[9]. Although the economic threshold for thrips damage has not been established, preliminary studies mentioned that inflorescences with more than 95% open flowers can tolerate up to 1,109 thrips per inflorescence without yield losses[18]. Because of their small size, mango thrips are challenging to be sampled and counted. Usually, thrips management is carried out by spraying synthetic insecticides regardless of the thrips population density[18]. In other agroecosystems, the use of colored sticky traps has been suggested for monitoring purposes to estimate thrips populations due to their low cost and rapid implementation[19, 20, 21].

Few studies have reported the attraction of thrips to different colored sticky traps for monitoring in mango plantations[22,23]. Thrips captures on sticky traps have also been used to estimate the population density in inflorescences[24, 25], and as an early warning for thrips infestation[26]. However, these studies have been conducted in mango agroecosystems with different thrips species to those present in Mexico. The single study that assessed sticky traps on Ataulfo mango in Mexico was performed by Virgen-Sánchez et al.[27]. They found that purple traps were more attractive for thrips than the blue and yellow ones. However, that study evaluated three colors only and did not identify the thrips species caught on traps. The impact on non-target insects was also overlooked.

Plans for thrips management involve developing a sampling tool for monitoring thrips and implementing control measures at the right time to control them. In this sense, the present study aimed to: 1) document the diversity of Thysanoptera fauna in mango agroecosystems; 2) determine the attractiveness of phytophagous thrips, such as the *Frankliniella* and *Scirtothrips* species, towards several colored sticky traps; 3) assess the impact of these traps on beneficial insects, with special emphasis in natural enemies (parasitoids and predators) and pollinators; and 4) assess the relationship between the density of *Frankliniella* thrips captured on colored sticky traps and those found in the inflorescences.

Materials and Methods

Site description. The experiment was conducted in the Ataulfo mango orchard El Vergel (N14°42'04"; W92°19'05"; 15 meters above sea level; m.a.s.l.), near Tapachula, Chiapas. This is a 70 ha commercial orchard. Mango trees were planted at a density of 68 trees/ha, and the production is usually exported. Because of the quantity of agrochemicals used, it is considered that the orchard receives intensive agronomic management. Each year, mango flowering is induced by the middle of November by spraying potassium nitrate (KNO_3) on trees. After flowering, farmers use a micro-spray irrigation system that constantly works during the fructification period. Several insecticides and fungicides are sprayed to control pests and diseases. Weed control is carried out mechanically and complemented with amine-based herbicides. Urea and potassium phosphate are used regularly as fertilizers.

Colored sticky trap preparation. Double-sided colored sticky traps used in this study were homemade constructed, using a 15 x 21 cm cardboard lined with colored contact paper (Office Depot de México, S.A. de C.V.). We selected the following colors: blue, green, orange, purple, white, and yellow. Separately, an acetate sheet same size of the cardboard was slightly coated on one side with tangle glue (The Tanglefoot Company, Marysville, Ohio, USA). Two acetates were fastened with plastic clips to each side of the colored cardboards to catch insects on both sides of the traps. The advantage of using acetates over the color cardboards is that traps did not need replacing after each sampling, as we only removed the acetates with the stuck insects.

Experimental procedure. The experimental plot was an area of ca. 5.5 ha. We used a completely randomized blocks design to evaluate the thrips and beneficial insects' attraction to color traps in the mango agroecosystem. Traps were randomly deployed in a 2 x 1.75 m (height and wide, respectively) T-shape stake, similar to those used by Hoddle et al.[28]. Color traps were separated by approximately 5 cm each other on the T-stake (Supplementary Fig. 1). Each block was a T-shape stake with all six treatments (colors) in random order. During each sampling date, eight T-stakes were placed evenly spaced throughout the orchard. They were perpendicularly orientated to the row of trees to reduce the possibility that thrips dwelling inflorescences were pushed to the traps by the wind. Traps were maintained in the field for 72 h and then removed and taken to the laboratory to identify thrips and other insects. The same procedure was repeated every 10 days for a total of eight sampling dates along the flowering period. Experiments began on December 7, 2019, following the initiation of mango flowering, and finished on February 18, 2020. The average temperature at the experimental plot was 28± 9°C and 75± 25% RH.

Sample processing. Once in the laboratory, each acetate was removed from traps and superimposed on a millimeter paper as a background to facilitate insects' counting. The number of individuals caught on traps was counted with the aid of a dissecting microscope. In the case of thrips, a sub-sample based on the different morphotypes was randomly taken from each color to be mounted on slides, to corroborate the thrips identification at species level. For this, thrips were carefully detached by cutting the acetate into smaller pieces and placed in a Petri dish with white gasoline as a dissolvent for 15 minutes. Subsequently, thrips were transferred to Eppendorf vials having distilled water and shaken to remove the remaining gasoline. Once clean, thrips were kept in vials with 70% ethanol. Specimens were then soaked in a 5% NaOH solution for four hours at room temperature, and the abdomen was punctured to expel the internal body content. Thrips were mounted on slides using Hoyer's medium and dried in an oven (45°C) for one week. Thrips were identified using specialized taxonomic keys[29, 30, 31, 32]. Voucher specimens were deposited at the entomological collection of El Colegio de la Frontera Sur in Tapachula, Chiapas, Mexico.

The non-target insects captured on sticky traps were identified to the family level, following the taxonomic keys in Goulet & Huber[33]; Arnett & Thomas[34]; Arnett et al.[35]; Triplehorn & Johnson.[36]; and Brown et al.[37]. Based on the scientific literature, the beneficial insects were separated in two ecological groups according to their biology and feeding habits: natural enemies such as, parasitoids and predators[38, 39] and insect mango pollinators[40, 41, 42, 43].

Reflectance of colored sticky traps. The spectral reflectance of the colored traps was determined by a spectrometer (USB4000-VIS-NIR, Ocean Optics, Dunedin, FL) with an optical resolution of 1.5 nm (full width at half maximum), a tungsten-halogen light source (LS-1, Ocean Optics, Dunedin, FL), and a reflection probe (R200-7-VIS-NIR, Ocean Optics, Dunedin, FL). The raw reflectance spectra were corrected to eliminate the dark current and normalized with the spectrum obtained from the light source reflected on a Teflon white standard reference[44]. The visible light transmission was measured from 400 to 1,000 nm for all colors and the reflectance pattern is presented in Fig. 1.

Sampling of mango inflorescences. At each sampling date of colored sticky traps, 20 mango inflorescences were collected in the experimental plot. Ten of these inflorescences were gathered simultaneously when the sticky traps were set up in the field, and the other 10 inflorescences were collected 72 hours later, i.e., when sticky traps were removed from the field. The same procedure was repeated every 10 days, for a total of seven sampling dates along the flowering period; the eighth planned sampling was not taken because there were no inflorescences in the field. We determined whether there was any relationship between the density of *Frankliniella* thrips captured on the sticky traps and the number of *Frankliniella* thrips existing in mango inflorescences.

