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Research

Thrips (Thysanoptera) of Coffee Flowers

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Abstract

Thrips (Thysanoptera) are opportunistic insects that exhibit a wide range of life histories. Most species are either fungivorous or phytophagous, while a few are predators. In coffee agroecosystems, the presence of these insects is noticeable, especially when coffee is flowering. The identity of thrips and the role they might be playing on coffee flowers is unknown. We conducted a survey of thrips in 30 commercial coffee plantations of Chiapas, Mexico, with the aim to investigate the species composition of thrips associated with coffee flowers and to determine whether they were carrying coffee pollen on their bodies. Thrips were collected at random in ∼1 ha. Coffee branches were shaken against a plastic tray to separate insects from flowers. A total of 42 thrips species in 24 genera and five families were identified. The most common species were *Karnyothrips merrilli* Watson, *Haplothrips gowdeyi* (Franklin), *Frankliniella difficilis* Hood, *Frankliniella gardeniae* Moulton, *Frankliniella insularis* (Franklin), *Frankliniella invasor* Sakimura, *Frankliniella parvula* Hood, and *Frankliniella varipes* Moulton. Of these species, *Karnyothrips merrilli* is considered a predator of thrips and other small arthropods, while the other species are phytophagous. We assumed these thrips might be living on other plants and shift to coffee due to the abundance of pollen and nectar during the flowering season. Using microscopy, we examined the bodies of thrips caught in sticky traps. We found coffee pollen on the bodies of seven thrips species, and discuss the possibility of these thrips serving as coffee pollinators.

Key words: Rubiaceae, flowering, *Coffea arabica*, *Coffea canephora*, Mexico

Coffee (*Coffea* sp.) is a perennial plant native to Africa (Le Pelley 1968, Vega 2008) that was introduced to Mexico around 1740 (Hernández-Martínez and Córdova-Santamaría 2011). The genus *Coffea* (Rubiaceae) comprises 124 species (Davis et al. 2011), with two of them being of enormous economic importance throughout the tropics: *Coffea arabica* L. and *Coffea canephora* Pierre ex A. Froehner (also known as Robusta; Vega 2008). Both species are commercially grown in the Soconusco region of Chiapas, Mexico, where they are important cash crops. *Coffea arabica* is tetraploid and self-fertile (autogamous), with heavy sticky pollen grains, needing neither insects nor wind for its pollination (Manrique and Thimann 2002). In contrast, *C. canephora* is diploid and self-sterile (allogamous), with light and dry pollen grains, depending on cross-pollination, mostly by wind and to a lesser extent by insects (Le Pelley 1973, Klein et al. 2003a). In presence of insect pollinators, especially bees, both species of coffee can increase their fruit set, and therefore productivity (Roubik 2002, Klein et al. 2003b).

Flower buds are induced during the dry season, when plants are subjected to drought stress for ca. 3 mo (Krishnan et al. 2012). Under Mexican climatic conditions, coffee flowering is initiated after the rainy season, generally from February to April (Philpott et al. 2006) and, depending on rain frequency, there may be one, two, or more flowering periods (Villaseñor 1987). Flowers are borne in clusters of 15–20 for *C. arabica* and up to 80 flowers per node for *C. canephora* (van der Vossen 1985). Depending on the weather conditions, individual flowers last up to 7 d in *C. arabica* and 3 d in *C. canephora* (Klein et al. 2003a). Coffee flowers are white, fragrant, and ephemeral, attracting a wide array of insects to the plant. Several species of bees have been reported to be the most common visitors (Klein et al. 2003a,c; Vergara and Badano 2009; Krishnan et al. 2012). Although many other small insects, such as thrips (Thysanoptera), frequent coffee flowers, these have often been overlooked. For instance, Krishnan et al. (2012) recorded 5,915 floral visitors of coffee, with 95.7% reported as bees and 4.3% as insects in the orders Thysanoptera, Diptera, Hemiptera, and Lepidoptera.

