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A checklist of natural enemies of *Diaphorina citri* Kuwayama (Hemiptera: Liviidae) in the department of Valle del Cauca, Colombia and the world

Takumasa Kondo

Corporación Colombiana de Investigación Agropecuaria (CORPOICA), takumasa.kondo@gmail.com

Guillermo González F.

La Reina, Santiago, Chile

Catherine Tauber

University of California Davis

Yoan Camilo Guzmán Sarmiento

Universidade Federal de Viçosa

Andrés Felipe Vinasco Mondragon

Universidad del Valle

See next page for additional authors

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Authors

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Takumasa Kondo

Corporación Colombiana de Investigación Agropecuaria (CORPOICA)
Centro de Investigación Palmira, Calle 23, Carrera 37, Continuo al Penal
Palmira, Valle, Colombia

Guillermo González F.
La Reina, Santiago, Chile

Catherine Tauber
Department of Entomology
University of California Davis
Davis, California, USA

Yoan Camilo Guzmán Sarmiento
Universidade Federal de Viçosa
Viçosa, Minas Gerais, Brazil

Andrés Felipe Vinasco Mondragon
Universidad del Valle
Cali, Colombia

Dimitri Forero
Laboratorio de Entomología, UNESIS
Departamento de Biología, Pontificia
Universidad Javeriana, Bogotá, Colombia

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A checklist of natural enemies of *Diaphorina citri* Kuwayama
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Takumasa Kondo

Corporación Colombiana de Investigación Agropecuaria (CORPOICA)
Centro de Investigación Palmira, Calle 23, Carrera 37, Continuo al Penal
Palmira, Valle, Colombia
takumasa.kondo@gmail.com

Guillermo González F.
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Catherine Tauber
Department of Entomology
University of California Davis
Davis, California, USA

Yoan Camilo Guzmán Sarmiento
Universidade Federal de Viçosa
Viçosa, Minas Gerais, Brazil

Andrés Felipe Vinasco Mondragon
Universidad del Valle
Cali, Colombia

Dimitri Forero
Laboratorio de Entomología, UNESIS
Departamento de Biología, Pontificia
Universidad Javeriana, Bogotá, Colombia

Abstract. In recent years, populations of the Asian citrus psyllid, *Diaphorina citri* Kuwayama (Hemiptera: Liviidae), have increased in rural citrus orchards and urban backyard gardens. In order to find biological control options for *D. citri*, a search for natural enemies was conducted in the department of Valle del Cauca, Colombia. The collections were carried out in citrus orchards in rural areas and house gardens and street trees in urban areas. Natural enemies were collected from *D. citri* found on *Citrus* spp. and *Murraya paniculata* (L.) Jack (Rutaceae). A total of 16 species of natural enemies of *D. citri* distributed in six families in five orders are reported from Colombia. Herein we provide an updated list of 95 species of arthropod (arachnids and insects) natural enemies of *D. citri* distributed in nine orders and 23 families recorded worldwide.

Key words. Arthropods, Asian citrus psyllid, biological control, insects, mites, parasitoids, predators, spiders.

Resumen. En los últimos años, las poblaciones del psílido asiático de los cítricos, *Diaphorina citri* Kuwayama (Hemiptera: Liviidae), han aumentado en huertos cítricos en zonas rurales y jardines de traspatio en zonas urbanas. Con el fin de encontrar opciones de control biológico de *D. citri*, se realizó una búsqueda de enemigos naturales en el departamento de Valle del Cauca, Colombia. Las recolectas se llevaron a cabo en huertos de cítricos en zonas rurales y jardines de casas y árboles en zonas urbanas. Los enemigos naturales de *D. citri* se recolectaron sobre *Citrus* spp. y *Murraya paniculata* (L.) Jack (Rutaceae). Un total de 16 especies de enemigos naturales de *D. citri* distribuidos en seis familias en cinco órdenes se reportan para Colombia. Proveemos un listado actualizado de 95 artrópodos (arácnidos e insectos) enemigos naturales de *D. citri* distribuidos en nueve órdenes y 23 familias registrados en el mundo.

Palabras clave. Ácaros, arañas, artrópodos, control biológico, Psílido asiático de los cítricos, insectos, parasitoides, depredadores.

Introduction

The citrus industry in Colombia plays a major role in the country's agricultural economic sector and is a valuable source of employment; with 62,409 hectares of planted area and an average yield of 10.9 t/ha (DANE 2010). In particular, the department of Valle del Cauca has one of the highest citrus productions in Colombia, with 22.6% (MADR 2010). The citrus industry, like other agricultural activities are affected by the proliferation of insect pests and diseases that limit their yield. One of the most important problems to the citrus industry at the global level is the plant disease known as citrus greening or Huanglongbing (HLB) (Halbert and Manjunath 2004). In the New World, this disease is caused by the bacteria *Candidatus Liberibacter asiaticus* and *Candidatus Liberibacter americanus* that block the plant vascular bundles leading to the dieback of the plant (Lafèche and Bové 1970). Huanglongbing is probably the most serious disease of citrus, even more serious than Citrus tristeza virus, representing a dangerous threat for regions still free of the disease (Bové 2006). The main vector of the bacterium that causes HLB is called *Diaphorina citri* Kuwayama, 1908 (Hemiptera: Liviidae) (Mead and Fasulo 2011). *Diaphorina citri* has a broad distribution and an extensive list of host plants in about 25 genera of Rutaceae (Halbert and Manjunath 2004). Currently, Huanglongbing has not been diagnosed in Colombia (Ángel et al. 2014), but the insect vector, *D. citri* has been reported since 2007 (ICA, 2010) as well as its parasitoid *Tamarixia radiata* (Waterston, 1922) (Hymenoptera: Eulophidae) (Ebratt et al. 2011a; Kondo et al. 2012). Recently, a new species of *Candidatus Liberibacter* bacteria *C. L. caribbeanus* was reported from Colombia (Manjunath et al. 2015); however, its association with HLB is unknown.