During samplings, inflorescences were collected at random between 08:00 and 10:00 hours from different trees, and about 2 m above the ground. They were placed individually in plastic bags and kept in an icebox before being taken to the laboratory. Samples were processed by rinsing the bag and contents in 70% ethanol to kill insects. Subsequently, the bag's contents were shaken and sieved. Using different sieve size gradations, this procedure was repeated several times until insects detached from flowers. Insects were then collected from the ethanol solution and preserved in 70%

ethanol. Thrips were separated and counted under a stereomicroscope; the beneficial insects were kept in vials for identification. Regarding the thrips identification, due to the high variability of the thrips numbers in inflorescences, we mounted subsamples of adult thrips on slides to be identified, according to the following quantities: Samples containing up to 10 thrips, 100%; from 11 to 50 thrips, 50%; 51-100, 20%; 101-500, 7%; 501-1000, 3%; 1001-2000, 2%; and 2000-5000, 1% individuals. This way, we mounted 3,015 specimens for identification. Thrips larvae were counted, but not identified to species level, since our main objective was to correlate the adult thrips from inflorescences to those found on sticky traps.

Statistical analysis. To test the effect of trap color on catch rates for thrips and beneficial insects, we ran five separate analyses for the following groups: *Frankliniella*, *Scirtothrips*, other thrips, natural enemies, and insect pollinators. We performed a generalized linear mixed model (GLMM) assuming a negative binomial distribution. Graphical assessment of Pearson residuals was used to assess the model assumptions. For the fixed effects, we included color treatment and sampling date, as well as the interaction. The block of T-stakes was included as random effects. If the interaction was not significant (log-likelihood ratio test), we removed the interaction from the model. For any significant treatment effect, a pairwise comparison with a Tukey correction was performed. For significant treatment by sampling date, we ran pairwise treatment comparison sliced by date, again with a Tukey correction. Finally, we also compared colors with peak reflectance in the short wavelengths (blue, purple, white) to colors with longer wavelengths (green, orange, yellow) using a linear contrast.

We used correlation analyses to assess the relationship between the density of *Frankliniella* thrips captured on sticky traps and those found in the inflorescences. As the experimental design was balanced and replicates were not paired, we averaged across all replicates to get a mean catch rate for each sampling date for the trap dataset of each color. Similarly, we obtained the mean of thrips across all replicates for the inflorescence dataset to get a single total catch rate for adults for each sampling date. We then used the square root transformation to normalize the data and ran Pearson's correlation analysis between thrips on sticky traps and inflorescences. All analyses were conducted using the R software[45].

Results

Thysanoptera diversity in mango agroecosystems. A total of 16,441 thrips were caught on sticky traps throughout the sampling period, of which 16,251 (98.8%) were thrips adults and 190 (1.2%) larvae (Supplementary Table 1). The number of thrips in the inflorescences was much higher than those caught on traps. A total of 439,352 individuals were collected in the inflorescences. From these, 97,294 (22.1%) were adults, and 342,058 (77.9%) larvae (Supplementary Table 2).

Samplings revealed the presence of 41 thrips species in the mango agroecosystem. The highest number of species (37) was collected with sticky traps, while 13 species were collected from inflorescences. Only nine species were recorded in both methods of capture (Table 1). According to the feeding habits reported for these species, five are known to feed on fungi, four are predators of thrips as well as other small arthropods, and 32 feed either on leaves or flowers.

Most adult thrips captured on sticky traps belonged to the genus *Frankliniella*, representing 88% of the total individuals caught, followed by 9% for *Scirtothrips* species and 3% for species of other genera. Likewise, the species of *Frankliniella* were the most abundant individuals in inflorescences, comprising 99% of the adults identified in the subsamples. From them, *F. invasor* was the dominant species having on average 71.9% of individuals, followed by *F. gardeniae* (17.3%), *F. cephalica* (9.5%), and other *Frankliniella* species (<0.1%) (Table 2).

Attraction of thrips to colored sticky traps. Considering the eight samplings as a whole, the trap color affected catch rates for *Frankliniella*, *Scirtothrips*, and other species of thrips too. For *Frankliniella* thrips, the white trap caught significantly more individuals than any other color tested ($\chi^2 = 180.2$; df = 5; $P < 0.001$; Fig. 2a). In general, *Frankliniella* thrips were more attracted to colors with reflectance peaks between 400 to 460 nm. Average capture rates for shorter wavelength colors were 76% ($p < 0.001$; 95%CI: 59% - 94%) higher than the longer wavelength colors. In contrast to *Frankliniella*, the yellow trap had the highest catch rate for *Scirtothrips* ($\chi^2 = 560.8$; df = 5; $P < 0.001$; Fig. 2b). Species of *Scirtothrips* responded better to colors with reflectance peaks between 500 to 550 nm. On average, the longer wavelengths, such as, green, orange, and yellow caught 349% more individuals ($P < 0.001$; 95%CI: 288% - 418%) than shorter wavelengths, such as, blue, purple, and white. For the other thrips, catch rates were very low and the significant effect of color was driven by the green traps having higher catch rates than white traps ($\chi^2 = 15.8$; df = 5; $P < 0.007$), but otherwise no other significant pairwise differences were present (Fig. 2c). Comparison of long vs short wavelengths found a 19% decrease (P = 0.03; 95%CI: 2% - 33%) in capture rates for short wavelength traps compared to long wavelength traps.

When comparing the interaction between treatments (color) with respect to the dates of sampling, only *Frankliniella* had a significant effect on the rate of captures (χ^2 = 147; df = 35; P < 0.001), indicating that catches by the colored traps were different in the eight samplings (Fig. 3). For instance, in the first date, white traps caught more than two times the number of *Frankliniella* thrips compared with the other traps. However, in the following samplings, no significant pairwise differences were found in the *Frankliniella* catches between the white and blue traps in six out of eight samplings. Similarly, there were no differences in the *Frankliniella* catches between the white and purple traps in five of the eight samplings. There was no interaction for *Scirtothrips* spp. (χ^2 = 37.7; df = 35; P = 0.35) or the other species of thrips captured (χ^2 = 33.2; df = 35; P = 0.56).

Impact of sticky traps on beneficial insects. Color treatments had a significant effect on the catch rates of natural enemies (χ^2 = 48.8; df = 5; P < 0.001; Fig. 4a) but did not significantly affect pollinators' catches (χ^2 = 5.7; df = 5; P = 0.33; Fig. 4b). The yellow, green, and orange traps caught the highest numbers of natural enemies and there was no significant difference among them. White, blue, and purple traps were less effective in capturing natural enemies. The interaction between treatment and sampling date showed no significant differences in the catch rates of either natural enemies (χ^2 = 20; df = 35; P = 0.98) or insect pollinators (χ^2 = 17.9; df = 35; P = 0.99).

Sticky traps captured 5,136 beneficial arthropods throughout the sampling period. A total of 83% of species captured were insect natural enemies and 17% were insect mango pollinators. The natural enemies included 41 insect families in six orders and members of the order Araneae (Fig. 4c). Hymenoptera and Coleoptera were the insect orders more diverse with 19 and 9 families, respectively. Araneae comprised the highest number of individuals trapped, followed by hymenopteran Scelionidae, Mymaridae, Encyrtidae and Aphelinidae (Supplementary Table 3). Regarding insect pollinators, 12 families in the orders Coleoptera, Diptera, and Hymenoptera, were identified (Fig. 4d). Sciaridae, Milichiidae, Formicidae, and Chloropidae were the families with the highest number of individuals (Supplementary Table 4).