While conducting field studies on the coffee berry borer, *Hypothenemus hampei* (Ferrari), in coffee agroecosystems in Chiapas, we observed for many years a great diversity and abundance of thrips on coffee flowers. Surprisingly, we did not find information in the scientific literature about the identity of thrips species

Table 1. General characteristics of coffee plantations that were sampled for thrips associated to coffee flowers in Chiapas, Mexico

Coffee plantation	Georeference	Elevation (masl)	Species	Sampling year
Finca Las Brisas	14° 58′59″ N, 92° 14′36″ W	329	Robusta/Arabica	2014, 2015
Manuel Lazos	14° 58′07″ N, 92° 11′54″ W	419	Robusta/Arabica	2013
Ejido Toluca	15° 01′17″ N, 92° 14′32″ W	460	Robusta/Arabica	2014, 2015
Finca Palestina	15° 00′00″ N, 92° 13′47″ W	472	Robusta/Arabica	2014, 2015
Finca Brasil	15° 06′09″ N, 92° 18′41″ W	489	Arabica	2013
Finca La Gloria	15° 00′11″ N, 92° 09′28″ W	522	Robusta/Arabica	2013
Finca S. L. Nejapa	15° 02′07″ N, 92° 14′32″ W	550	Arabica	2014, 2015
Salvador Urbina	15° 02′25″ N, 92° 12′03″ W	594	Robusta	2015
Finca San Lorenzo	15° 03′24″ N, 92° 15′32″ W	620	Arabica	2014
Faja de Oro-Mixcúm	15° 01′48″ N, 92° 08′54″ W	704	Robusta/Arabica	2013, 2014
Finca Perú	15° 07′44″ N, 92° 17′03″ W	732	Arabica	2014
Finca Argovia	15° 08′01″ N, 92° 17′32″ W	748	Arabica	2015
Ejido 11 de Abril	15° 02′23″ N, 92° 07′42″ W	761	Robusta/Arabica	2014, 2015
Santo Domingo	15° 01′57″ N, 92° 06′56″ W	787	Robusta/Arabica	2013, 2014, 2015
Ejido Mexiquito	15° 08′55″ N, 92° 17′32″ W	842	Robusta/Arabica	2013, 2015
Finca San Nicolás	15° 08′12″ N, 92° 16′18″ W	877	Arabica	2013, 2014
Agustín de Iturbide	15° 04′48″ N, 92° 11′08″ W	922	Robusta/Arabica	2015
Finca Génova	15° 09′02″ N, 92° 19′83″ W	933	Arabica	2014
Guatimoc	15° 03′48″ N, 92° 09′01″ W	973	Robusta	2013
Monte Perla	15° 03′16″ N, 92° 05′23″ W	1,106	Robusta/Arabica	2013, 2014, 2015
Finca Irlanda	15° 10′34″ N, 92° 20′09″ W	1,173	Arabica	2014
Finca Gpe. Zajú	15° 09′38″ N, 92° 16′42″ W	1,207	Arabica	2013, 2015
Finca Chanjul	15° 10′33″ N, 92° 17′02″ W	1,212	Arabica	2015
Ejido El Águila	15° 06′12″ N, 92° 11′20″ W	1,233	Robusta/Arabica	2014, 2015
Pico de Loro	15° 03′16″ N, 92° 05′42″ W	1,335	Robusta/Arabica	2013
Unión Juárez	15° 04′01″ N, 92° 04′44″ W	1,371	Robusta/Arabica	2013, 2015
Finca Miriam	15° 04′08″ N, 92° 04′54″ W	1,413	Robusta/Arabica	2015
Finca S. Francisco	15° 11′48″ N, 92° 19′36″ W	1,421	Arabica	2014
Talquián	15° 04′54″ N, 92° 04′57″ W	1,597	Arabica	2014, 2015
Cantón Sinaí	15° 12′09″ N, 92° 19′16″ W	1,604	Arabica	2014

or the role they might be playing during coffee flowering. Therefore, we conducted a survey in commercial coffee plantations in Chiapas, aimed at identifying the composition of thrips species associated with coffee flowers, and determining their coffee pollen-carrying ability.

Materials and Methods

Study Area

Sampling for thrips was conducted in the coffee plantation zone of the Soconusco region. The Soconusco comprises ~5,776 km^2 and is located in the southern state of Chiapas, Mexico, next to the border with Guatemala. The original vegetation in the Soconusco highlands was an evergreen tropical forest that has been partially modified to grow shaded coffee. Plants providing shade in coffee plantations comprise over 100 species in 56 genera and 33 families, including trees, shrubs, palms, and tall herbs (Soto-Pinto et al. 2001). The most numerous families are Fabaceae, followed by Tiliaceae, Asteraceae, Arecaceae, Euphorbiaceae, and Rutaceae (Soto-Pinto et al. 2001). There are also numerous epiphytic plants growing on coffee trees in the families Araceae, Bromeliaceae, Cactaceae, Gesneriaceae, Moraceae, Orchidaceae, Piperaceae, and several families of ferns (Pteridophyta) (L.S.-M., unpublished data). Elevation of the coffee-growing areas ranges from 350 to 1,700 m above sea level (masl). This agroecosystem is characterized by a humid environment due to a constant presence of clouds that promotes abundant vegetation. It is one of the most humid regions in Mexico, with a typical rainy season of 8–9 mo (Richter 1993). A minimum of 2,500 mm of rain per year is normal, but in some coffee plantations, a precipitation of ca. 5,000 mm per year has been recorded (Richter and Schmiedecken 1993). The prevailing temperature varies with altitude and annual average temperatures are between 20 and 25°C (Richter 1986).