Vector control is a critical factor in the prevention, containment and management of HLB (Kondo et al. 2012). Despite the importance of *D. citri* as a vector of HLB, very few studies on natural enemies of this psyllid have been carried out in Colombia, with the exception of those that report the presence of the ectoparasitoid *T. radiata* which is considered a potential effective parasitoid in Colombia in various regions of mainland Colombia (Ebratt et al. 2011a; Kondo et al. 2012), and a recent report of the dragonfly *Erpetogomphus sabaleticus* Williamson (Odonata: Anisoptera: Gomphidae) feeding on an adult of *D. citri* (Kondo et al. 2015). Kondo et al. (2015) presented a list of more than 63 arthropod (insects and spiders) species distributed in seven orders and 17 families as natural enemies of *D. citri* in the world. In anticipating the arrival of HLB, identifying natural enemies of the insect vector could help minimize the environmental impact that could cause the heavy use of synthetic chemical insecticides to control this insect vector.

The objective of this study is to report natural enemies of *D. citri* of the Class Insecta collected in the department of Valle del Cauca, Colombia and to provide an updated checklist of arthropod natural enemies (insects, mites and spiders) worldwide.

Materials and Methods

In order to find biological control options for the Asian citrus psyllid, *D. citri*, a search was made for natural enemies of nymphs and adult psyllids in the department of Valle del Cauca, Colombia. Field collections were made in garden plants, trees in urban areas and farms planted with *Citrus* spp. and *Murraya paniculata* (L.) Jack (Rutaceae).

Natural enemies were collected using small brushes and put into 70% alcohol. For the identification of coccinellids (Coleoptera), extraction of genitalia and species identifications were carried out by the second author (G. González). The genitalia of the coccinellids were extracted by macerating the abdomens in 10% KOH solution inside a glass tube submerged in hot water for 20–30 minutes, and later washed with distilled water. Components of the genitalia were separated under the microscope using insect pins and slide-mounted in glycerin on glass slides in order to study the important morphological features. For subsequent storage, the genitalia were put into micro vials filled with glycerin and attached to the insect pin of the specimen from which they were extracted. Both male and female specimens were dissected. The wasp (Hymenoptera) was identified using the keys by Fernandez and Sharkey (2006). The chrysopids (Neuroptera) were collected in the larval stage while feeding on nymphs of *D. citri*; these were fed sufficient *D. citri* nymphs and raised to the adult stage in the laboratory in order to enable

their identification. For the chrysopids, species identification by examination of genitalia was carried out by the third author (C. Tauber). The abdomens of representative male and female specimens from each species were snipped from the specimens with surgical scissors. Soft tissue in the abdomens was cleared in 10% KOH solution inside a Stender dish submerged in hot water for several hours. Subsequently, the male genitalia were everted with a fine syringe, whereas the female genitalia were left in place in the abdomen; then the abdomens were rinsed with distilled water and transferred to glycerine containing Chlorazol Black stain. The abdomens remained in the stain for varying times depending on the degree of sclerotization of the specimen. Stained abdomens were examined in glycerine on slides and stored in microvials containing glycerin and attached to the insect pin of the specimen from which they were removed. The chrysopids were identified primarily with keys by Adams and Penny (1985) and Freitas et al. (2009). The syrphid species (Diptera) were originally identified by the fourth author (Y.C. Guzman) using the illustrated key to genera of Syrphidae of Marinoni et al. (2007). Then the fifth author (A.F. Vinasco) further identified the specimens based on external morphological characters, e.g., coloration patterns of the abdomen and chaetotaxy of the thorax using the keys by Thompson (2006). The assassin bug (Hemiptera: Reduviidae) was identified by the sixth author (D. Forero) based on coloration and other external features using the taxonomic treatment of Hart (1972).

Herein we have updated the list by Kondo et al. (2015) based on newly collected natural enemies of *D. citri*. Many hymenopterous parasitoids have been reported associated with *D. citri*, however, herein we list only primary parasitoids and excluded hyperparasitoids from the list, e.g., *Marietta leopardina* Motschulsky, 1863, reported from Iran by Rakhshani and Saedifar (2013). Likewise, there are many ant species that have been listed as predators of *D. citri* (e.g., Michaud 2004), however, many of those species were only observed nearby the psyllids or tending them (i.e., feeding on the honeydew). Thus, only those species that show some evidence of predation, i.e., carrying away *D. citri* nymphs, or feeding directly on the psyllid should be considered as natural enemies. Of the eight ant species listed by Michaud (2004) only two showed some evidence of predation, i.e., carrying away *D. citri* nymphs (Kondo et al. 2015).