Relationship between *Frankliniella* thrips caught on traps *versus* inflorescences. We found positive although non-significant correlations (Table 3) between the numbers of *Frankliniella* caught on colored sticky traps and those collected from inflorescences (Supplementary Fig. 2). The green trap had the highest correlation values (r = 0.73, P = 0.06) in comparison to the other color traps. The overall catches of *Frankliniella* thrips on traps and inflorescences along the sampling dates can be seen in Fig. 3. In general, the highest captures of thrips on sticky traps coincided with the high thrips density in the inflorescences, and vice versa. At the end of the experiment, there were no inflorescences in the experimental plot, and it was not possible to collect the last sample. Thrips abundance was highly variable throughout the study, either in traps or inflorescences. In the latter, the overall average was 3,138 thrips per inflorescence (695 adults and 2,443 larvae; Supplementary Table 5).

Discussion

Diversity of Thysanoptera in Mango Agroecosystems

The use of colored sticky traps has revealed a great diversity of thrips and beneficial insects in the Ataulfo mango agroecosystem. Regarding thrips, after collecting more than 455 thousand individuals, either with traps or directly from mango inflorescences, we identified 41 species in 28 genera and four families. We are not aware of a similar study in this crop with such an extensive sampling effort.

Despite the high species richness, we assumed that most thrips species were not feeding on mango flowers, as numerous thrips captured on traps were not captured in the inflorescences. These species were presumably living on grasses and herbaceous plants near mango trees or came from the surrounding vegetation of the mango orchard. It is well known that weeds are usually hosts of numerous species of thrips and other insects, serving as a temporary refuge[46, 47]. For example, species in the genera *Arorathrips*, *Bregmatothrips* and *Plesiothrips*, are known to breed only on grasses (Poaceae)[48]. Some recorded species are known to be highly specific to certain plants, as *Gynaikothrips uzeli* Zimmermann, which feeds on leaves of ornamental figs[49], and *Microcephalothrips abdominalis* (Crawford DL), known as the 'composite thrips' due to its preference for Asteraceae[50]. Predatory species of thrips in the genera *Karnyothrips, Scolothrips* and *Stomatothrips*, are common on grasses and herbaceous plants, where they feed on mites and other thrips[51, 52], whereas *Androthrips ramachandrai* Karny is known as a predator of *Gynaikothrips* spp.[53]. Species of the genera *Allothrips*, *Diceratothrips*, *Gastrothrips, Macrophthalmothrips*, and *Strepterothrips* feed on fungi and are usually collected from leaf litter and dead branches of trees[54, 55, 56, 57, 58]. Although colored sticky traps have been traditionally used for monitoring insect populations, the high numbers of thrips and other non-target species recorded in the present study, suggest that they can also be useful for biodiversity studies in mango agroecosystems. This approach has already been used in olive agroecosystems, to study arthropod aggregation, richness, diversity, and distribution[59].

Our results on thrips diversity are in agreement with other studies. Most of the 14 species of thrips that we collected in the inflorescences had already been recorded from Ataulfo mango orchards in Chiapas[9, 16, 60, 18]. However, there are other thrips collected on traps that have never been recorded either in mango or other plants in Mexico. As far as we know, this is the first record of the following species: *Chaetanaphothrips leeuweni* (Karny), *Halmathrips citricinctus* Hood, *H. tricinctus* Stannard, and *Scirtothrips manihoti* Hood. The species *C. leeuweni*, also known as the banana rust thrips, feeds and breeds on banana leaves, on which sometimes is a pest[29, 61]. Species of *Halmathrips* are generally feeding on forest trees' leaves[29]. *Scirtothrips manihoti* has been typically found damaging cassava leaves in several countries of Central and South America, and apparently its presence is strictly limited to this plant[29].

Attraction of phytophagous thrips to colored sticky traps

Our findings of the *Frankliniella* attraction towards colored sticky traps suggest that although thrips catches were highly variable throughout the flowering period of mango, the white trap captured more adults than any other color in the eight samplings altogether. However, when considering the interaction between treatments (colors) and samplings dates, the white and blue traps captured statistically the same numbers of *Frankliniella* thrips in six out of eight samplings. Likewise, thrips captures by the white and purple traps were not significantly different in five of those samplings. In this manner, the sequence of attraction would be white>blue>purple, with slight differences among them. Green and orange traps appeared to be the least attractive colors to *Frankliniella*. Numerically, most of the *Frankliniella* captures on sticky traps and inflorescences consisted of three main species: *F. cephalica*, *F. gardeniae*, and *F. invasor*. It is important to emphasize that we measured the color preference for all *Frankliniella* species together, and it is possible that the variation found in the species composition of these three species throughout the mango flowering (Table 2), influenced the *Frankliniella* catch rates on different traps (Fig. 3), since each particular species should have its own color preference. It is well known that insect catches in colored sticky traps depend on many factors, where insect behavior and other biological traits are involved[19]. In this sense, different species of thrips are attracted to different color traps[20]. Future studies should test the specific response of each *Frankliniella* species to determine color preferences. However, in this study we treated the *Frankliniella* species as a whole for practical purposes, considering they are phytophagous on mango flowers and with small differences in their biology.

Although our results of thrips catches are different to those reported by Virgen Sánchez et al.[27], who mentioned the purple trap as the most attractive for Ataulfo mango thrips, it has to be considered that they did not include the white color trap in experiments. Moreover, in that study, thrips caught on sticky traps were not discriminated by species or genera, i.e., all thrips species were included in the color response, whereas we excluded all genera different to *Frankliniella* or *Scirtothrips*. Thus, differences between the two studies could be explained by the methods used.

The color preference by *Frankliniella* species has been studied in several crops. Responses are varied, but generally, blue, and white colors have been considered the most attractive. The white color was reported the best capturing *Frankliniella intonsa* (Trybom) in cowpea greenhouses[62], *Frankliniella occidentalis* Pergrande in avocado orchards[30], and *Frankliniella bispinosa* Morgan, in citrus groves[63]. Conversely, blue traps were more attractive to *Frankliniella schultzei* (Trybom) in bean fields[64], and *F. intonsa* in mango orchards of China[23].

This study confirmed that yellow traps were consistently the most attractive to *Scirtothrips* species throughout all samplings. In contrast to *Frankliniella*, white, blue, and purple traps were the less attractive for *Scirtothrips*. Yellow is considered to be universally attractive to all foliage-seeking insects and has been extensively used in capturing important agricultural insect pests of different orders[65, 66, 67]. Its major disadvantage is that also attract many beneficial insects[68]. Our study is in line with previous findings that mentioned the yellow color as the most effective in capturing *Scirtothrips* species in mango[22, 25], avocado[28, 69], and pepper[70].