Fig. 1. A purple sticky trap to catch flying thrips placed on a flowering coffee plant in a coffee plantation of Chiapas, Mexico.

Thrips Collection

The survey of thrips from coffee flowers was conducted during the 2013, 2014, and 2015 flowering seasons in 30 coffee plantations at elevations ranging from 329 to 1,604 masl (Table 1). These locations were planted with *C. arabica*, *C. canephora*, or both. Samplings were conducted once (one year) in 16 plantations, twice (two years) in 12 plantations, and three times (three years) in two plantations (Table 1). Because coffee flowers are open for a very short period of time (see Introduction), thrips sampling was carried

Table 2. Species of thrips collected during three consecutive years (2013–2015) from coffee flowers in Chiapas, Mexico

Family and species	Elevation (masl)		
	Low (300–700)	Middle (701–1,000)	High (1,001–1,600)
Tubulifera			
Idolothripinae			
Elaphrothrips sp.		✓	
Phlaeothripinae			
Adraneothrips abdominalis Hood	✓		
Adraneothrips alternatus Hood		✓	
Adraneothrips nov. sp.		✓	
Aleurodothrips fasciapennis (Franklin)	✓		
Bamboosiella cingulata (Hood)			✓
Gynaikothrips uzeli (Zimmermann)			✓
Haplothrips gowdeyi (Franklin)	✓	✓	✓
Karnyothrips merrilli Watson	✓	✓	✓
K. venustus (Moulton)	✓		
Leptothrips sp.	✓	✓	✓
Liothrips sp.	✓		
Trybomia sp.		✓	✓
Terebrantia			
Aeolothripidae			
Aeolothrips mexicanus Priesner	✓	✓	✓
Erythrothrips durango Watson		✓	✓
Franklinothrips orizabensis Johansen		✓	
F. vespiformis Crawford	✓	✓	✓
Heterothripidae			
Heterothrips nov. sp.			✓
Thripidae			
Anisopilothrips venustulus (Priesner)	✓	✓	
Bravothrips kraussi (Crawford)			✓
Brooksithrips chamaedoreae Retana & Mound		✓	
Chaetisothrips striatus Hood		✓	
Frankliniella annulipes Hood		✓	✓
F. brevicaulis Hood	✓	✓	✓
F. brunnea Priesner	✓	✓	✓
F. cephalica Crawford	✓		✓
F. difficilis Hood	✓	✓	✓
F. gardeniae Moulton	✓	✓	✓
F. gossypiana Hood	✓	✓	✓
F. insularis (Franklin)	✓	✓	✓
F. invasor Sakimura	✓	✓	✓
F. parvula Hood	✓	✓	✓
F. simplex Priesner	✓		✓
F. vargasi Retana & Mound			✓
F. varipes Moulton	✓	✓	✓
F. zeteki Hood		✓	
Heliothrips haemorrhoidalis (Bouché)	✓	✓	✓
Leucothrips sp.			✓
Neohydatothrips varius (Moulton)		✓	
Neohydatothrips n. sp.			✓
Retanathrips sp.		✓	
Scirtothrips citri (Moulton)		✓	

Plantations were grouped in three categories according to their altitude.

out once per flowering season in each coffee plantation. Thrips were collected at random for 1 h per plantation, covering ~1 ha. Coffee branches were shaken against a plastic tray to separate insects from flowers. Afterwards, thrips were handled with a camel-hair brush and placed in vials containing 70% ethanol. Samples were taken to the laboratory and thrips were separated into morphotypes using a stereomicroscope. A subsample of about 25 specimens per site was selected, trying to include all morphotypes. Thrips were mounted on slides using Hoyer's medium and dried in an oven at 45 °C for 1 wk. Taxonomic keys by Mound and Marullo (1996) and Hoddle et al. (2012) were used in the identification of species. When necessary, species were compared to specimens at The Australian National Insect Collection, CSIRO, Canberra, Australia.

