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# Natural Enemies of the *Frankliniella* Complex Species (Thysanoptera: Thripidae) in Ataulfo Mango Agroecosystems

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**ABSTRACT.** A field survey was conducted in Ataulfo mango (*Mangifera indica* L.) orchards in Chiapas, Mexico, with the objective of determining the natural enemies of the *Frankliniella* complex species (Thysanoptera: Thripidae). Seven species of this genus feed and reproduce in large numbers during the mango flowering. Two representative orchards were selected: the orchard "Tres A" characterized by an intensive use of agrochemicals directed against thrips, and the orchard "La Escondida" that did not spray insecticides. During mango flowering, five inflorescences were randomly collected every 5 d in both orchards, for a total of 18 sampling dates. Results revealed the presence of 18 species of arthropods that were found predating on *Frankliniella*. There were 11 species in the families Aeolothripidae, Phlaeothripidae, Formicidae, Anthocoridae and Chrysopidae; and seven species of spiders in the families Araneidae, Tetragnathidae, and Uloboridae. Over 88% of predators were anthocorids, including, *Paratriphleps* sp. (Champion), *Orius insidiosus* (Say), *Orius tristicolor* (White), and *O. perpunctatus* (Reuter). The orchard that did not spray insecticides had a significantly higher number of predators suggesting a negative effect of the insecticides on the abundance of these organisms.

**Key Words**: Thysanoptera, *Frankliniella*, Anthocoridae, mango, predator

Anthophilous thrips in the genus *Frankliniella*, are opportunistic species exploiting ephemeral plant resources (Morse and Hoddle 2006; Baez et al. 2011). This genus is the third largest in the order Thysanoptera, with ∼230 species (ThripsWiki 2015), 90% of which are from the Neotropics (Mound and Marullo 1996). *Frankliniella* species are often polyphagous and several species are considered of economic importance in agriculture (Kirk 2002; Northfield et al. 2008). They damage a great variety of crops, including mango (*Mangifera indica* L.), where they feed and reproduce in flowers (Sakimura 1972; Peña et al. 1998; Galán-Saúco 2009; Aliakbarpour et al. 2010). In Ataulfo mango orchards of Chiapas, Mexico, there is a complex of seven species that appear in large numbers during mango flowering; namely, *F. borinquen* Hood, *F. gossypiana* Hood, *F. williamsi* Hood, *F. cephalica* (Crawford), *F. gardeniae* Moulton, *F. invasor* Sakimura, and *F. parvula* Hood (Johansen 2002; Rocha et al. 2012).

In the Chiapas region of Mexico, thrips populations increase greatly during mango flowering. A mean of 867 thrips (larvae and adults) have been recorded on a single inflorescence (Rocha et al. 2012). Over 98% of the thrips belonged to species in the genus *Frankliniella*, with *F. invasor* the dominant species (Rocha et al. 2012). The appearance of such large numbers of thrips has been associated with the decline of Ataulfo mango production in Chiapas (Gehrke 2008). The farmers have responded by making frequent applications of a wide range of insecticides, and other methods of control have not been explored. The purpose of this study was to identify the natural enemies of *Frankliniella* in Ataulfo mango agroecosystems, as a first step toward the development of a conservation program for biological control agents. The work was conducted in two orchards: one with intensive use of insecticides and the other without insecticide spraying.

## Materials and Methods

The methodology was adapted from Rocha et al. (2012). Basically, the survey of natural enemies of *Frankliniella* species was conducted in two commercial orchards of Ataulfo mango in Chiapas, Mexico. Insecticides were frequently sprayed in the orchard "Tres A", while no insecticides were used at "La Escondida". Mango trees began flowering by the middle of November 2008 and ceased flowering by the end of February 2009. During this period, five inflorescences were randomly collected every 5 d in both orchards, for a total of 18 sampling dates. Samples were collected between 08:00 and 10:00 a.m., and each inflorescence was placed in a plastic bag. Samples were processed by rinsing the bag and contents with 70% ethanol. Arthropods were then collected from the ethanol solution and identified using a stereomicroscope.