Impact of traps on beneficial insects

One of the undesirable effects of sticky traps in agriculture is their impact on non-target organisms. In our experiments, over five thousand of beneficial insects were captured by traps during samplings. Natural enemies were by far, more numerous than insect pollinators. Green, orange, and yellow traps caught the higher numbers of natural enemies, whereas the blue, purple, and white had a lesser effect. Yellow sticky traps are known to trap high numbers of natural enemies of Diptera and Hymenoptera[71]. An evaluation of sticky traps for monitoring thrips in a cowpea crop, found that beneficial insects were caught 1.7 times more on yellow than on blue traps[20].Our results suggest the monitoring of *Frankliniella* thrips using the white trap that also has the least detrimental effect on natural enemies.

Surprisingly, the impact of traps in capturing insect pollinators was similar for all colors tested. From the 12 insect families captured on sticky traps in the orders Coleoptera, Diptera and Hymenoptera, there were no catches for species in the families Calliphoridae, Muscidae, Sarcophagidae and Syrphidae. These families are very important in mango orchards because most insect pollinators of mango belong to such groups[72, 73]. It was established that green sticky traps captured on average the highest numbers of insect mango pollinators with 3.2 individuals/trap per sampling date; whereas white traps captured the lowest numbers with 1.5 individuals/trap. According to these low numbers, the use of color sticky traps in mango orchards would not be detrimental for insect mango pollinators.

Thrips catches on the sticky traps versus thrips in the inflorescences

Although this study represents a substantial progress in the use of color traps in mango agroecosystems, sticky traps catches did not predict the density of *Frankliniella* populations in mango inflorescences. The lack of a significant correlation could be explained by the high variation in thrips densities on traps and inflorescences over time[74]. Further studies are required to find this relationship that should focus on improving the sampling methods to reduce the sampling variability to increase the degree of correlation. Estimation of *Frankliniella* thrips densities in mango inflorescences based on sticky traps would be of great importance in sampling thrips for management purposes.

A comparative study was conducted in Malaysia on the main pest species of mango flowers in that country: *Frankliniella schultzei* (Trybom), *Megalurothrips usitatus* Bagnal, *Scirtothrips dorsalis* Hood, and *Thrips hawaiiensis* (Morgan). It was determined that the number of thrips inhabiting mango inflorescences was highly correlated with the number of thrips caught on yellow sticky traps[25]. We think that these high correlations were significant because of the low variances found in samples. In our study, the number of *Frankliniella* adults caught in sticky traps and inflorescences were more variable than the thrips captures in the cited work. For instance, in the inflorescences, captures varied in samplings from 105 to 1,525 thrips adults per inflorescence. These high variable numbers lead to high variances yielding a low correlation.

Conclusions

With an average of 3,138 *Frankliniella* thrips per inflorescence, the mango in Chiapas possibly has the highest numbers of thrips reported for mango in the world. Such large numbers of thrips can damage inflorescences rapidly, affecting fruit set. The use of colored sticky traps would be a good option for monitoring mango thrips in earlier stages of infestation to implement management tactics and avoid the building-up of thrips populations.

This study suggests the use of two different color traps for the main phytophagous thrips of mango. The white trap for the *Frankliniella* species, that also shows the least detrimental impact on natural enemies; and the yellow trap for *Scirtothrips*, with low detrimental effects on insect pollinators, although high impact to natural enemies. Considering that *Frankliniella* species are anthophilous and abundant during mango flowering, while *Scirtothrips* species are more critical during the mango set fruit (FI personal observations), the use of white traps would be more advisable for monitoring *Frankliniella* populations during mango flowering, and yellow traps for monitoring *Scirtothrips* after set fruit. Since herbivorous insects combine visual and chemical cues to locate plants[75], future research on mango thrips should focus on traps that combine the most attractive color with semiochemicals, to improve trapping efficiency. Increasing thrips captures by baited colored traps, could evolved in a mass-trapping device that deploying in sufficient numbers in the field, would surely reduce the damage to flowers by thrips.

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Author Contributions

F.I., J.A.O., J.G. and L.C.A. conceived and designed the study. L.C.A. performed the experiments. L.C.A., F.I. and A.C. identified the species of Thysanoptera. L.C.A. identified the families of natural enemies and pollinators. F.J.G. performed the spectral reflectance analysis. B.G.F. analyzed the data. F.I. and L.C.A. drafted and wrote the manuscript. All the authors read, reviewed, edited, and approved the manuscript.

Competing Interests

The authors declare no competing interests.

Table 1. Diversity of thrips species inhabiting Ataulfo mango agroecosystems.

Species	Sticky traps	Inflorescences
Terebrantia		
Aeolothripidae		
Ambaeolothrips romanruizi (Ruiz-De la Cruz et al. 2013)	✓	✓
Stomatothrips flavus Hood, 1912	✓	
Heterothripidae		
Heterothrips decacornis Crawford DL, 1909	✓	
Thripidae		
Arorathrips mexicanus (Crawford DL, 1909)	✓	
A. spiniceps (Hood, 1915)	✓	
Bregmatothrips venustus Hood, 1912	✓	
Caliothrips phaseoli (Hood, 1912)	✓	
Chaetanaphothrips leeuweni (Karny, 1914)	✓	
Frankliniella borinquen Hood, 1942		✓
F. cephalica (Crawford DL, 1910)	✓	✓
F. gardeniae (Moulton, 1948)	✓	✓
F. insularis (Franklin, 1908)	✓	
F. invasor Sakimura, 1972	✓	✓
F. parvula Hood, 1925		✓
Halmathrips citricinctus Hood, 1936	✓	
H. tricinctus Stannard, 1953	✓	
Heliothrips haemorrhoidalis (Bouché, 1833)	✓	✓
Hydatothrips nr. gliricidiae Mound & Marullo, 1996	✓	
H. sternalis (Hood, 1935)	✓	
Leucothrips furcatus Hood, 1931	✓	
Macrophthalmothrips helenae Hood, 1934	✓	
Microcephalothrips abdominalis (Crawford DL, 1910)	✓	
Neohydatothrips gracilipes (Hood, 1924)	✓	
N. inversus Hood, 1928	✓	
Plesiothrips perplexus (Beach, 1896)	✓	
Salpingothrips minimus Hood, 1935	✓	
Scirtothrips citri (Moulton, 1909)	✓	✓
S. manihoti Bondar, 1924	✓	✓
Scirtothrips sp.		✓
Scolothrips pallidus (Beach, 1896)	✓	
Thrips sp.	✓	
Tubulifera		
Phlaeothripidae		
Allothrips megacephalus Hood, 1908	✓	
Androthrips ramachandrai Karny, 1926		✓
Diceratothrips bicornis Bagnall, 1908	✓	
Gastrothrips nr. *fulvicauda* Hood, 1937	✓	
Gynaikothrips uzeli (Zimmermann, 1900)	✓	✓
Karnyothrips texensis (Hood, 1940)	✓	✓
Liothrips jatrophae (Moulton, 1929)	✓	
L. nr. *tabascensis* Johansen, 1976	✓	
Liothrips sp.	✓	
Strepterothrips floridanus (Hood, 1938)	✓	

Table 2. Species composition of thrips adults collected from mango inflorescences in seven samplings throughout the flowering period of Ataulfo mango. Figures in each column represent the percentage of thrips species in a subsample that was mounted on slides (n=3,015 specimens).

