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## Scale insects (Hemiptera: Coccoidea) associated with avocado crop, *Persea americana* Mill. (Lauraceae) in Valle del Cauca and neighboring departments of Colombia

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**Abstract.** Scale insects (Hemiptera: Coccoidea) of avocado, *Persea americana* Mill. (Lauraceae) were collected in the State of Valle del Cauca, Colombia. The study was conducted for one year, during October 2008–October 2009. As a result of this study, 34 scale insect species in seven families (Coccidae, Diaspididae, Kerriidae, Margarodidae, Monophlebidae, Pseudococcidae and Putoidae) were collected. Together with previous records, the number of scale insects collected on avocado in Colombia increased to 44 species and to 137 species worldwide. Species commonly collected on avocado in Colombia include *Hemiberlesia cyanophylli* (Signoret), *Pseudoparlatoria parlatorioides* (Comstock) (Diaspididae), *Ceroplastes rubens* Maskell, *Coccus hesperidum* L., *Protopulvinaria pyriformis* (Cockerell), *Pulvinaria psidii* Maskell, *Saissetia neglecta* De Lotto (Coccidae) and *Ferrisia williamsi* Kaydan and Gullan (Pseudococcidae). Twenty-two scale insect species are new records on avocado for Colombia of which nine species are new records worldwide, namely, *Lindingaspis rossi* (Maskell), *Pseudischnaspis bowreyi* (Cockerell) (Diaspididae), *Pulvinaria psidii* Maskell, *Saissetia neglecta* De Lotto (Coccidae), *Ferrisia kondoi* Kaydan and Gullan, *Pseudococcus jackbeardsleyi* Gimpel and Miller, *Ps. landoi* (Balachowsky) (Pseudococcidae), *Eurhizococcus colombianus* Jakubski (Margarodidae) and *Austrotachardiella colombiana* Kondo and Gullan (Kerriidae).

**Key words.** Coccidae, Diaspididae, Kerriidae, Margarodidae, Monophlebidae, Pseudococcidae, Putoidae.

**Resumen.** Se realizó un muestreo de insectos escama (Hemiptera: Coccoidea) del aguacate en el Departamento del Valle del Cauca, Colombia, entre el periodo octubre 2008–octubre 2009. En total se colectaron 34 especies de insectos escama distribuidos en siete familias (i.e., Coccidae, Diaspididae, Kerriidae, Margarodidae, Monophlebidae, Pseudococcidae y Putoidae). Los resultados de este estudio, junto con registros bibliográficos, el número de insectos escama colectados sobre el aguacate en Colombia, elevan a 44 especies de estos insectos en el país y a 137 a nivel mundial. Las especies comunmente colectadas sobre el aguacate en el Valle del Cauca, Colombia, incluyen: *Hemiberlesia cyanophylli* (Signoret), *Pseudoparlatoria parlatorioides* (Comstock) (Diaspididae), *Ceroplastes rubens* Maskell, *Coccus hesperidum* L., *Protopulvinaria pyriformis* (Cockerell), *Pulvinaria psidii* Maskell, *Saissetia neglecta* De Lotto (Coccidae) y *Ferrisia williamsi* Kaydan y Gullan (Pseudococcidae). Como nuevos registros de insectos escama del aguacate se listan 22 especies para Colombia y nueve especies a nivel mundial, i.e., *Lindingaspis rossi* (Maskell), *Pseudischnaspis bowreyi* (Cockerell) (Diaspididae), *Pulvinaria psidii* Maskell, *Saissetia neglecta* De Lotto (Coccidae), *Ferrisia kondoi* Kaydan y Gullan, *Pseudococcus jackbeardsleyi* Gimpel y Miller, *Ps. landoi* (Balachowsky) (Pseudococcidae), *Eurhizococcus colombianus* Jakubski (Margarodidae) y *Austrotachardiella colombiana* Kondo y Gullan (Kerriidae).