Sticky Traps

Purple 20 by 12-cm sticky traps were used to ascertain whether thrips are transferring coffee pollen from one plant to another.

Purple sticky traps have been shown to be effective capturing thrips in the Soconusco region (Virgen-Sánchez et al. 2011). Eleven sticky traps were placed in two 0.5-ha plots planted with *C. arabica* (Malacate, Pavencul; 1,650 masl), and 11 sticky traps were used in another site planted with *C. canephora* (Guatimoc; 800 masl). Traps were equally spaced in the 0.5-ha plantation, and were hung in coffee branches at a height of <2 m above the ground (Fig. 1). Sticky traps were removed the following day and taken to the laboratory. Trapping was conducted only once during the coffee flowering at the beginning of 2016.

A subsample from each sticky trap was selected to assess whether thrips were carrying coffee pollen grains on their cuticle. Specimens were soaked in a drop of 0.1% acid fuchsine for about 3 min to stain pollen grains (if present; Kearns and Inouye 1993), and then mounted on microscope slides. The presence of coffee pollen grains on the body of thrips, as well as their location on the body, was determined using a light microscope. Prior to this, we previously characterized the size and structure of *C. arabica* and *C. canephora* pollen grains. We measured >30 pollen grains for each species of coffee. The pollen structure was observed and photographed using a TOPCON SM-510 (Tokyo, Japan) scanning electron microscope.

Results

A total of 7,862 thrips (87.4% adults and 12.6% larvae) were collected on *C. arabica* flowers, while 20,440 thrips (68.6% adults and 31.4% larvae) were collected on *C. canephora*. Forty-two thrips species in 24 genera and five families were captured from flowers of both species of coffee (Table 2). Thripidae was the most diverse family with 23 species, and the most common genus was *Frankliniella*, comprising 14 species. Although thrips species were present in many of the places sampled regardless of elevation, when grouping the 30 coffee plantations at three altitudinal strata (Table 2), we found more thrips species at middle elevation (28 species), than plantations located at low elevation (22 species) or high elevation (26 species).

The results of our samplings were consistent through the different flowering seasons, as most thrips species were found more than one year (Table 3). The most common and consistent species in the 3-yr sampling were *Karnyothrips merrilli* Watson, *Haplothrips gowdeyi* (Franklin), *Frankliniella difficilis* Hood, *Frankliniella gardeniae* Moulton, *Frankliniella insularis* (Franklin), *Frankliniella invasor* Sakimura, *Frankliniella parvula* Hood, and *Frankliniella varipes* Moulton. Two undescribed species were collected: *Adraneothrips* nov. sp. and *Heterothrips* nov. sp. Unfortunately, they both consist of single specimens and are therefore insufficient for description as new species. In the suborder Tubulifera (Table 3), species of *Adraneothrips* and *Elaphrothrips* belong to families reported to feed on fungi. The species *Bamboosiella cingulata* Hood, *Gynaikothrips uzeli* Zimmermann, and *Haplothrips gowdeyi* (Franklin), are phytophagous, while *K. merrilli*, *Karnyothrips venustus* (Moulton), *Aleurodothrips fasciapennis* (Franklin), *Leptothrips* sp., and *Trybomia* sp. are predatory on small arthropods. The vast majority of specimens in the suborder Terebrantia (Table 3) are species reported as pollen consumers or phytophagous (e.g., the species of *Frankliniella*). However, there are also some specimens that belong to families with predatory species: *Aeolothrips mexicanus* Priesner, *Erythrothrips durango* Watson, *Franklinothrips orizabensis* Johansen, and *F. vespiformis* Crawford.

The examination of coffee pollen revealed that pollen grains of *C. arabica* (Fig. 2a and c) are spherical with verrucose exine, 30–37 µm diameter, with four pores in the colpus apparently joined without polar or equatorial symmetry. Pollen grains of *C. canephora* (Fig. 2b and d) are spherical, 14–33 µm diameter, with three pores apparently joined in a sunken colpus. This description of both types of pollen was useful in the detection and discrimination of pollen on the body of thrips.