Species	Samplings						
	1	2	3	4	5	6	7
Terebrantia							
Aeolothripidae							
Ambaeolothrips romanruizi	0	0.2	0.6	0.2	0.2	0	0
Thripidae							
Frankliniella borinquen	0	0.2	0	0	0	0	0
F. cephalica	3.3	13.6	3.2	10.4	9.3	6.1	21.0
F. gardeniae	11.2	27.0	34.6	14.7	7.6	8.6	17.6
F. invasor	84.7	58.5	61.1	73.3	81.3	85.1	59.7
F. parvula	0	0	0	0	0.2	0	0
Heliothrips hemorroidalis	0.2	0	0	0	0	0	0
Scirtothrips citri	0.4	0.2	0.4	1.4	0.4	0.2	0.8
S. manihoti	0.2	0	0	0	0	0	0
S. nr*. dorsalis*	0	0.2	0	0	0	0	0
Tubulifera							
Phlaeothripidae							
Androthrips ramachandrai	0	0	0	0	0.2	0	0
Gynaikothrips uzeli	0	0	0	0	0.4	0	0
Karnyothrips texensis	0	0	0	0	0.2	0	0.8

*Sampling eight was not carried out because there were no mango inflorescences in the field

Table 3. Pearson correlation analyses of the mean catches of *Frankliniella* thrips on colored sticky traps, with the mean populations of thrips collected on mango inflorescences.

Sticky trap	*r*	p-value
Blue	0.43	0.33
Green	0.73	0.06
Orange	0.64	0.12
Purple	0.24	0.60
White	0.66	0.11
Yellow	0.65	0.12

Figure Legends

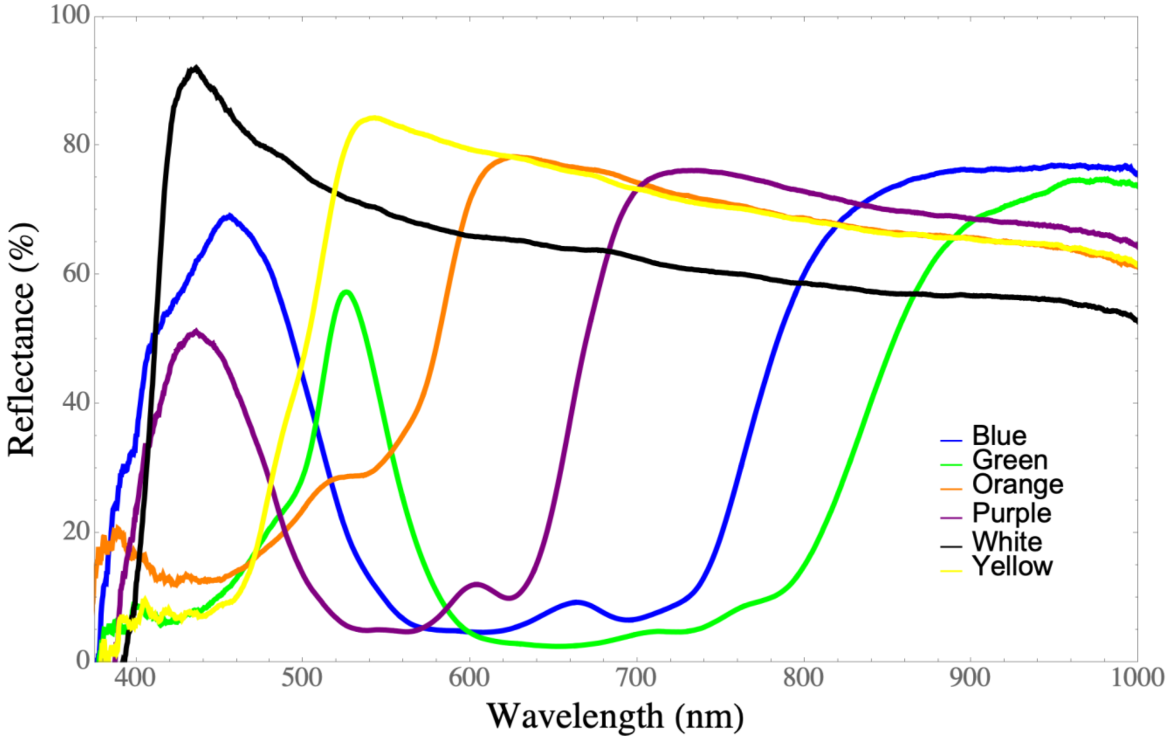
Figure 1. Spectral reflectance curves (%) of the six color traps used in the experiment to attract thrips adults in a mango orchard.

Figure 2. Attraction of thrips adults to colored sticky traps during the Ataulfo mango flowering: a) *Frankliniella* spp., b) *Scirtothrips* spp., and c) other thrips. Each point shows the estimate marginal mean and error bars at 95% CI. Different letters indicate Tukey significant differences ($p<0.05$).

Figure 3. Attraction of thrips adults of the genus *Frankliniella* to colored sticky traps during the Ataulfo mango flowering. Each bar represents the mean catches (±SE) of eight replicates to six colors in eight sampling dates (axis y_1). The line shows the mean (±SE) thrips adults of *Frankliniella* in 20 inflorescences in seven sampling dates (axis y_2). Bars capped with the same letter within a sampling date are not significant different ($p>0.05$) (untransformed data).

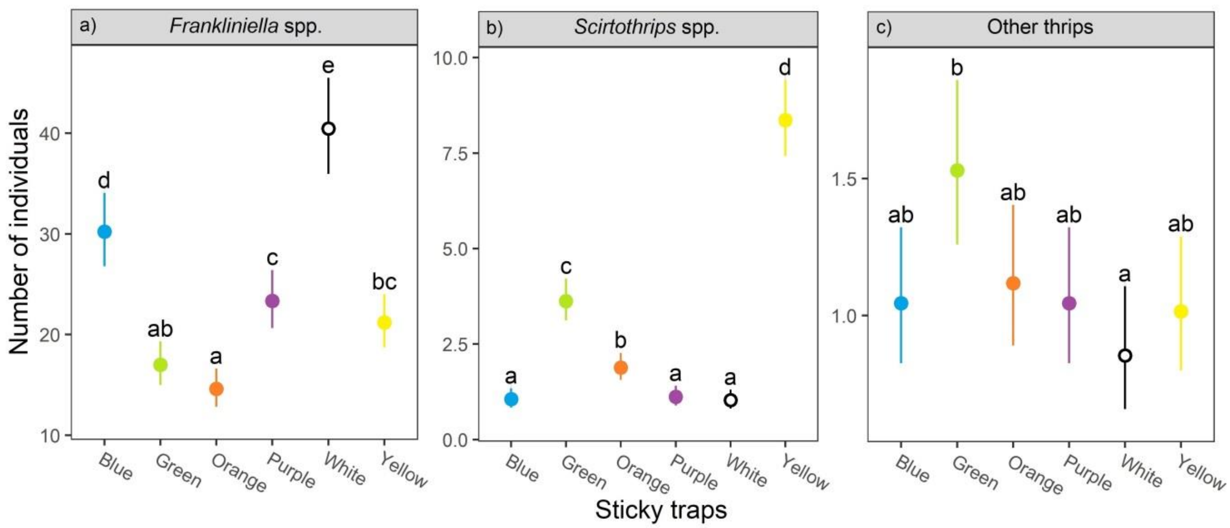
Figure 4. Attraction of beneficial insects to colored sticky traps during the Ataulfo mango flowering. Each point shows the estimate marginal mean and error bars at 95% CI for natural enemies (a) and pollinators (b). Different letters indicate Tukey significant differences ($p<0.05$). Relative abundances (%) of insect orders (plus Aranea) for natural enemies (c) and pollinators (d) are presented on the right side.