**Palabras clave.** Coccidae, Diaspididae, Kerriidae, Margarodidae, Monophlebidae, Pseudococcidae, Putoidae.

### Introduction

Scale insects are sap-sucking hemipterous insects that include all members of the superfamily Coccoidea (Hemiptera) (Kondo et al. 2008a). They occur in all zoogeographical regions of the world. Scale insects are closely related to aphids (Aphidoidea), whiteflies (Aleyrodoidea) and psyllids (Psylloidea), and together constitute the suborder Sternorrhyncha (Gullan and Martin 2003). These insects are usually less than 5 mm in length and their taxonomy is based primarily on the morphological charac-

teristics of the cuticle of the adult female. The adult female is paedomorphic, maturing sexually in a juvenile form, while the adult male (when present), after passing through a prepupal and pupal stage, becomes a winged insect (sometimes with reduced wings) with non-functional mouthparts (Kondo et al. 2008a). There are about 32 families of scale insects; the most common families are those with the most species, namely the Diaspididae, Coccidae and Pseudococcidae, in order of number of described species (Ben-Dov et al. 2015). Although there are some species of scale insects that are beneficial to humans, many are considered agricultural pests. Scale insects can weaken or kill plants by sucking their sap, injecting toxins or transmitting viruses, by excreting honeydew, which serves as a medium for sooty mold (Williams and Granara de Willink 1992; Gullan and Martin 2003). All these types of scale insect damages can be observed in the avocado tree with the exception of virus transmission (T. Kondo, personal observation). Scale insects can cause cosmetic damage when they are on the fruit, or when the sooty mold that grows on the honeydew they produce affects the fruit.

Colombia ranks as the fourth largest avocado producer, after Mexico, Indonesia and the United States in their respective order, with 160,671.43 metric tons (MT)/year (1993–2013) (FAOSTATS 2015). However, there have been few studies on the arthropod fauna associated with fruit crops in Colombia. In 1989, Lázaro Posada-Ochoa of the Colombian Agricultural Institute, ICA, published a technical bulletin entitled: “Lista de insectos dañinos y otras plagas en Colombia” [List of injurious insects and other pests in Colombia] (Posada-Ochoa 1989) in which he recorded 74 species of insects and mites associated with avocado, *Persea americana* Mill. (as *P. gratissima*) (Lauraceae) in Colombia. The list by Posada-Ochoa (1989) included 21 species of scale insects belonging to three families, roughly 30% of the arthropods recorded on avocados in Colombia. In the last decade, three new species of scale insects have been added to the list of scale insects recorded on avocados in Colombia, namely the soft scales *Akermes colombiensis* Kondo and Williams (2004), *Bombacoccus aguacatae* Kondo (2010) (Coccidae) and the giant scale *Laurencella colombiana* Foldi and Watson (2001) (Monophlebidae). More recently, Kondo et al. (2011) gave a list of 13 common scale insects in three families from the State of Valle del Cauca and neighboring departments, an area commonly known as the coffee-growing region of Colombia.

The present study aimed at further understanding the diversity of scale insects (Hemiptera: Coccoidea) present on avocado crops in Colombia. This study should also provide a scientific base for conducting “risk analyses” when accessing international markets for future avocado exports from Colombia to markets abroad, and will help to establish prevention programs and more effective management strategies for avocado insect pests, thus reducing the negative impact of indiscriminate use of insecticides in avocado crops in this country.

Some information included here was previously published in Spanish in the Proceedings of the III Latin American Congress of Avocado (Kondo and Muñoz 2009), however, that was not a peer-reviewed publication. In addition, we have added new information, i.e., identified more taxa to species level and included collecting data and notes on collected species.