Direct observations were made of the feeding habits of the predators. On each sampling date, mango inflorescences were observed in the field for ∼2 h, in order to detect predation of *Frankliniella*. A binocular head-mounted 4× magnifier with light was used. When thrips predators were observed, they were placed in 70% ethanol for subsequent identification. Thrips attacked by predators and thrips trapped in spider webs were collected and mounted onto microscope slides for identification. Predators were compared through the absolute abundance, i.e., the overall number of predators collected in 18 sampling dates, and the relative abundance, i.e., the percentage of predators in each taxa.

The abundance of anthocorids in both orchards was compared using a general linear model (JMP software, SAS Institute). Data were transformed to the square root $(x + 0.5)$ before being subjected to analysis. Dates were considered replicates with the five samples of inflorescences treated as subsamples. Pearson's correlation analyses were used to study relationships between anthocorids and thrips density over dates in the two orchards. All effects were considered significant at $\alpha \leq 0.05$.

Voucher specimens were deposited in the Florida State Collection of Arthropods, Florida Department of Agriculture and Consumer Services, Gainesville.

## Results

The complex of predatory species of different taxa and their abundance is presented in Table 1. A total of 5,220 predators were collected from the families Aeolothripidae, Phlaeothripidae, Formicidae, Anthocoridae, Chrysopidae, Araneidae, Tetragnathidae, and Uloboridae. Eighteen predatory species from 14 genera were represented. There was a significant difference in the total number of predators between the two fields when samples dates were used as replicates ($F = 12.96$; df = 1, 17; $P < 0.001$). There were 3,336 total natural enemies collected in the La Escondida orchard where no insecticides were used, versus 1,884 total natural enemies in the Tres A orchard where insecticides were sprayed. Each of the predatory species listed in Table 1 were found in the La Escondida orchard, but not all species were collected in the Tres A orchard, including *Orius tristicolor*, *Ceraeochrysa cubana*, *Leucauge argyra*, *Cyclosa* sp., and *Wagneriana* sp.

Four species of Anthocoridae accounted for 88% of the predator abundance in the two orchards (Table 1). The next most common predators were the Formicidae and the Chrysopidae. The anthocorids *Paratriphleps* sp. and *Orius insidiosus* were the most abundant species. We verified through direct observation the predation of *Frankliniella* by all species of Formicidae, Anthocoridae, and Chrysopidae. Predation by spiders was never observed, but they were included as natural enemies of *Frankliniella* because they are considered generalist predators and we detected numerous adults trapped in their webs. Predation of *Frankliniella* species by entomophagous thrips was never seen, but their role as predators was inferred according to their feeding habits. Species of Aeolothripidae were facultative predators of thrips (Ruiz-De la Cruz et al. 2013). *Aeolothrips intermedius* Bagnal is reported to be a predator of *Frankliniella occidentalis* (Pergrande) (Conti 2009).

The dynamics of *Frankliniella* species and the four species of anthocorids during the flowering cycle of mango is presented in Fig. 1. The numbers of thrips increased gradually after the first sampling date, reaching peaks of 2,454 and 3,169 thrips (adults and larvae) per inflorescence in Tres A and La Escondida, respectively. Anthocorids were almost absent on the first six sampling dates, but they were present on later sample dates. Overall numbers of anthocorids were significantly different between orchards ($F = 13.78$; df = 1, 17; $P < 0.001$), being more abundant in La Escondida (2,974 individuals) than in Tres A (1,635 individuals). The highest number of anthocorids was detected in orchard La Escondida on sampling date 15 (90 individuals) and in orchard Tres A on sampling date 9 (48 individuals; Fig. 1). There were no significant correlations between the presence of anthocorids and the abundance of *Frankliniella* species in La Escondida orchard ($r = 0.0749$; df = 88; $P = 0.4829$) or Tres A orchard ($r = -0.0978$; df = 88; $P = 0.3591$) (Fig. 2).