Figure 1



100
80
60
40
20
0
400
500
600
700
800
900
1000
Reflectance (%)
Wavelength (nm)
Blue
Green
Orange
Purple
White
Yellow

Figure 2



a)
Frankliniella spp.
b)
Scirtothrips spp.
c)
Other thrips
Number of individuals
Sticky traps
Blue
Green
Orange
Purple
White
Yellow
d
ab
a
c
e
bc
a
c
b
a
a
d
ab
b
ab
ab
a
ab
10
20
30
40
0.0
2.5
5.0
7.5
10.0
1.0
1.5

Figure 3

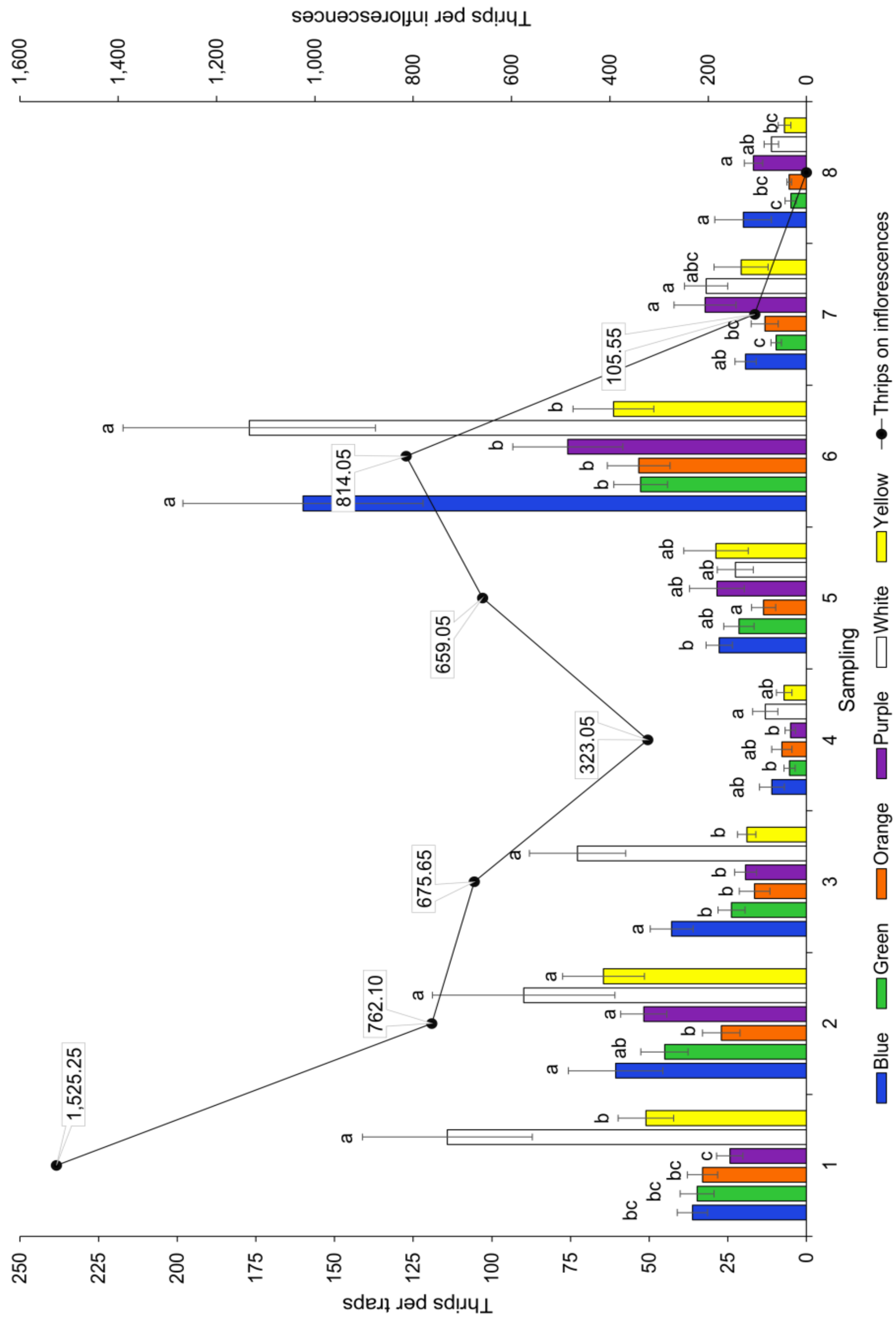
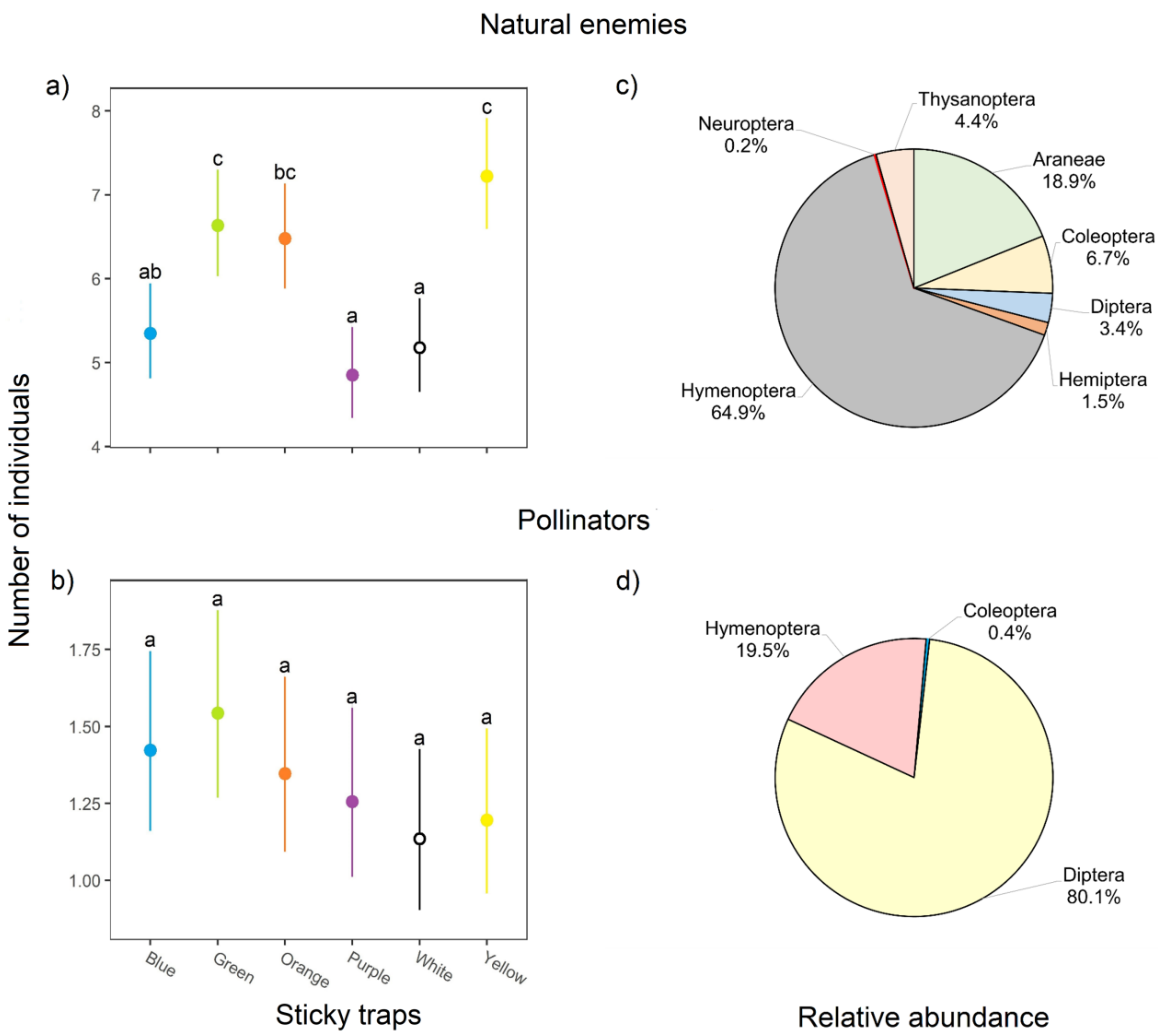