Depositories. Specimens are deposited at the insect collections of Guillermo González, Santiago, Chile (CPGG); Bohart Museum of Entomology, University of California, Davis, California, USA (BME); and Museo de Entomología, Corporación Colombiana de Investigación Agropecuaria, Centro de Investigación Palmira, Palmira, Valle del Cauca, Colombia (MECP).

Material studied. Coleoptera: Coccinellidae. *Azya orbigera*, Colombia, Valle del Cauca, Caicedonia, Finca Las Brisas, 04°23'19.7"N, 75°51'05.2"W, 1080 m, 03.vii.2013, coll. Y.C. Guzman, No. 9.7, *ex* feeding on *D. citri* on *Citrus reticulata*, 1 specimen (CPGG); *Cheilomenes sexmaculata*, Colombia, Valle del Cauca, Pradera, Finca Sitio 5, 03°24'20.8"N, 76°14'30.0"W, 1080 m, 09.x.2013, coll. Y.C. Guzman, No. 90.5, *ex* feeding on *D. citri* on *M. paniculata*, 1 specimen (CPGG); *Chilocorus* cf. *cacti*, Colombia, Valle del Cauca, Pradera, Finca: Sitio 5, 03°24'20.8"N, 76°14'30.0"W, 1080 m, *ex* feeding on nymph of *D. citri* on *M. paniculata*, 09.x.2013, coll. Y. C. Guzmán; *Curinus colombianus*, Colombia, Valle del Cauca, Palmira, Finca El Almendro, 03°36'23.6"N, 76°22'50.3"W, 988 m, 04.ix.2013, coll. Y.C. Guzman, No. 58.1, *ex* feeding on *D. citri* on *M. paniculata*, 2 specimens (CPGG); *Cycloneda sanguinea*, Colombia, Valle del Cauca, Caicedonia, Finca Las Brisas, 04°23'19.7"N, 75°51'05.2"W, 1080 m, 03.vii.2013, coll. Y.C. Guzman, No. 9.2b, *ex* feeding on *D. citri* on *C. reticulata*, 2 specimens (CPGG); *C. sanguinea*, Colombia, Valle del Cauca, Palmira, Finca El Almendro, 03°36'23.6"N, 76°22'50.3"W, 988 m, 04.ix.2013, coll. Y.C. Guzman, No. 58.2, *ex* feeding on *D. citri* on *M. paniculata*, 1 specimen (CPGG); *Harmonia axyridis*, Colombia, Valle del Cauca, Caicedonia, Finca Las Brisas, 04°23'19.7"N, 75°51'05.2"W, 1080 m, 03.vii.2013, coll. Y.C. Guzman, No. 9.2, *ex* feeding on *D. citri* on *C. reticulata*, 3 specimens (CPGG); *H. axyridis*, Colombia, Valle del Cauca, Caicedonia, Finca Las Brisas, 04°23'19.7"N, 75°51'05.2"W, 1080 m, 03.vii.2013, coll. Y.C. Guzman, No. 9.3, *ex* feeding on *D. citri* on *C. reticulata*, 5 specimens (CPGG); *Hippodamia convergens*, Colombia, Valle del Cauca, Caicedonia, Finca Las Brisas, 04°23'19.7"N, 75°51'05.2"W, 1080 m, 03.vii.2013, coll. Y.C. Guzman, No. 9.4, *ex* feeding on *D. citri* on *C. reticulata*, 1 specimen (CPGG); *Olla v-nigrum*, Colombia, Valle del Cauca, Pradera, Finca Sitio 5, 03°24'20.8"N, 76°14'30.0"W, 1080 m, 09.x.2013, coll. Y.C. Guzman, No. 90.1, *ex* feeding on *D. citri* on *M. paniculata*, 1 specimen (CPGG); *Scymnus rubicundus*, Colombia, Valle del Cauca, Roldanillo, Finca La Rumbita,