Table 3. Species of thrips collected from coffee flowers during three different seasons in coffee plantations of Chiapas, Mexico

Family and Species	Year					
	2013		2014		2015	
	CA	CC	CA	CC	CA	CC
Tubulifera						
Idolothripinae						
Elaphrothrips sp.				✓		
Phlaeothripinae						
Adraneothrips abdominalis					✓	
Adraneothrips alternatus	✓					
Adraneothrips nov. sp.	✓					
Aleurodothrips fasciapennis			✓			
Bamboosiella cingulata						✓
Gynaikothrips uzeli						✓
Haplothrips gowdeyi	✓	✓	✓	✓	✓	✓
Karnyothrips merrilli	✓		✓	✓	✓	✓
K. venustus					✓	
Leptothrips sp.	✓	✓	✓	✓	✓	✓
Liothrips sp.		✓				
Trybomia sp.		✓		✓	✓	✓
Terebrantia						
Aeolothripidae						
Aeolothrips mexicanus	✓	✓	✓			
Erythrothrips durango Watson					✓	✓
Franklinothrips orizabensis				✓		
F. vespiformis			✓	✓	✓	
Heterothripidae						
Heterothrips nov. sp.						✓
Thripidae						
Anisopilothrips venustulus	✓		✓		✓	✓
Bravothrips kraussi	✓					
Brooksithrips chamaedoreae					✓	
Chaetisothrips striatus			✓		✓	
Erythrothrips durango					✓	✓
Frankliniella annulipes	✓				✓	✓
F. brevicaulis	✓	✓	✓		✓	✓
F. brunnea		✓	✓		✓	✓
F. cephalica			✓		✓	
F. difficilis	✓	✓	✓	✓	✓	✓
F. gardeniae	✓	✓	✓	✓	✓	✓
F. gossypiana					✓	✓
F. insularis	✓	✓	✓	✓	✓	✓
F. invasor	✓	✓	✓	✓	✓	✓
F. parvula	✓	✓	✓	✓	✓	✓
F. simplex	✓		✓			✓
F. vargasi					✓	✓
F. varipes	✓	✓	✓	✓	✓	✓
F. zeteki					✓	
Heliothrips haemorrhoidalis	✓	✓	✓	✓		
Neohydatothrips varius					✓	
Neohydatothrips sp.		✓				
Leucothrips sp.	✓					
Retanathrips sp.						✓
Scirtothrips nr. *citri*			✓			

CA, *Coffea arabica*; CC, *Coffea canephora*.