## Materials and methods

The study was conducted over a period of 12 months (between October 2008 and October 2009). Scale insects were collected in avocado orchards in the municipalities of La Ceja, Rio Negro, Támesis, Venecia (Antioquia), Anserma, Chinchiná, Palestina, Villamaría (Caldas), Belén de Umbria (Risaralda), Quimbaya (Quindío), Alcalá, Caicedonia, Palmira, Ulloa (Valle del Cauca) in Colombia. Avocado cultivars, namely, ‘Booth’, ‘Booth 7’, ‘Booth 8’, ‘Choquette’, ‘Hass’, ‘Lorena’, ‘Trinidad’, ‘Santa Ana’, ‘Reed’ and another undetermined cultivar were studied. The scale insects were collected on different parts of the plants such as branches, roots, tree trunk, twigs, flowers and fruits. Collecting was carried out about once every two weeks for the duration of the study. Samples consisted of 50 cm long twigs collected per tree from the lower third of the tree and included leaves, and sometimes inflorescences. The samples were kept wrapped in newspaper, with the collecting data written with a magic marker directly on the paper. Scale insects were also collected by inspecting the fruits, tree trunk, large branches and the root system *in situ* and were stored in vials with 70% alcohol with their corresponding collecting data. Scale insects found on the tree trunks and roots were collected carefully using a knife to cut the bark around the insects without damaging their cuticle.

In the laboratory, the plant samples infested with the scale insects were spread on newspaper to dry them by ventilation and prevent damage by fungal contamination. The scale insect specimens were later either put into alcohol with their corresponding data label or were slide-mounted following the method of Williams and Granara de Willink (1992). The scale insects were identified to the species level when possible using taxonomic keys according to their taxonomic group. For the identification of genera and species of the family Diaspididae, the keys by Evans et al. (2009), Ferris (1937), Gill (1997), Miller and Davidson (2005) and Williams and Watson (1988a) were used. For the family Pseudococcidae, the keys by Williams and Granara de Willink (1992), Williams and Watson (1988b), Kaydan and Gullan (2012) [for the genus *Ferrisia*]; for the family Coccidae, the keys by Hamon and Williams (1984), Hodgson (1994), Williams and Watson (1990), Kondo (2010) [for *Bombacoccus aguacatae*] and Mosquera (1979, 1984) [for *Ceroplastes*] were used. Other additional keys used in this study are those of Kondo and Gullan (2005) for species of Kerriidae and Williams and Granara de Willink (1992) for Putoidae species.

**Species list.** An updated list of scale insects on avocado worldwide was compiled based on data obtained from the scale insect database ScaleNet (Ben-Dov et al. 2015). The checklist of scale insects on avocados in Colombia is based mainly on the checklist given by Posada-Ochoa (1989), other studies (e.g., Ben-Dov et al. 2015; Kondo 2010; Kondo and Williams 2004, Kondo et al. 2011) and species identified in the present study (Table 1). The checklist of scale insects recorded on avocado in Chile was adapted from Renato and Larral (2008); Mexico from APHIS (2004), Evans et al. (2009) and Peña and Wysoki (2008); Peru from Renato and Larral (2008), USDA and APHIS (2006); U.S.A. (California and Florida) from APHIS (2004) and Dekle (1976) (Table 1). Valid names were checked against ScaleNet (Ben-Dov et al. 2015). *Persea gratissima* is considered a junior synonym of *P. americana* (Tropicos 2015), thus our search results in ScaleNet (Ben-Dov et al. 2015) include species recorded on both *P. americana* and *P. gratissima*.

### Abbreviations of insect repositories

**MECP:** Museo de Entomología, Corporación Colombiana de Investigación Agropecuaria, Centro de Investigación Palmira, Palmira, Valle del Cauca, Colombia.