04°28'52.9"N, 76°06'47.8"W, 943 m, 09.xi.2013, coll. Y.C. Guzmán, No. 95.1, *ex* feeding on *D. citri* on *M. paniculata*, 1 specimen (CPGG). **Diptera: Syrphidae.** *Allograpta (Fazia) CR-2 aff. hians*, Colombia, Valle del Cauca, Pradera, Finca: Sitio 5, 03°24'20.8"N, 76°14'30.0"W, 1080 m, 09.x.2013, coll. Y.C. Guzmán, *ex* feeding on nymphs of *D. citri* on *M. paniculata*, 3 specimens (UVCO); Colombia, Valle del Cauca, Roldanillo, Finca La Rumbita, 04°28'52.9"N, 76°06'47.8"W, 943 m, 09.xi.2013, coll. Y.C. Guzmán, *ex* feeding on nymphs of *D. citri* on *M. paniculata*, 1 specimen (UVCO); *Leucopodella* sp., Colombia, Valle del Cauca, Palmira, Cra19# 19–14, 03°31'04.1"N, 76°17'27.1"W, 1025 m, 12.ix.2013, coll. Y.C. Guzmán, *ex* feeding on nymphs of *D. citri* on *M. paniculata*, 1 specimen (UVCO). **Hemiptera: Reduviidae.** *Zelus cf. nugax*, Colombia, Valle del Cauca, Pradera, vereda La Concordia, 03°24'20,8" N76°14'30.0" W, 1080 m, 09.x.2013, coll. Y. C. Guzmán, *ex* feeding on *D. citri* on *M. paniculata*, 1 specimen (MECP). **Hymenoptera: Eulophidae.** *Tamarixia radiata*, Colombia, Valle del Cauca, Palmira, Finca Variedades Liliana, 04°24'52.5"N, 76°03'25.4"W, 982 m, 17.vii.2013, coll. Y.C. Guzmán, *ex. D. citri* on *M. paniculata*, 1 specimen (MECP); *T. radiata*, Colombia, Valle del Cauca, Palmira, Finca Familia Díaz, 03°37'03.8"N, 76°25'02.9"W, 985 m, 17.vii.2013, coll. Y.C. Guzmán, *ex. D. citri* on *M. paniculata*, 1 specimen (MECP); *T. radiata*, Colombia, Valle del Cauca, Palmira, Tienda Mixta, 03°36'32.2"N, 76°22'55.3"W, 988 m, 17.vii.2013, coll. Y.C. Guzmán, *ex. D. citri* on *M. paniculata*, 1 specimen (MECP); *T. radiata*, Colombia, Valle del Cauca, Caicedonia, Finca Las Brisas, 03°36'0.5"N, 76°22'31.9"W, 1080 m, 24.vii.2013, coll. Y.C. Guzmán, *ex. D. citri* on *Citrus reticulata*, 1 specimen (MECP); *T. radiata*, Colombia, Valle del Cauca, Roldanillo, Finca Villa Liria, 03°36'00.5"N, 76°22'31.9"W, 929 m, 31.vii.2013, coll. Y.C. Guzmán, *ex. D. citri* on *M. paniculata*, 1 specimen (MECP). **Vespidae.** *Polybia* sp., Colombia, Valle del Cauca, Zarzal, Frutales Las Lajas, 04°25'03.9"N, 76°03'38.0"W, 969 m, 26.ii.2014, coll. T. Kondo, *ex* preying upon *D. citri* on *Citrus* sp., 1 specimen (MECP); *Polybia* sp., Colombia, Valle del Cauca, Caicedonia, Finca Las Brisas, 04°23'19.7"N, 75°51'05.2"W, 1080 m, 03.vii.2013, coll. Y.C. Guzmán, *ex* feeding on nymph of *D. citri* on *C. reticulata*, 1 specimen (MECP). **Neuroptera: Chrysopidae.** *Ceraeochrysa* sp. (female, teneral), Colombia, Valle de Cauca, Palmira, Corpoica, Centro de Investigación Palmira, 03°30'31.2"N, 76°19'11.6"W, 1015 m, 24.xi.2011, coll. E.M. Quintero, larva feeding on nymph of *D. citri*, 1 specimen (BME); *Ceraeochrysa cf. claveri* (female), Colombia, Valle de Cauca, Palmira, Corpoica, Centro de Investigación Palmira, 03°30'31.2"N, 76°19'11.6"W, 1015 m, 24.xi.2011, coll. E. M. Quintero, larva feeding on nymph of *D. citri*, 1 specimen (BME).

Results

A total of 16 species of natural enemies distributed in six families in five orders was identified preying upon *D. citri* in Colombia, i.e., nine ladybeetles: *Azya orbiger* Mulsant, 1850 (Fig. 1A), *Cheilomenes sexmaculata* (Fabricius, 1781) (Fig. 1B), *Chilocorus cf. cacti* (L., 1767) (Fig. 1C), *Curinus colombianus* Chapin, 1965 (Fig. 1D), *Cycloneda sanguinea* (L., 1763) (Fig. 1E), *Harmonia axyridis* (Pallas, 1773) (Fig. 1F), *Hippodamia convergens* Guérin-Ménéville, 1842 (Fig. 1G), *Olla v-nigrum* (Mulsant, 1866) (Fig. 1H), *Scymnus rubicundus* Erichson, 1847 (Fig. 1I) (Coleoptera: Coccinellidae); two species of hover flies: *Allograpta (Fazia) CR-2 aff. hians* (Enderlein, 1938) (Fig. 1J), *Leucopodella* sp. (Fig. 1K), (Diptera: Syrphidae); the predatory bug *Zelus cf. nugax* Stål, 1862 (Fig. 1L), (Hemiptera: Reduviidae); the paper wasp *Polybia* sp. (Fig. 1M), (Hymenoptera: Vespidae); the ectoparasitoid *T. radiata* (Fig. 1N), (Hymenoptera: Eulophidae); two species of lacewings: *Ceraeochrysa* sp. (Fig. 1O) and *Ceraeochrysa cf. claveri* (Navás, 1911) (not illustrated) (Neuroptera: Chrysopidae).