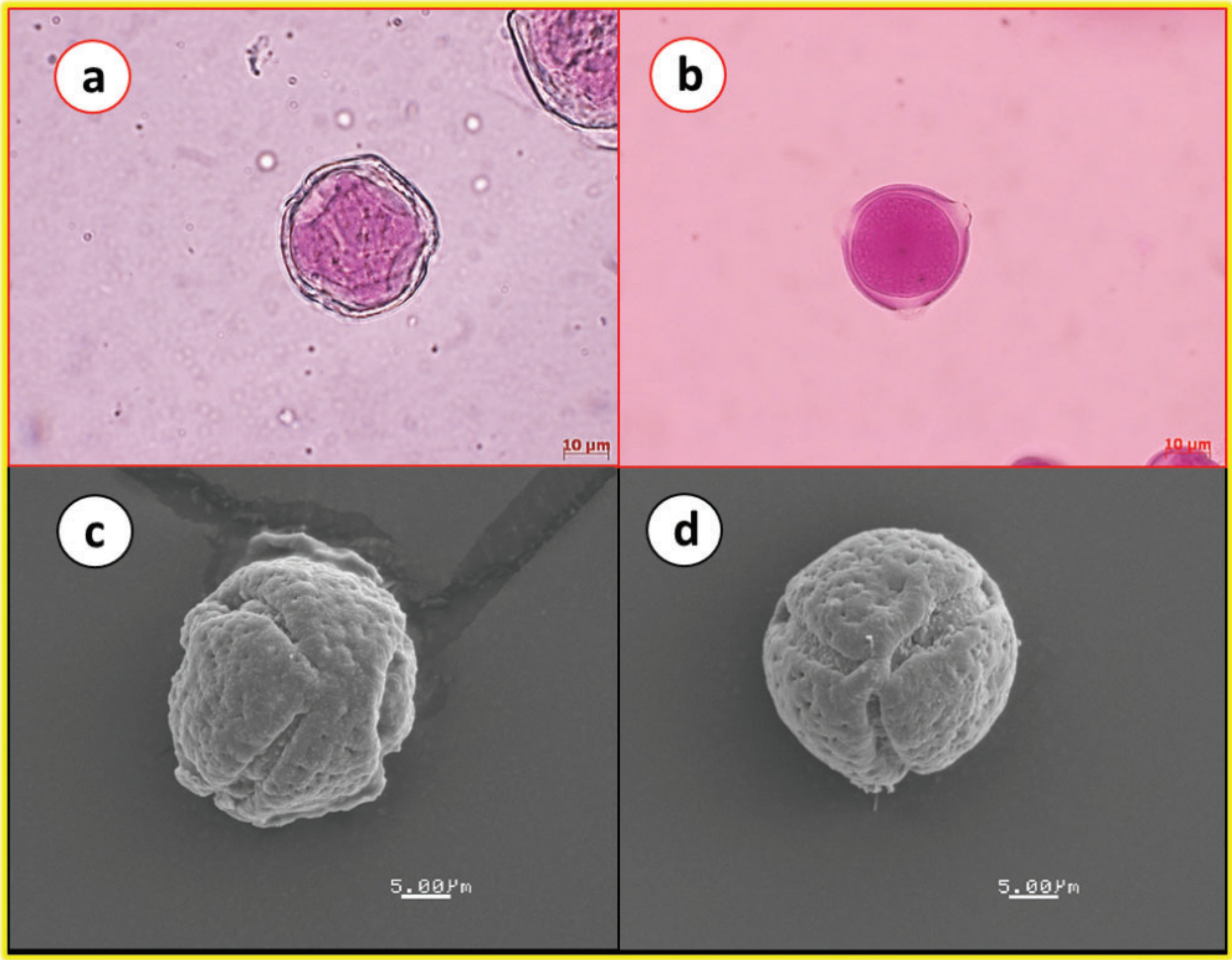

Fig. 2. Polar view of *Coffea arabica* (**a**, **c**) and *Coffea canephora* (**b**, **d**) pollen grains. Microphotographs were taken with light microscope (**a**, **b**) and scanning electron microscope (**c**, **d**).

Purple sticky traps were effective in capturing flying thrips in coffee plantations: 82 and 6,909 individuals were captured in *C. arabica* and *C. canephora*, respectively (Table 4). Microscope observations of subsamples of thrips detected six and 63 individuals, for *C. arabica* and *C. canephora*, respectively, with coffee pollen on their bodies. The taxonomic identification revealed seven species of thrips with coffee pollen on their cuticle (Fig. 3; Table 4): *F. invasor*, *F. insularis*, *F. parvula*, *F. gardeniae*, *F. difficilis*, *F. varipes*, and *H. gowdeyi*. On average, each thrips had 1.7 grains of coffee pollen attached to their cuticle (range 1–8). Individuals of *F. invasor* were detected with coffee pollen loads with more frequency than other thrips species (Table 4).

Discussion

To the best of our knowledge, this is the first work studying the diversity of thrips in coffee flowers. Our results have revealed the presence of a large diversity of thrips species during the coffee flowering period. Most thrips recorded here have also been found in a study carried out on the understory vegetation of the "Biosphere Reserve of Volcán Tacaná" (Goldarazena et al. 2014), an ecological reserve very close to coffee plantations. Many of these species have also been found feeding on cultivated plants in the Soconusco region. For instance, *Heliothrips haemorrhoidalis* is known to feed on the leaves of cacao, avocado, mango and other ornamentals. The complex of *Frankliniella* species are common visitors to flowers of maize, sesame, cashew trees, oak, mango, and many other plants (Rocha et al. 2012; F.I., unpublished data). Apparently the geographic distribution of most thrips species collected from coffee flowers is broad, as each is widespread throughout several countries of Central America (Mound and Marullo 1996, Goldarazena et al. 2012).

The survey from coffee flowers revealed that thrips were more abundant, by at least two and half times, in *C. canephora* than in *C. arabica*. Similarly, the purple sticky traps captured more flying thrips (up to 84 times more) in *C. canephora* than in *C. arabica*. Considering that sampling efforts were equal for both species of coffee, differences in captures might be partially explained by the climatic conditions of coffee plantations, and the intrinsic characteristics of both species of coffee, such as volatile production, floral structure, or quantity of nectar. For instance, it is well known that caffeine is higher in the nectar of *C. canephora* than in *C. arabica* and this has a positive interaction with insect pollinators (Wright et al. 2013). We are not aware of studies related to profile of volatiles performed on coffee flowers. However, there are several studies that compare volatiles between fruits of *C. arabica* and *C. canephora* at different stages of ripeness (Mathieu et al. 1998,