Thrips per traps
Thrips per inflorescences
Sampling
1,525.25
762.10
675.65
323.05
659.05
814.05
105.55
Blue
Green
Orange
Purple
White
Yellow
Thrips on inflorescences

Figure 4



Natural enemies
a)
8
7
6
5
4
c
bc
ab
a
a
c
c)
Thysanoptera 4.4%
Neuroptera 0.2%
Araneae 18.9%
Coleoptera 6.7%
Diptera 3.4%
Hemiptera 1.5%
Hymenoptera 64.9%
Number of individuals
Pollinators
b)
1.75
1.50
1.25
1.00
a
a
a
a
a
a
Blue
Green
Orange
Purple
White
Yellow
Sticky traps
d)
Hymenoptera 19.5%
Coleoptera 0.4%
Diptera 80.1%
Relative abundance

Supplementary Information

Supplementary Table 1. Total numbers of thrips captured on colored sticky traps throughout the flowering period of Ataulfo mango. Figures in each sampling represent the thrips captured in six treatments (colors) with eight replicates each.

Sampling	*Frankliniella*	*Scirtothrips*	Other thrips	Larvae
1	2,348	91	45	56
2	2,712	394	63	56
3	1,555	131	34	4
4	397	52	39	6
5	1,142	87	53	34
6	4,644	203	34	26
7	1,017	301	85	4
8	525	203	96	4
Total	14,340	1,462	449	190

Supplementary Table 2. Total numbers of *Frankliniella* thrips collected from mango inflorescences in seven samplings throughout the flowering period of Ataulfo mango. Each figure in the last column represents the total number of thrips collected from 20 mango inflorescences (10 before traps and 10 after traps).

Sampling	Before sticky traps			After sticky traps			Total
	Larvae	Adults	L + A	Larvae	Adults	L + A	
1	24,541	19,295	43,836	98,762	11,210	109,972	153,808
2	19,140	3,795	22,935	27,433	11,447	38,880	61,815
3	11,842	6,960	18,802	17,595	6,553	24,148	42,950
4	13,621	2,945	16,566	31,991	3,516	35,507	52,073
5	24,573	5,841	30,414	37,275	7,340	44,615	75,029
6	9,921	5,659	15,580	4,470	10,622	15,092	30,672
7	10,334	1,430	11,764	10,560	681	11,241	23,005
Total	113,972	45,925	159,897	228,086	51,369	279,455	439,352

Supplementary Table 3. Absolute abundance of natural enemies (parasitoids and predators) on colored sticky traps in Ataulfo mango agroecosystems.

Order: Family	Blue	Green	Orange	Purple	White	Yellow
Araneae	120	131	141	133	141	139
Coleoptera	37	41	49	40	52	67
Anthicidae	0	1	0	0	0	0
Carabidae	2	5	7	5	11	4
Coccinellidae	10	15	19	9	6	40
Derodontidae	0	0	0	0	1	0
Histeridae	1	0	2	0	1	0
Hydrophilidae	0	1	0	0	0	0
Noteridae	0	0	0	0	1	0
Rhizophagidae	0	0	0	0	1	0
Staphylinidae	24	19	21	26	31	23
Diptera	10	14	28	19	10	65
Dolichopodidae	9	8	24	18	10	62
Pipunculidae	0	2	0	0	0	0
Scenopinidae	0	1	0	0	0	0
Tachinidae	1	3	4	1	0	3
Hemiptera	7	12	5	14	15	9
Anthocoridae	6	8	4	11	9	5
Enicocephalidae	1	3	1	3	5	2
Reduviidae	0	1	0	0	1	2
Hymenoptera	360	568	538	289	301	711
Aphelinidae	38	62	42	24	24	53
Bethylidae	15	24	20	6	9	32
Braconidae	1	6	5	1	4	6
Ceraphronidae	13	22	26	27	15	31

Chalcididae	0	5	3	1	0	5
Diapriidae	3	2	1	1	2	4
Elasmidae	0	2	0	1	0	0
Encyrtidae	60	79	72	45	50	169
Eulophidae	25	22	25	9	17	15
Eupelmidae	0	1	0	4	0	1
Eurytomidae	1	1	1	0	0	0
Figitidae	0	5	1	0	2	0
Ichneumonidae	0	0	0	1	0	2
Mymaridae	77	119	116	94	81	108
Platygastridae	2	9	14	5	5	20
Pteromalidae	7	24	12	1	3	20
Scelionidae	86	132	156	52	57	197
Signiphoridae	8	15	18	7	12	15
Trichogrammatidae	24	38	26	10	20	33
Neuroptera	0	1	2	1	2	0
Chrysopidae	0	0	1	0	0	0
Coniopterygidae	0	1	1	1	1	0
Mantispidae	0	0	0	0	1	0
Thysanoptera	34	36	41	36	22	20
Aeolothripidae *Stomatothrips flavus*	1	4	2	1	2	2
Thripidae *Scolothrips pallidus*	1	3	1	2	0	3
Phlaeothripidae *Karnyothrips texensis*	32	29	38	33	20	15
Total	568	803	804	532	543	1,011

Supplementary Table 4. Absolute abundance of mango insect pollinators captured with colored sticky traps in Ataulfo mango agroecosystems.