As a result, together with literature records, the total number of arthropod natural enemies of *D. citri* is increased to 95 species distributed in nine orders and 23 families worldwide (Table 1). Most recorded natural enemies of *D. citri* are the ladybeetles (Coleoptera: Coccinellidae) with 38 species (40%), followed by lacewings (Neuroptera: Chrysopidae) with 13 species (14%) and the hoverflies with eight species (10%). In Colombia, the number of natural enemies of *D. citri* is increased to 17 species distributed in seven families in six orders, all in the class Insecta (Table 1).

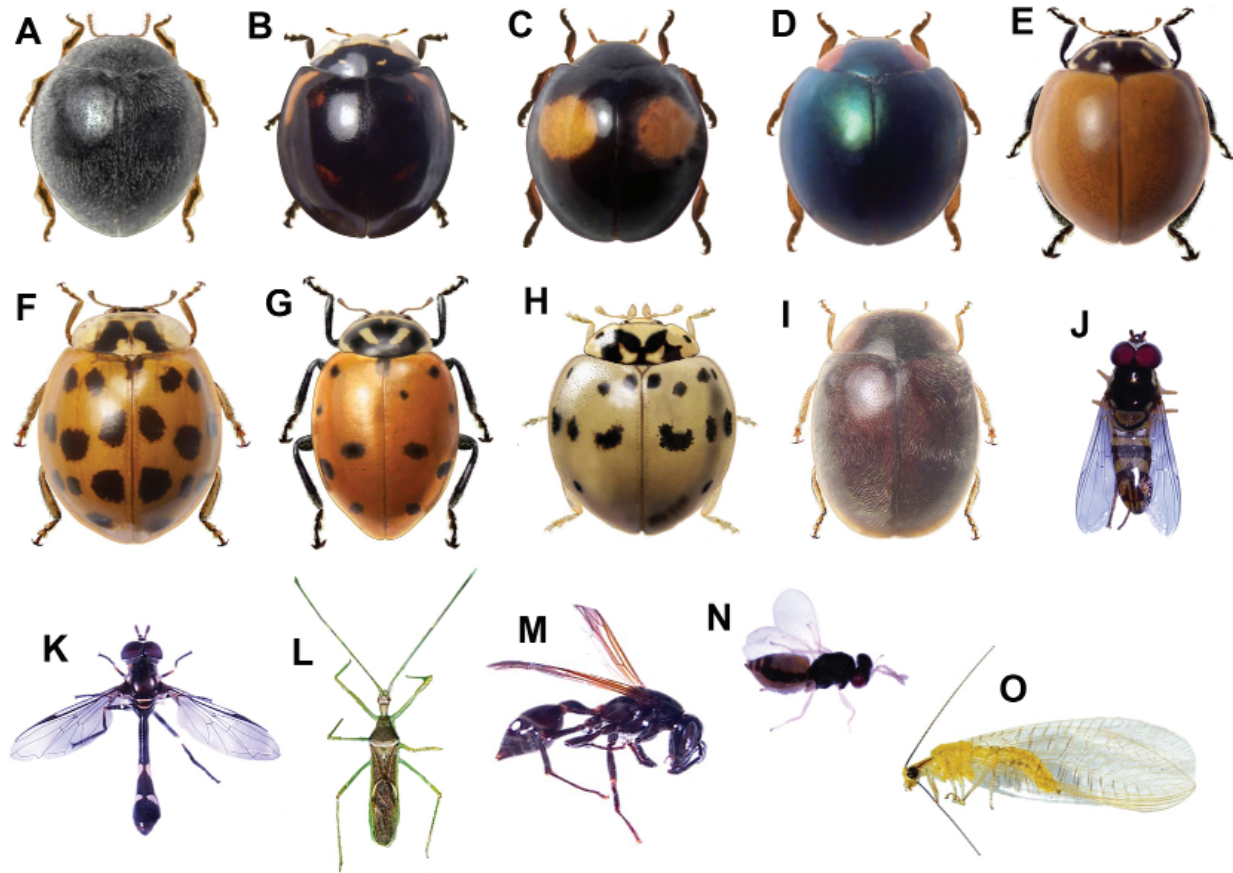


Figure 1. Natural enemies associated with *Diaphorina citri* in Colombia. **Coleoptera: Coccinellidae:** A. *Azya orbigerana* Mulsant, B. *Cheilomenes sexmaculata* (Fabricius), C. *Chilocorus cacti* (L.), D. *Curinus colombianus* Chapin, E. *Cycloneda sanguinea* (L.), F. *Harmonia axyridis* (Pallas), G. *Hippodamia convergens* (Guerin-Meneville). H. *Olla v-nigrum* (Mulsant), I. *Scymnus rubicundus* Erichson. **Diptera: Syrphidae:** J. *Allograpta* (*Fazia*) CR-2 aff. *hians*, K. *Leucopodella* sp. **Hemiptera: Reduviidae:** L. *Zelus* cf. *nugax* Stål, **Hymenoptera: Vespidae:** M. *Polybia* sp. **Eulophidae:** N. *Tamarixia radiata* (Waterston). **Neuroptera: Chrysopidae:** O. *Ceraeochrysa* sp.