## Discussion

As far as we know, the present study is the first survey of natural enemies of thrips in mango flowers in Mexico. This is the first report of the spiders *Cyclosa* sp., *Gasteracantha cancriformis*, *Leucauge argyra*, *Leucauge* sp., *Micrathena* sp., *Uloborus* sp., and *Wagneriana* sp. as predators, or at least, as mortality factors for adults of the genus *Frankliniella*. Most of the collected spiders were juveniles and they could not be identified to species. The identification keys for spiders are mainly based on the morphology of genitalia of adults (Huber 2004). The importance of spiders as predators of insects was discussed by Sunderland (1999) and Riechert (1999). Nentwig (1987) emphasized the importance of web-weaving spiders as mortality factor of

**Table 1. Absolute (Abs) and relative (Rel) abundance of natural enemies of the *Frankliniella* complex species, collected from two orchards in the State of Chiapas, Mexico**

| Family and species | Abundance of natural enemies | | | | | |
|---|---|---|---|---|---|---|
| | La Escondida | | Tres A | | Total | |
| | Abs | Rel | Abs | Rel | Abs | Rel |
| Aeolothripidae | 4 | **0.12** | **2** | **0.11** | **6** | **0.12** |
| *Aeolothrips microstriatus* Hood | 2 | 0.06 | 2 | 0.00 | 4 | 0.04 |
| *Franklinothrips orizabensis* Johansen | 2 | 0.06 | 0 | 0.11 | 2 | 0.08 |
| Phlaeothripidae | **14** | **0.42** | **14** | **0.74** | **28** | **0.54** |
| *Karnyothrips flavipes* (Jones) | 14 | 0.42 | 14 | 0.74 | 28 | 0.54 |
| Formicidae | **278** | **8.33** | **190** | **10.08** | **468** | **8.97** |
| *Crematogaster* nr. *sumichrasti* Mayr | 278 | 8.33 | 190 | 10.08 | 468 | 8.97 |
| Anthocoridae | **2,974** | **89.15** | **1,635** | **86.78** | **4,609** | **88.29** |
| *Orius insidiosus* (Say) | 46 | 1.38 | 8 | 0.42 | 54 | 1.03 |
| *Orius tristicolor* (White) | 1 | 0.03 | 0 | 0.00 | 1 | 0.02 |
| *Orius perpunctatus* (Reuter) | 4 | 0.12 | 2 | 0.11 | 6 | 0.11 |
| *Paratriphleps* sp. | 335 | 10.04 | 163 | 8.65 | 498 | 9.54 |
| *Orius*/*Paratriphleps* nymphs | 2,588 | 77.58 | 1,462 | 77.60 | 4,050 | 77.59 |
| Chrysopidae | **37** | **1.11** | **29** | **1.54** | **66** | **1.26** |
| *Ceraeochrysa claveri* Navás | 5 | 0.15 | 2 | 0.11 | 7 | 0.13 |
| *Ceraeochrysa cubana* Hagen | 2 | 0.06 | 1 | 0.05 | 3 | 0.06 |
| *Ceraeochrysa everes* (Banks) | 1 | 0.03 | 0 | 0.00 | 1 | 0.02 |
| *Ceraeochrysa* larvae | 29 | 0.87 | 26 | 1.38 | 55 | 1.05 |
| Araneidae | **6** | **0.18** | **4** | **0.21** | **10** | **0.20** |
| *Gasteracantha cancriformis* (L.) | 2 | 0.06 | 3 | 0.16 | 5 | 0.10 |
| *Cyclosa* sp. | 1 | 0.03 | 0 | 0.00 | 1 | 0.02 |
| *Wagneriana* sp. | 1 | 0.03 | 0 | 0.00 | 1 | 0.02 |
| *Micrathena* sp. | 2 | 0.06 | 1 | 0.05 | 3 | 0.06 |
| Tetragnathidae | **5** | **0.15** | **2** | **0.11** | **7** | **0.14** |
| *Leucauge argyra* (Walckenaer) | 2 | 0.06 | 0 | 0.00 | 2 | 0.04 |
| *Leucauge* sp. | 3 | 0.09 | 2 | 0.11 | 5 | 0.10 |
| Uloboridae | **18** | **0.54** | **8** | **0.42** | **26** | **0.50** |
| *Uloborus* sp. | 18 | 0.54 | 8 | 0.42 | 26 | 0.50 |
| Total | 3,336 | 100 | 1,884 | 100 | 5,220 | 100 |

Abs figures represent the total number of individuals collected from Ataulfo mango inflorescences in a period of 3 mo, after 18 sampling dates. Note: Figures in a given family of insects or spiders are the sum of total species within the same family.