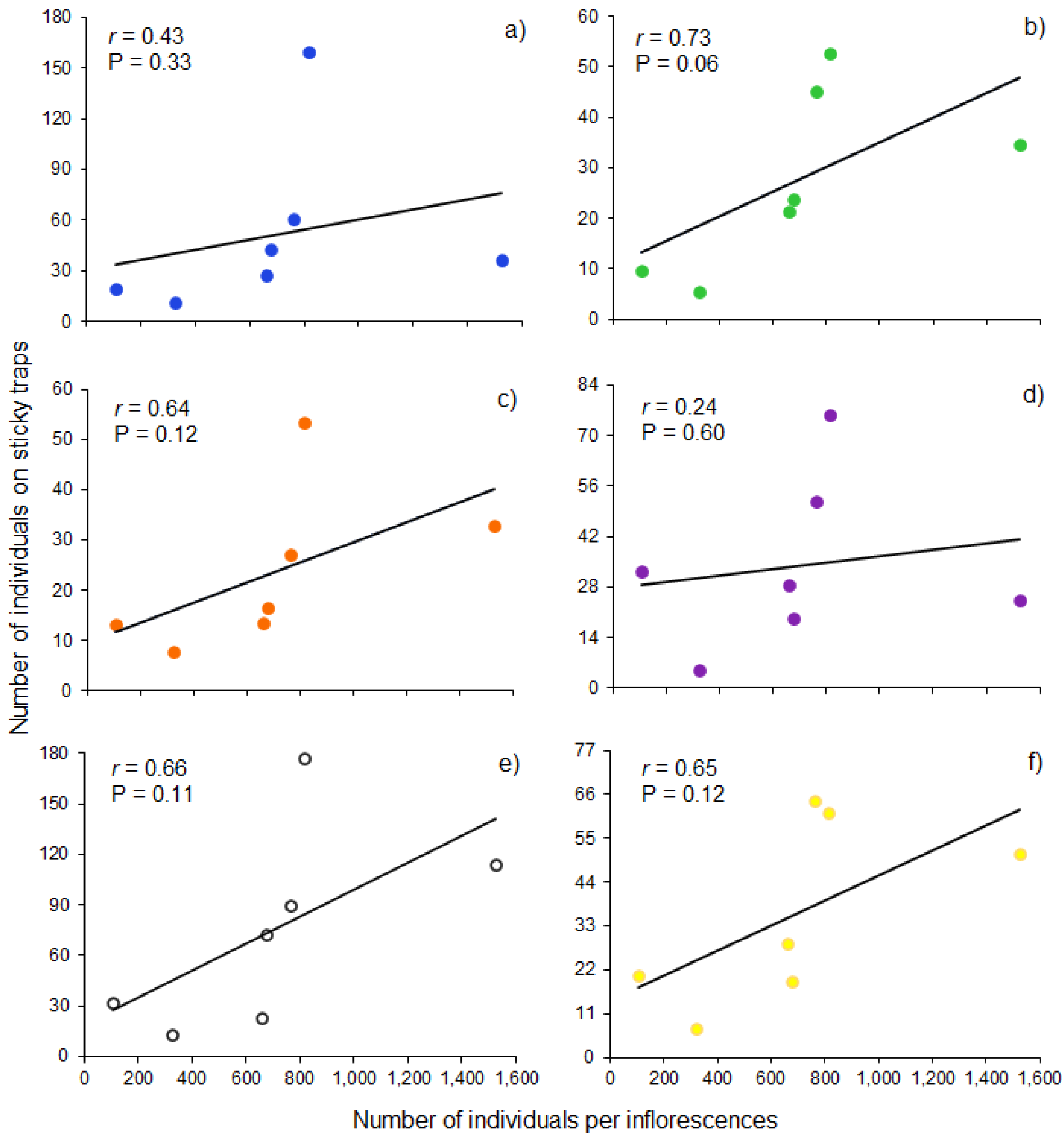
Order: Family	Blue	Green	Orange	Purple	White	Yellow
Coleoptera	0	1	1	0	1	0
Cantharidae	0	1	1	0	1	0
Diptera	114	172	159	87	62	107
Chironomidae	13	15	17	16	17	20
Chloropidae	21	23	24	11	9	21
Milichiidae	27	40	49	15	10	19
Sciaridae	53	93	65	44	26	44
Tabanidae	0	0	1	0	0	0
Tipulidae	0	1	3	1	0	3
Hymenoptera	27	34	29	29	35	17
Agaonidae	8	3	4	7	3	4
Apidae	1	0	0	1	1	1
Formicidae	16	30	25	21	31	11
Halictidae	1	1	0	0	0	0
Vespidae	1	0	0	0	0	1
Total	141	207	189	116	98	124

Supplementary Table 5. Means of *Frankliniella* thrips in seven samplings throughout the flowering period of Ataulfo mango in Chiapas, Mexico. Figures of each sampling represent the average specimens collected in 20 mango inflorescences.

Sampling	Larvae	Adults	Larvae + Adults
1	6,165.15	1,525.25	7,690.40
2	2,328.65	762.10	3,090.75
3	1,471.85	675.65	2,147.50
4	2,280.60	323.05	2,603.65
5	3,092.40	659.05	3,751.45
6	719.55	814.05	1,533.60
7	1,044.70	105.55	1,150.25
Total Avg.	2,443.27	694.96	3,138.23

Supplementary Fig. 1. Manner in which colored sticky traps were disposed in the mango orchard to attract thrips and other insects.

Supplementary Fig. 2. Relationship between the average number of *Frankliniella* species captured on colored sticky traps and the average number of *Frankliniella* in the inflorescences.



Capítulo III

Conclusiones

El cultivo de mango Ataulfo presentó en promedio 3,138 trips por inflorescencia del género *Frankliniella* (larvas y adultos) durante el período de floración.

El uso de las trampas pegajosas de colores es una buena opción para detectar las especies de trips en el agroecosistema. Su uso sería de utilidad para detectar individuos en etapas tempranas de infestación, con el fin de implementar tácticas de manejo oportunas y evitar o retrasar el incremento de las poblaciones de trips.

El presente estudio sugiere el uso de dos diferentes trampas de color para los principales trips fitófagos del mango. Las trampas blancas para las especies de *Frankliniella*, que además capturaron la menor proporción de enemigos naturales; y las trampas amarillas para *Scirtothrips*, con bajo efecto detrimental en los insectos polinizadores, pero alto impacto en la captura de enemigos naturales.

Considerando que las especies de *Frankliniella* son antófilas y abundantes durante la floración, mientras que las de *Scirtothrips* son más más abundantes en las hojas tiernas y en frutos pequeños, el uso de ambas trampas parece viable en dos etapas fenológicas del cultivo: las trampas blancas durante la floración y las amarillas durante la fructificación.

Dado que los insectos herbívoros combinan señales visuales y químicas para localizar a las plantas, futuros estudios sobre los trips en mango deberían enfocarse en la evaluación del color más atractivo añadiendo semioquímicos para mejorar la eficiencia de las trampas. El eventual incremento de las capturas de trips usando trampas de colores con atrayentes, podría dar como resultado una herramienta de captura masiva. Estás trampas con atrayentes podrían usarse en grandes cantidades en las huertas de mango, lo que seguramente reduciría el daño de los trips en las flores.

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