Discussion

A general characteristic of arthropods reported as natural enemies of *D. citri* is that all recorded species are generalist predators, with the exception of the parasitoids *T. radiata* and *Diphorencyrtus aligarhensis* Shafee, Alam and Agarwal, 1975 (Hymenoptera: Encyrtidae) (Kondo et al. 2015). Hussain and Nath (1927) reported nine species of parasitoids attacking nymphs of *D. citri* in Punjab province, Pakistan, but, according to Hoddle et al. (2014) most of those species are hyperparasitoids or parasitoids of other species of insects and that there are just two species of primary parasitoids of *D. citri* in Punjab Province, namely, *T. radiata* and *D. aligarhensis*.

Many species of ants have been listed as predators of *D. citri* (e.g., Michaud 2004), although no observations on predation have been observed. According to Way (1963) *apud* Navarrete et al. (2013), ants which tend Hemiptera may feed on their trophobionts when sources of proteins and lipids are scarce. Navarrete et al. (2013) reported that the presence of the ants *Pheidole megacephala* Fabricius, 1793, *Brachymyrmex patagonicus* Mayr, 1868, and *Solenopsis invicta* Buren, 1972, was positively correlated with higher parasitism rates of *T. radiata* in an ant exclusion experiment conducted in Homestead, Florida (USA). In their study, Navarrete et al. (2013) did not see any aggressive behavior of ants against nymphs of *D. citri*, and the number of *D. citri* nymphs did not show a statistical difference between ant tended and not-tended *D. citri* nymphs, suggesting that the ants did not eat the tended psyllids.

The present study focused on arthropod natural enemies of *D. citri*, however, nymphs and adults of *D. citri* were occasionally found infected by entomopathogenic fungi, thus these organisms appear to have some control on *D. citri* populations in natural conditions. Several species of entomopathogenic fungi have been reported to infect *D. citri* worldwide and may be useful as biopesticides, including *Isaria fumosorosea* Wize (= *Paecilomyces fumosoroseus*), *Hirsutella citriformis* Speare, *Lecanicillium* (= *Verticillium*) *lecanii* Zimm., *Beauveria bassiana* (Bals.) Vuill., *Cladosporium* sp. nr. *oxysporum* Berk. and MA Curtis, *Acrostalagmus aphidum* Oudem, *Paecilomyces javanicus* (Friederichs and Bally) AHS Brown and G Smith, and *Capnodium citri* Berk. and Desm. (Hall, 2012).

Due to the limited scope of this study, we expect that many more natural enemies will be discovered in the future in Colombia and elsewhere. During the present study, several species of assassin bugs in the genus *Zelus* were found feeding on adult *D. citri*, suggesting that this group of hemipterous predators may be important natural enemies of *D. citri* in the studied area (T.K., personal observations). Little is known regarding the extent to which these predators reduce infestations of *D. citri*, but some of these are considered important biological control agents (Hall et al. 2012).

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Table 1. Arachnids and insects reported as natural enemies of *Diaphorina citri* Kuwayama (Hemiptera: Liviidae) in the world. Species collected in the present study are marked with an asterisk (*).

Taxonomy	Family/Species	Distribution and references
(Order)		
ACARI		
	Anystidae	
	<i>Anystis baccarum</i> (L., 1758)	China (Yang et al. 2006)
	Phytoseiidae	
	<i>Typhlodromips swirskii</i> (Athias-Henriot, 1962)	USA (Juan-Blasco et al. 2012)
ARANEAE	Anyphaenidae	
	<i>Hibana velox</i> (Becker, 1879)	USA (Michaud 2002, 2004)
	Clubionidae	
	<i>Cheiracanthium</i> sp.	Iran (Rakhshani and Saeedifar 2013)
	Gnaphosidae	
	<i>Zelotes</i> sp.	Iran (Rakhshani and Saeedifar 2013)
	Miturgidae	
	<i>Cheiracanthium inclusum</i> (Hentz, 1847)	USA (Michaud 2002)
	Oxyopidae	
	<i>Oxyope</i> sp.	USA (Michaud 2002)
	Salticidae	
	<i>Hentzia palmarum</i> (Hentz, 1832)	USA (Michaud 2002)
	<i>Marpissa tigrina</i> Tikader, 1965	India (Sanda 1991)
COLEOPTERA	Carabidae	
	<i>Egaploa crenulata</i> (Dejean, 1829)	Saudi Arabia (Al-Ghamdi 2000)
	Coccinellidae	
	<i>Arawana cubensis</i> (Dimmock, 1906)	Cuba (González et al. 2001, 2002)
	<i>Arawana</i> sp.	Mexico (Lozano-Contreras et al. 2012)
	* <i>Azya orbiger</i> a Mulsant, 1850	*Colombia, Mexico (Lozano-Contreras et al. 2012)
	<i>Brachiacantha dentipes</i> (Fabricius, 1801)	USA (Michaud 2004)
	<i>Brumus suturalis</i> (Fabricius, 1798)	India (Husain and Nath 1927, Pruthi and Mani 1945)
	* <i>Cheilomenes sexmaculata</i> (Fabricius, 1781)	China (Lin et al. 1973), *Colombia, Taiwan (Chien and Chu 1996), India (Husain and Nath 1927, Pruthi and Mani 1945), Iran (Rakhshani and Saeedifar 2013)
	<i>Chilocorus cacti</i> (L., 1767)	Cuba (González et al. 2001, 2002, Rodríguez-Toledo et al. 2008), Mexico (Lozano-Contreras et al. 2012, Rodríguez-Palomera et al. 2012, Puerto Rico (Pluke et al. 2005)
	* <i>Chilocorus</i> cf. <i>cacti</i> (L., 1767)	*Colombia