**UVCO:** Museo de Entomología, Universidad del Valle, Cali, Valle del Cauca, Colombia.

## Results

### Family Diaspididae

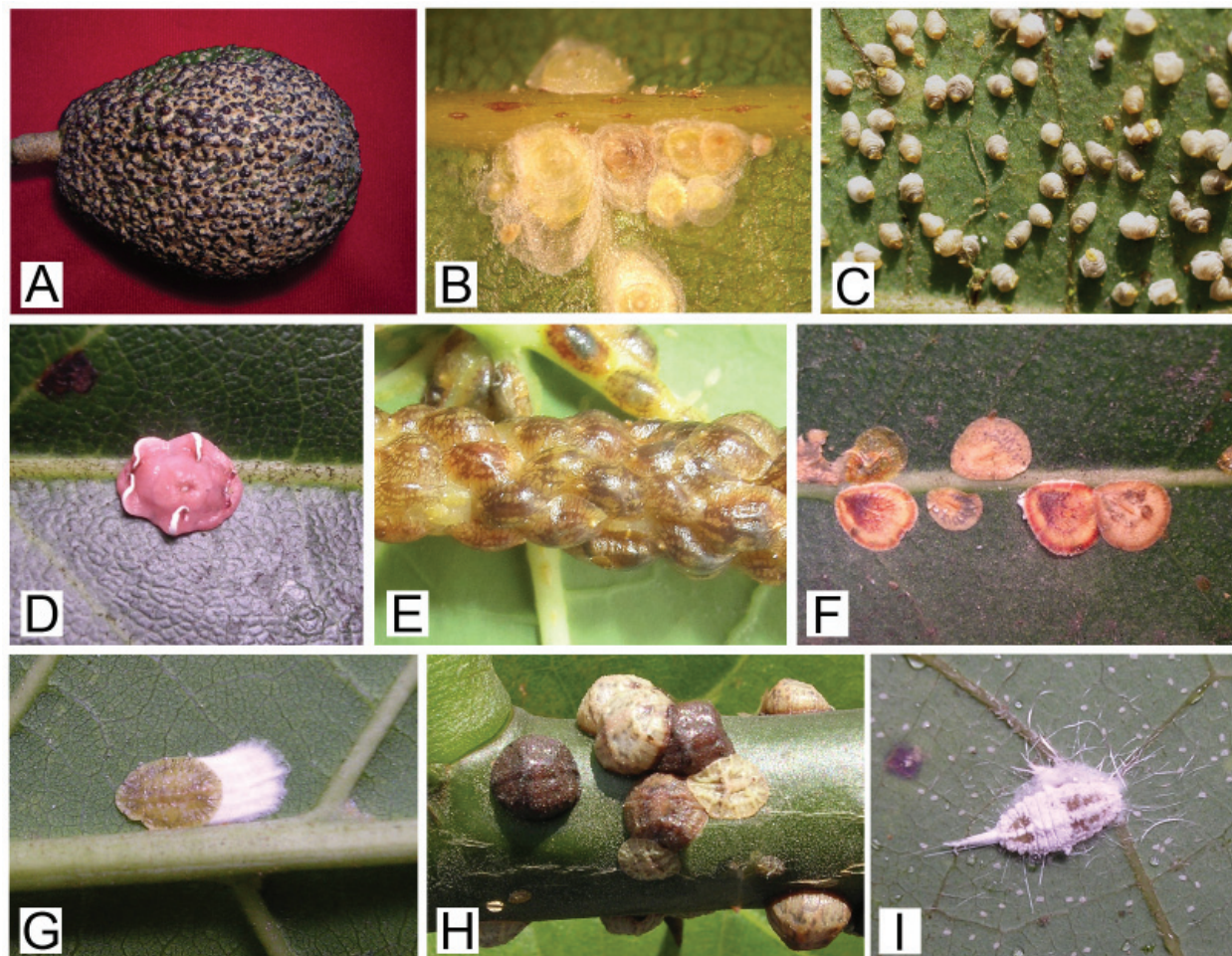
#### *Acutaspis perseae* (Comstock)