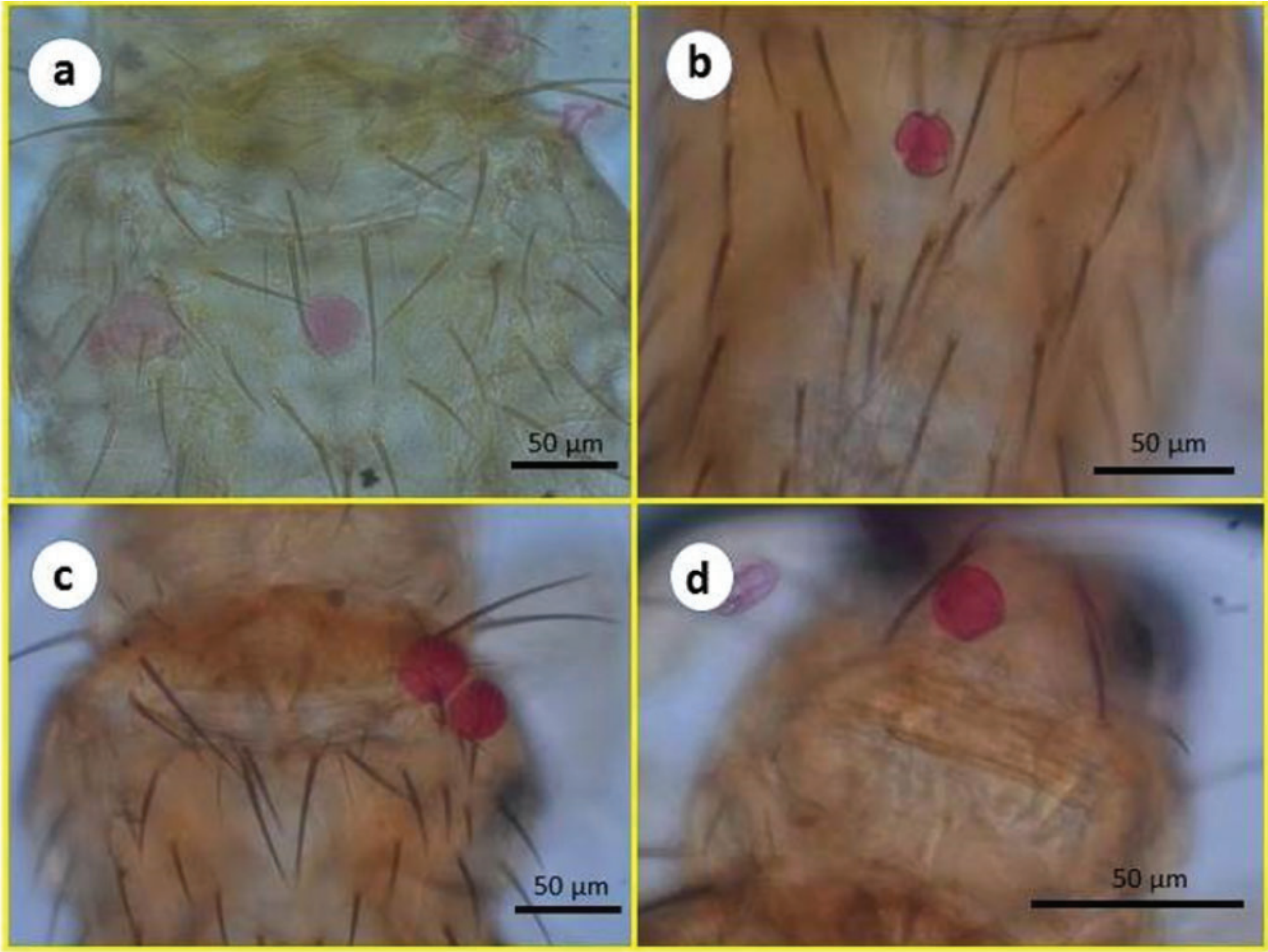

Fig. 3. Coffee pollen on the body of *Frankliniella invasor*: (**a**) pollen grains on pronotum, mesonotum, and metanotum; (**b**) pollen grain between the wings; (**c**) two pollen grains attached to the thorax; and (**d**) a pollen grain on the head.

Cruz Roblero and Malo 2013). Quantitative and qualitative differences in the volatiles of both species of coffee have been detected (Vega et al. 2015). It is possible that these differences are also manifested in the flower stage, where they might influence thrips abundance.