	<i>Chilocorus nigrita</i> (Fabricius, 1798)	India (Husain and Nath 1927, Pruthi and Mani 1945)
	<i>Chilocorus stigma</i> (Say, 1835)	Mexico (González-Cárdenas et al. 2012), USA (Chong et al. 2010)
	<i>Cladis nitidula</i> (Fabricius, 1792)	Puerto Rico (Pluke et al. 2005)
	<i>Coccinella repanda</i> Thunberg, 1781	India (Husain and Nath 1927, Pruthi and Mani 1945)
	<i>Coccinella septempunctata</i> (L., 1758)	India (Husain and Nath 1927, Pruthi and Mani 1945), Iran (Rakhshani and Saeedifar 2013)
	<i>Coelophora inaequalis</i> (Fabricius, 1775)	Puerto Rico (Pluke et al. 2005), USA (Michaud 2002, 2004)
	<i>Coleomegilla innotata</i> Mulsant, 1850	Puerto Rico (Pluke et al. 2005),
	<i>Coleomegilla maculata</i> (De Geer, 1775)	USA (Michaud 2002)
	<i>Cryptolaemus montrouzieri</i> Mulsant, 1853	Puerto Rico (Pluke et al. 2005)
	<i>Curinus coeruleus</i> (Mulsant, 1850)	Mexico (González-Cárdenas et al. 2012), USA (Chong et al. 2010, Hall et al. 2008, Michaud 2002, 2004)
	* <i>Curinus colombianus</i> Chapin, 1965	*Colombia
	<i>Cycloneda devestita</i> (Mulsant, 1850)	Venezuela (Solano et al. 2014)
	* <i>Cycloneda sanguinea</i> (L., 1763)	*Colombia, Cuba (González et al. 2001, 2002, Rodríguez-Toledo et al. 2008), USA (Chong et al. 2010; Michaud 2002, 2004), Mexico (González-Cárdenas et al. 2012, Hall et al. 2008, Lozano-Contreras et al. 2012, Miranda-Salcedo and López-Arroyo 2010, Rodríguez-Palomera et al. 2012)
	<i>Cycloneda sanguinea limbifer</i> (Casey, 1899).	Puerto Rico (Pluke et al. 2005)
	<i>Delphastus</i> sp.	Mexico (Lozano-Contreras et al. 2012)
	<i>Exochomus childreni</i> Mulsant, 1850	USA (Michaud 2002, 2004)
	<i>Exochomus nigripennis</i> (Erichson, 1843)	Iran (Rakhshani and Saeedifar 2013)
	* <i>Harmonia axyridis</i> (Pallas, 1773)	*Colombia, USA (Chong et al. 2010, Hall et al. 2008, Michaud 2002, 2004)
	* <i>Hippodamia convergens</i> (Guérin-Méneville, 1842)	*Colombia, Mexico (González-Cárdenas et al. 2012, Miranda-Salcedo and López-Arroyo 2010), Puerto Rico (Pluke et al. 2005)
	<i>Nephus</i> sp.	Mexico (Rodríguez-Palomera et al. 2012)
	* <i>Olla v-nigrum</i> (Mulsant, 1866)	*Colombia, USA (Hall et al. 2008, Michaud 2002, 2004), Mexico (Lozano-Contreras et al. 2012, Miranda-Salcedo and López-Arroyo 2010, Rodríguez-Palomera et al. 2012)