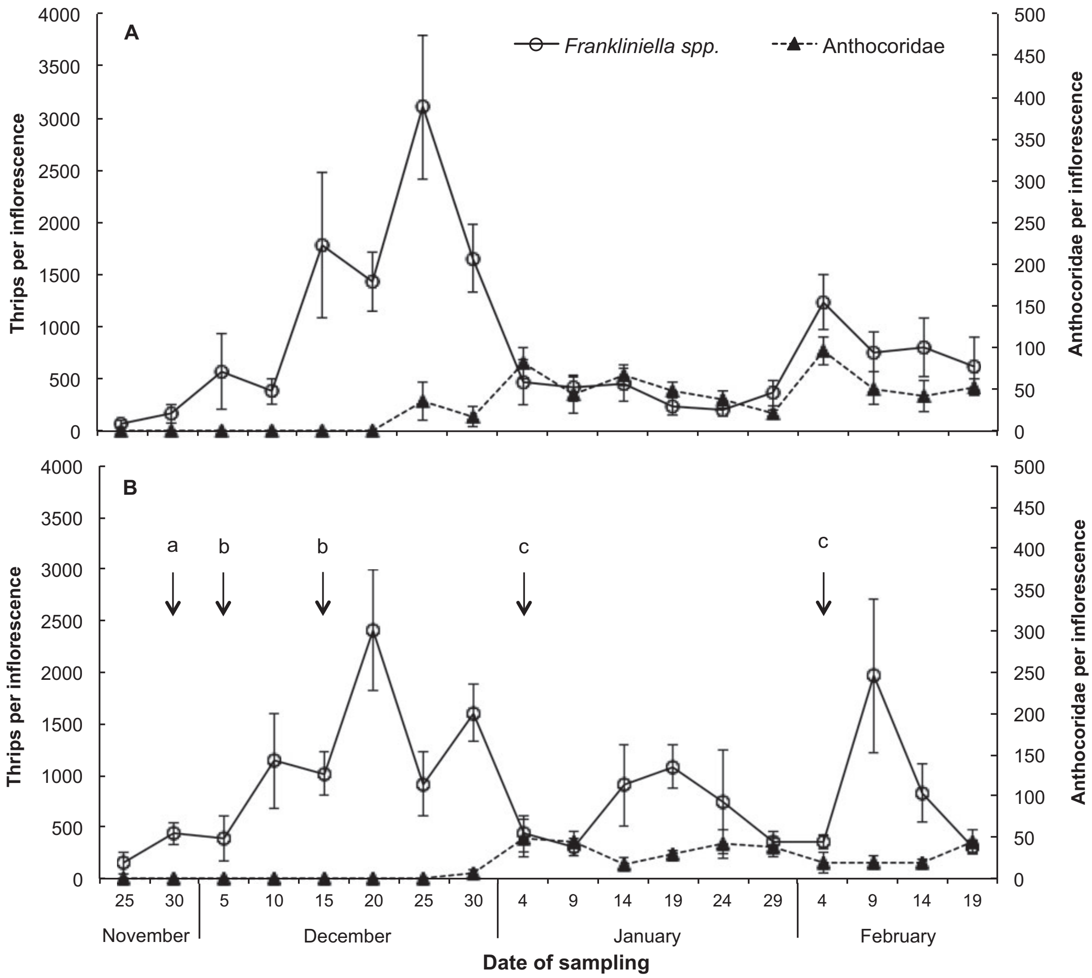


**Fig 1.** Seasonal abundance of *Frankliniella* thrips (larvae and adults) and four species of Anthocoridae (*Orius insidiosus*, *Orius tristicolor*, *Orius perpunctatus*, and *Paratriphleps* sp.) predators of *Frankliniella*. Each of the 18 sampling dates denote the average number of individuals per mango inflorescence (mean ± SEM, $n = 5$) in two orchards of Chiapas State, Mexico: (**A**) "La Escondida" did not spray insecticides, and (**B**) "Tres A" received five sprays of insecticides against thrips. Arrows indicate the dates in which insecticides were sprayed: (**a**) Deltamethrin, (**b**) Dimethoate, and (**c**) Malathion.

thrips. Such mortality can be of significant value for biological control of herbivores (Sunderland 1999). Although the spider diversity in mango agroecosystems of Chiapas has not been studied, 94 species of spiders were recorded on cocoa trees (Ibarra-Nuñez et al. 2004), an important crop growing near mango plantations in the lowlands of Chiapas.

In order to complement our field observations, further studies using other methods to determine the predator species that feed on *Frankliniella* are warranted. Several techniques have been used in ecological studies to identify the diet of arthropod predators. For instance, predator-prey relationships can be established through the use of radioactive tracers or serological tests like the enzyme-linked immunosorbent assays (Grant and Shepard 1985; Greenstone 1999). More recently, the polymerase chain reaction has been used to analyze the gut content of predators (Boreau-de-Roincé et al. 2012; O'Rorke et al. 2012).