**Material studied.** **Colombia. Valle del Cauca: Alcalá:** Finca Los Alpes, 04°42'24.8"N, 75°49'01.0"W, 1194 m, 02.xii.2008, coll. J. Muñoz, *ex Persea americana* cv. not determined, 2 (UVCO), 1 (MECP); Finca Villa del Sol, 04°42'06.1"N, 75°45'00.5"W, 1215 m, 02.xii.2008, coll. J. Muñoz, *ex avocado* cv. 'Booth 8', 1 (MECP); **El Cerrito:** Finca Alvecia, 03°38'51.1"N, 76°06'14.7"W, 1925 m, 19.xii.2008, coll. J. Muñoz, *ex avocado* cv. 'Booth 8', 1 (MECP); Same data except *ex avocado* cv. 'Booth, 1' (UVCO); **Palmira:** Rozo, Finca Brasil, 03°36'36.0"N, 76°25'08.5"W, 967 m, 19.xii.2008, coll. J. Muñoz, *ex avocado* cv. 'Booth 8', 1 (MECP); Same data, except, *ex avocado* cv. 'Booth', 1 (UVCO), 1 (MECP).

**Distribution.** **Nearctic:** Mexico, USA. **Neotropical:** Brazil, Cuba, Trinidad and Tobago (Trinidad), Venezuela. **Palaeartic:** Ukraine, United Kingdom (England) (Ben-Dov et al. 2015).

**Remarks.** This species was found on the underside of leaves of 'Booth 8', 'Lorena' and an undetermined native cultivar. This is the first record of this species from Colombia.





**Figure 1.** Common scale insects on avocado trees. Diaspididae: **A.** *Hemiberlesia cyanophylli* (Signoret) on fruit of 'Hass' cultivar; **B.** *H. cyanophylli* on leaf; **C.** *Pseudoparlatoria parlatorioides* (Comstock) on leaf of 'Lorena' cultivar; Coccidae: **D.** *Ceroplastes rubens* Maskell on leaf of 'Lorena' cultivar; **E.** *Coccus hesperidum* L. on leaf of guava; **F.** *Protopulvinaria pyriformis* (Cockerell) on leaf of 'Lorena' cultivar; **G.** *Pulvinaria psidii* Maskell on leaf of 'Lorena' cultivar; **H.** *Saissetia neglecta* De Lotto on *Erythrina* sp.; Pseudococcidae: **I.** *Ferrisia williamsi* Kaydan and Gullan on leaf of 'Lorena' cultivar. Photos by T. Kondo.

### *Aspidiotus destructor* Signoret

**Material studied.** Colombia. Valle del Cauca: El Cerrito: Finca La Alvecia, 03°38'51.1"N, 76°06'14.7"W, 1925 m, 19.xii.2008, coll. A. Arias, *ex* avocado cv. 'Papelillo' ('Lorena'), 2 UVCO, 2 (MECP); **Toro:** Finca Toluca, 04°40'24.9"N, 76°02'43.0"W, 932 m, 19.xii.2008, coll. A. Arias, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (UVCO).

**Distribution.** Cosmopolitan (Ben-Dov et al. 2015).

**Remarks.** This species was collected on the underside of leaves of the 'Lorena cultivar'. Known as the coconut scale, this species attacks many crops in tropical and subtropical regions. It has been recorded on 76 genera and 46 plant families (Borchsenius 1966). *Aspidiotus destructor* is commonly found on coconut palm, but is often found on other palms, fruit trees and ornamental plants (Miller Davidson and 2005).

### *Aulacaspis tubercularis* Newstead

**Material studied.** Colombia. Antioquia: Amagá: found on fruits sold at the "III Congreso Latinoamericano del Aguacate" held in Medellín, 12.xi.2009, coll. T. Kondo, *ex* avocado cv. 'Hass', 4 (MECP).

**Distribution.** Cosmopolitan (Ben-Dov et al. 2015).

**Remarks.** It is not a common species on avocado in Colombia. *Aulacaspis tubercularis* has been previously recorded on avocados (including *Persea* sp.) from Brazil and Mexico (Evans et al. 2009; Miller and Davidson 2005). See also comments for *Hemiberlesia cyanophylli*.