	<i>Pentilia</i> sp.	Mexico (Rodríguez-Palomera et al. 2012)
	<i>Rodolia cardinalis</i> (Mulsant, 1850)	USA (Michaud 2004)
	<i>Scymnus levaillantii</i> (Mulsant, 1850)	Iran (Rakhshani and Saeedifar 2013)
	<i>Scymnus distinctus</i> Casey, 1924	Cuba (González et al. 2001, 2002)
	* <i>Scymnus rubicundus</i> Erichson, 1847	*Colombia
	<i>Scymnus</i> spp.	Brazil (Gravena et al. 1996), Puerto Rico (Pluke et al. 2005)
	<i>Serangium</i> sp.	Taiwan (Chien and Chu 1996)
	<i>Zagloba</i> sp.	Mexico (Lozano-Contreras et al. 2012)
	Histeridae	
	<i>Saprinus chalcites</i> (Illiger, 1807)	Arabia Saudita (Al-Ghamdi 2000)
DIPTERA		
	Syrphidae	
	<i>Allobaccha sapphirina</i> (Wiedemann, 1830)	Iran (Rakhshani and Saeedifar 2013)
	<i>Allograpta obliqua</i> (Say, 1823)	USA (Michaud 2002, 2004)
	<i>Allograpta</i> sp. (probably <i>A. obliqua</i> Say)	USA (Hall et al. 2008)
	<i>Allograpta</i> spp.	Nepal (Aubert 1987), Reunion Island (Aubert 1987)
	* <i>Allograpta (Fazia) CR-2 aff. hians</i>	*Colombia
	* <i>Leucopodella</i> sp.	*Colombia
	<i>Ocyptamus</i> sp.	Cuba (González et al. 2001, 2002, Rodríguez-Toledo et al. 2008)
	<i>Ocyptamus fuscipennis</i> (Say, 1823)	USA (Michaud 2004)
	<i>Pseudodorus clavatus</i> (Fabricius, 1794)	USA (Michaud 2002)
HEMIPTERA		
	Anthocoridae	
	<i>Anthocorus</i> sp.	USA (Michaud 2002)
	<i>Orius</i> sp.	USA (Michaud 2002)
	Geocoridae	
	<i>Geocoris</i> sp.	Taiwan (Chien and Chu 1996)
	Reduviidae	
	<i>Zelus longipes</i> (L., 1767)	Mexico (Miranda-Salcedo and López-Arroyo 2010), USA (Hall et al. 2008, Navarrete et al. 2014)
	* <i>Zelus</i> cf. <i>nugax</i> Stål, 1862	*Colombia
	<i>Zelus</i> sp.	USA (Michaud 2002)
HYMENOPTERA		
	Encyrtidae	
	<i>Diphorencyrtus aligarhensis</i> Shafee, Alam and Agarwal, 1975	Argentina (García-Darderes 2009), China (Yang et al. 2006), India, Filipinas (Aubert 1987), Reunion Island (Aubert and Quilici 1984), USA (Hoy and Nguyen 1998, Michaud

		2002), Taiwan (Chien and Chu 1996, Chu and Chien 1991), Vietnam (Aubert 1987)
	Eulophidae	
	* <i>Tamarixia radiata</i> (Waterston, 1922)	Argentina (García-Darderes 2009); *Colombia (Ebratt-Ravelo et al. 2011a, b, Kondo et al. 2012, PS), China (Yang et al. 2006), Cuba (Baños-Díaz et al. 2013, González et al. 2001, 2002, Miranda et al. 2011, Rodríguez-Toledo et al. 2008), Guadeloupe (Étienne et al. 2001), Iran (Rakhshani and Saedifar 2013), USA (Hoy and Nguyen 1998; Michaud 2002, 2004), Mexico (Miranda-Salcedo and López-Arroyo 2010), Taiwan (Chien and Chu 1996; Chu and Chien 1991)
	Formicidae	
	<i>Dorymyrmex bureni</i> (Trager, 1988)	USA (Michaud 2004)
	<i>Pseudomyrmex gracilis</i> (Fabricius, 1804)	USA (Michaud 2004)
	Vespidae	
	<i>Brachygastra mellifica</i> (Say 1837)	Mexico (Reyes-Rosas et al. 2014)
	* <i>Polybia</i> sp.	*Colombia
MANTODEA		
	Family undetermined	
	Species undetermined	China (Yang et al. 2006)
NEUROPTERA		
	Chrysopidae	
	<i>Ceraeochrysa claveri</i> (Navás, 1911)	Mexico (Lozano-Contreras et al. 2012)
	* <i>Ceraeochrysa</i> cf. <i>claveri</i> (Navás, 1991)	*Colombia
	<i>Ceraeochrysa cubana</i> (Hagen, 1861)	Mexico (Lozano-Contreras et al. 2012)
	<i>Ceraeochrysa everes</i> (Banks, 1920)	Mexico (Lozano-Contreras et al. 2012)
	<i>Ceraeochrysa</i> sp. nr. <i>cincta</i> (Schneider, 1851)	Mexico (Lozano-Contreras et al. 2012)
	<i>Ceraeochrysa valida</i> (Banks, 1895)	Mexico (Lozano-Contreras et al. 2012)
	* <i>Ceraeochrysa</i> spp.	*Colombia, Mexico (Rodríguez-Palomera et al. 2012), USA (Michaud 2002, 2004),
	<i>Chrysopa septempunctata</i> Wesmæl, 1841	China (Yang et al. 2006)
	<i>Chrysopa</i> spp.	Cuba (González et al. 2001, 2002, Rodríguez-Toledo et al. 2008), Mexico (Lozano-Contreras et al. 2012), USA (Hall et al. 2008)
	<i>Chrysoperla carnea</i> (Stephens, 1836)	Iran (Rakhshani and Saedifar 2013)

	<i>Chrysoperla rufilabris</i> (Burmeister, 1839)	USA (Michaud 2002, 2004), Mexico (Lozano-Contreras et al. 2012; Miranda-Salcedo and López-Arroyo 2010)
	<i>Chrysoperla</i> spp.	USA (Michaud 2004), Mexico (Lozano-Contreras et al. 2012)
	<i>Mallada boninensis</i> (Okamoto, 1914)	China (Lin et al. 1973, Yang et al. 2006), Taiwan (Chien and Chu 1996)
	Hemerobiidae	
	<i>Micromus posticus</i> (Walker, 1853)	USA (Michaud 2002)
ODONATA		
	Gomphidae	
	<i>Erpetogomphus sabaleticus</i> Williamson, 1918	Colombia (Kondo et al. 2015)