Up to 31% of the individuals sampled were larvae (first and second instar), indicating that one or more thrips species was breeding in coffee flowers. Species identification was not possible because there are no reliable taxonomic keys for thrips larvae (Mound and Marullo 1996). Thrips adults of various species are clearly attracted to the abundant pollen and nectar in coffee flowers. Given that adult thrips may enter floral buds, and lay eggs, there may be ample time for larval development, covering periods longer than the seven (*C. arabica*) or three (*C. canephora*) days the flowers are open. In fact, some species of *Frankliniella* have a short life-cycle under tropical conditions. For instance, *F. invasor* completes the cycle from egg to adult in 7.9 d at temperature of 30 °C (Ortiz et al. 2016). For this reason, coffee could be playing a role as an alternative host for most of the identified thrips species.

An important finding of the present work was the identification of coffee pollen on the cuticle of seven species of thrips. Thrips feed on floral tissues, nectar, and pollen grains in flowers (Kirk 1984). Consequently, they are potential pollinators of plants, despite their role as pollinators having been largely ignored (Mound 2005). Debates concerning thrips as pollinators have been controversial, because they do not fit the general profile of an effective pollinator (Peñalver et al. 2012).Considering that *C. canephora* needs cross pollination for fruit set, it is highly possible that species such as *F. invasor*, *F. varipes*, *F. insularis*, among others, are acting as pollinators, while they consume coffee pollen. The pollination of tropical plants by thrips has been demonstrated in other ecosystems. For instance, Sakai (2001) reported *Frankliniella diversa* and *F. insularis* as pollinators of the Panama rubber tree, *Castilla elastica* (Moraceae). These thrips are attracted to flowers by volatiles, and the tree has an inflorescence structure adapted to thrips pollination. Similarly, in Malaysia, the trees *Macaranga hullettii* (Euphorbiaceae) is predominantly pollinated by thrips of the genus *Neoheegeria*, and are rewarded by the plant with nectar (Moog et al. 2002). More recently, *Neoheegeria* has been placed in the genus *Dolichothrips* (Fiala et al. 2015). Although we cannot state that coffee flowers are pollinated by thrips, it is highly possible that some species of thrips (e.g., *Frankliniella* spp.) pollinate coffee flowers to some extent. Pollen grain size in plants pollinated by thrips is <34 µm (Sakai 2001), which matches up well with the average coffee pollen size (range = 14–37 µm; see above).

In summary, we verified the presence of a high diversity of thrips on coffee flowers of both *C. arabica* and *C. canephora*. There were more species of thrips in plantations located at middle elevation (701–1,000 masl), than plantations located at low elevation (300–700 masl) or high elevation (1,001–1,600 masl). The results of our samplings were consistent through the three flowering seasons

Table 4. Capture of thrips using purple sticky traps in coffee plantations of Chiapas, Mexico, to determine the presence of coffee pollen in their bodies

Trap no.	Coffee sp.	Thrips captured	Thrips mounted	Thrips with pollen	Thrips species[a]
1	*C. arabica*	13	13	2	1, 2
2	*C. arabica*	5	5	0	–
3	*C. arabica*	6	6	0	–
4	*C. arabica*	8	8	0	–
5	*C. arabica*	11	11	0	–
6	*C. arabica*	9	9	0	–
7	*C. arabica*	6	6	1	6
8	*C. arabica*	12	12	0	–
9	*C. arabica*	4	4	1	2
10	*C. arabica*	5	5	1	2
11	*C. arabica*	3	3	1	7
1	*C. canephora*	1,329	23	8	1, 2, 3
2	*C. canephora*	382	17	4	1
3	*C. canephora*	561	22	6	1, 2, 3, 4, 5
4	*C. canephora*	393	17	6	1, 2, 3
5	*C. canephora*	415	11	4	2,3
6	*C. canephora*	708	22	5	1
7	*C. canephora*	548	24	9	1, 2, 3
8	*C. canephora*	388	18	6	1, 3
9	*C. canephora*	506	27	8	1, 2
10	*C. canephora*	376	13	5	2
11	*C. canephora*	1,303	12	2	1

Eleven sticky traps were placed in 0.5-ha plot planted with *C. arabica* (Malacate, Pavencul; 1,650 masl), and 11 sticky traps were used in a site planted with *C. canephora* (Guatimoc; 800 masl).

[a]1—*Frankliniella invasor*, 2—*Frankliniella insularis*, 3—*Frankliniella parvula*, 4—*Frankliniella gardeniae*, 5—*Frankliniella difficilis*, 6—*Haplothrips gowdeyi*, 7—*Frankliniella varipes*.

(2013–2015), as most thrips species were found more than once. We have shown that several species of thrips are able to carry coffee pollen on their bodies. Even though pollen loads on thrips consisted of few pollen grains, it is possible that thrips could serve as pollinators of coffee flowers. Further studies are needed to confirm this hypothesis.

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