***Chrysomphalus dictyospermi* (Morgan)**

**Material studied.** **Colombia. Valle del Cauca: Alcalá:** Finca La Polonia, 04°40'09.8"N, 75°45'14.1"W, 1369 m, 31.x.2008, coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (UVCO), 1 (MECP); Finca La Porra, 04°40'13.1"N, 75°44'34.3"W, 1395 m, 10.xi.2008, coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 2 (UVCO), 2 (MECP); Finca Los Alpes, 04°42'24.8"N, 75°49'01.0"W, 1194 m, 02.xii.2008, coll. J. Muñoz, *ex* avocado cv. 'Booth', 1 (UVCO), 2 (MECP); Finca Los Alpes, 04°17'56.0"N, 75°53'00.0"W, 1376 m, 28.x.2008, coll. J. Muñoz, *ex* avocado cv. not determined, 2 (MECP); **Caicedonia:** Finca El Palmar, 04°17'56.0"N, 75°53'00.0"W, 1376 m, 28.x.2008, coll. J. Muñoz, *ex* avocado cv. 'Booth 7', 1 (UVCO), 2 (MECP); Same data except, *ex* avocado cv. 'Booth 8', 2 (MECP); Same data except, 4.xi.2008, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (MECP); Same data except 28.x.2008, coll. A. Arias, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (UVCO); Finca Las Margaritas, 04°17'37.1"N, 75°53'18.0"W, 1352 m, 26.v.2009, coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 2 (UVCO), 3 (MECP); Finca El Chaquiro, 04°17'00.0"N, 75°51'24.7"W, 1651 m, 02.iii.2009, coll. J. Muñoz, *ex* avocado cv. 'Booth 8', 2 (UVCO), 4 (MECP); Same data except *ex* avocado cv. 'Hass', 1 (UVCO); **El Cerrito:** Finca La Alvecia, 03°38'51.1"N, 76°06'14.7"W, 1925 m, 19.xii.2008, coll. A. Arias, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (UVCO), 2 (MECP).

**Distribution.** Cosmopolitan (Ben-Dov et al. 2015).

**Remarks.** *Chrysomphalus dictyospermi* was found on the twigs of the following cultivars: 'Booth 7', 'Booth 8', 'Hass', 'Lorena', and an undetermined cultivar. This species is a serious pest of citrus, avocados and many tropical and subtropical plants (Miller and Davidson 2005).