Natural enemies exert an important contribution toward controlling a wide range of agricultural pests (Van Lenteren 2012). Surveys of natural enemies are the first step to provide an understanding of the role of biological control agents in suppressing pest populations. Generalist predators, like those reported in the present study, are thought to be important for controlling pest species in a number of crops. They can reduce the pest damage by directly contributing to pest mortality and indirectly by disrupting the feeding activities of pest species (Sunderland 1999; Mackfayden et al. 2015). Despite this, generalist predators have been neglected by researchers, because they feed opportunistically, and are not able to track pest populations. However, studies have shown that the generalist anthocorid predators can regulate *Frankliniella* thrips (Ramachandran et al. 2001; Funderburk 2009).

The orchard that sprayed broad spectrum insecticides had fewer species and less abundance of natural enemies than the orchard that did not use insecticides. Further, anthocorids appeared later in the season in the orchard sprayed with insecticide. The effects of broad spectrum insecticides on generalist predators are well established in the literature. The regular application of broad spectrum insecticides has been shown to decrease spider populations (Riechert 1999). The use of dimethoate and deltamethrin has been shown to severely impact natural enemies of thrips (Croft and Brown 1975; Bellows et al. 1985; Silveria et al. 2004). Funderburk (2009) reviewed the literature showing the insecticide applications that suppress generalist predators frequently result in an increase in *Frankliniella* thrips populations. Our results suggest that generalist predators are numerous in mango flowers in the Chiapas region of Mexico, and our ultimate goal is to develop a sustainable crop protection strategy that conserves their populations.

Anthocorids appear to be the most important predators of thrips associated with Ataulfo mango in Chiapas. These results are in agreement with studies conducted in Florida showing that anthocorids were the primary predators of *Frankliniella* thrips (Funderburk et al. 2000).

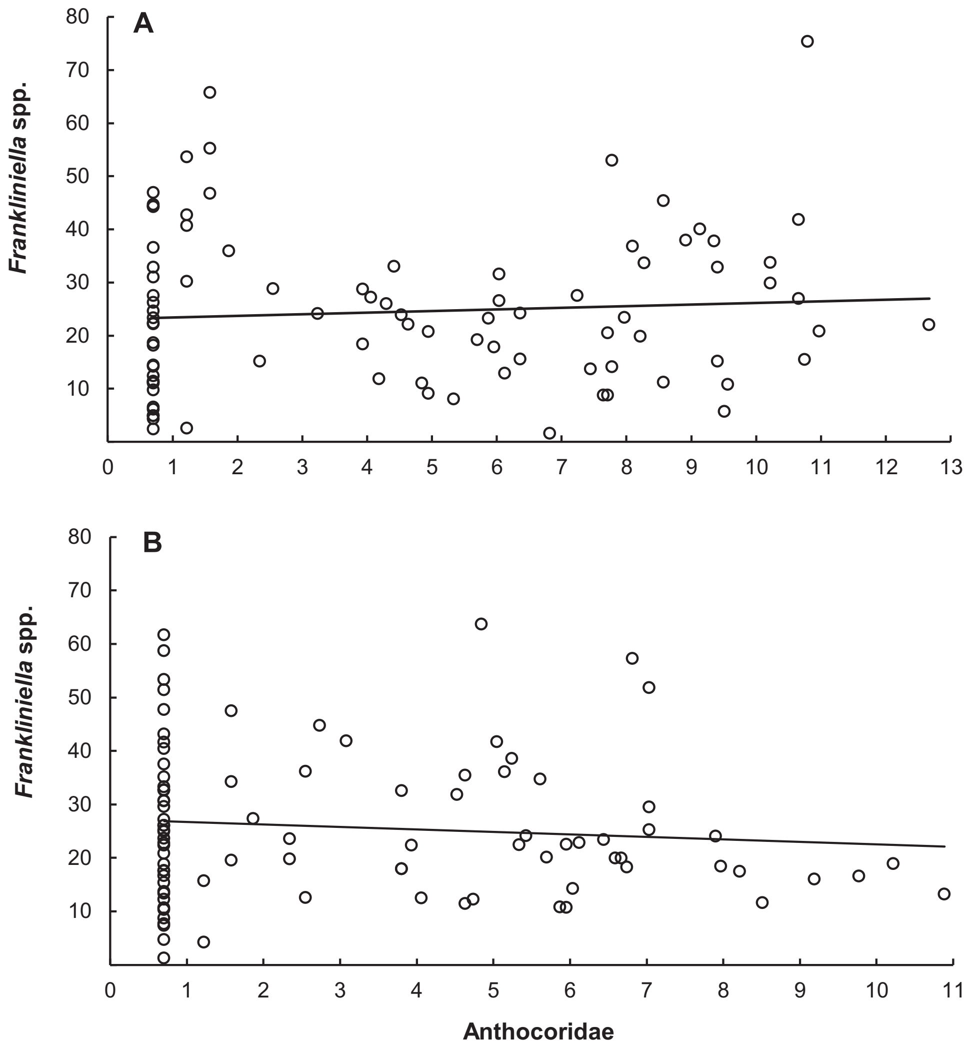


**Fig 2.** Relationship between thrips (*Frankliniella* spp.) and four species of Anthocoridae (*O. insidiosus*, *O. tristicolor*, *O. perpunctatus*, and *Paratriphleps* sp.) in two mango plantations of Chiapas, Mexico. (**A**) "La Escondida" orchard that did not spray insecticides, and (**B**) "Tres A" orchard that received five sprays of insecticides against thrips during mango flowering. Each data point represents the mean density of thrips and anthocorid predators in five mango inflorescences, across 18 sampling dates. Data presented in the figure were transformed for Pearson's correlation analysis using sqrt ($x+0.5$). There was no correlation between the density of anthocorids and the abundance of *Frankliniella* thrips neither in "La Escondida" ($r=0.0749$; df = 88; $P=0.4829$), nor in "Tres A" ($r=-0.0978$; df = 88; $P=0.3591$).

Although no significant correlation between the abundances of thrips and anthocorids was found in this study, this do not necessary indicate a low impact of these predators on thrips populations, because there was a time lag of about a month in the appearance of the first anthocorids that affected the results of the correlation. Further studies are needed to determine the ability of the anthocorids to reduce thrips populations in mangoes.

To conclude, this study revealed the presence of 18 predators of the *Frankliniella* complex species in mango orchards of Chiapas, Mexico. Because of efforts to prevent thrips damage in Ataulfo mango rely on the spray of insecticides, these results could be useful to considering the use of biological control in the management of *Frankliniella* thrips.

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