***Hemiberlesia cyanophylli* (Signoret) (Fig. 1A, B)**

**Material studied.** **Colombia. Caldas: Belalcazar:** Peñitas, 1400 m, coll. A. Ramos, *ex* avocado cv. 'Hass', 1 (MECP). **Valle del Cauca: Alcalá:** Finca La Esmeralda, 04°39'58.4"N, 75°48'27.4"W, 1223 m, 16.ii.2009, coll. J. Muñoz, *ex* avocado 'Papelillo' ('Lorena'), 1 (UVCO); Finca La Porra, 04°40'13.1"N, 75°44'34.3"W, 1395 m, 10.xi.2008, coll. J. Muñoz, *ex* avocado 'Booth 8', 2 (UVCO); 2 (MECP); Same data except coll. A. Arias, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (UVCO); Finca Los Alpes, 04°42'24.8"N, 75°49'01.0"W, 1194 m, 02.xii.2008, coll. J. Muñoz, *ex* avocado cv. 'Booth 8', 1 (UVCO), 3 (MECP); Same data except 28.x.2008, *ex* avocado cv. 'Booth', 1 (UVCO); Same data except 28.x.2008, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (UVCO); Same data, except no coordinates nor elevation given, 9.xii.2008, coll. J. Muñoz, *ex* avocado cultivar not determined, 1 (MECP); Finca Villa del Sol, 04°42'06.1"N, 75°50'00.5"W, 1215 m, 02.xii.2008, coll. A. Arias, *ex* avocado cultivar 'Papelillo' ('Lorena'), 2 (UVCO), 2 (MECP); **Caicedonia:** Finca El Chaquiro, 04°17'00.0"N, 75°51'24.7"W, 1651 m, 02.iii.2009, coll. J. Muñoz, *ex* avocado cv. 'Hass', 2 (UVCO), 2 (MECP); Finca Corinto, 04°17'04.2"N, 75°51'53.9"W, 1650 m, 20.iv.2009, coll. J. Muñoz, *ex* avocado cv. 'Trinidad', 1 (UVCO), 1 (MECP); Same data except *ex* avocado cv. 'Booth', 1 (UVCO); Finca El Palmar, 04°17'56"N, 75°53'00"W, 1376 m, 28.x.2008, coll. J. Muñoz, *ex* avocado cv. 'Booth 8', 1 (UVCO), 2 (MECP); Same data except, coll. A. Arias, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (MECP); Same data except coll. T. Kondo, *ex* avocado cv. 'Booth', 1 (UVCO); Finca La Cabaña, 04°17'43.8"N, 75°50'39.4"W, 1705 m, 9.ii.2009, coll. J. Muñoz, *ex* avocado cv. 'Booth', 1 (UVCO), 2 (MECP); Same data, coll. A. Arias, *ex* avocado cv. 'Papelillo' ('Lorena'), 2 (MECP); Finca Linares, 04°17'53.2"N, 75°51'50.9"W, 1490 m, 2.iii.2009, coll. A. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (UVCO); **El Cerrito:** Finca La Alvecia, 03°38'51.1"N, 76°06'14.7"W, 1925 m, 19.xii.2008, coll. A. Arias, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (UVCO), 2 (MECP); **Palmira:** Roza, Finca Brasil, 03°36'36.0"N, 76°25'08.5"W, 967 m, 10.xii.2008, coll. J. Muñoz, *ex* avocado cv. 'Papelillo', 2 (UVCO), 1 (MECP); Same data except, 03°38'51.1"N, 76°06'14.7"W, 1925 m, 19.xii.2008, coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (MECP); **Ulloa:** Finca La Catalina, 04°41'38.8"N, 75°45'10.4"W, 1301 m, 4.v.2009, coll. J. Muñoz, *ex* avocado cv. 'Santana', 1 (UVCO), 1 (MECP).

**Distribution.** Cosmopolitan (Ben-Dov et al. 2015).

**Remarks.** The species was found on the underside of avocado leaves on the following cultivars: 'Booth 8', 'Choquette', 'Hass', 'Lorena' and an undetermined cultivar. The Cyanophyllum scale, *H. cyanophylli*



is highly polyphagous and has been recorded on 75 genera in 18 plant families (Borchsenius 1966). *Hemiberlesia cyanophylli*, *A. tubercularis* and *C. dictyospermi* are frequently found on the fruit of 'Hass' avocado, although their damage appears to be only cosmetic. It should be noted that we did not find any other diaspidid species on fruits of other avocado cultivars. This could be due to the rugose texture of the fruit of 'Hass' avocados, which provides a perfect place for feeding and settling. These three diaspidid species are here considered of quarantine importance because they can be found on fruit.

### ***Hemiberlesia lataniae* (Signoret)**

**Material studied.** Colombia. Valle del Cauca: Alcalá: Finca Los Alpes, 04°42'24.8"N, 75°49'01.0"W, 1194 m, 02.xii.2008, coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 2 (UVCO); Same data except 04°17'56.0"N, 75°53'00.0"W, 1376 m, 28.x.2008, coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 2 (UVCO); **Caicedonia:** Finca El Palmar, 04°17'56"N, 75°53'00"W, 1376 m, 31.x.2008, coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 3 (UVCO), 1 (MECP); Finca La Cabaña, 04°17'43.8"N, 75°50'39.4"W, 1705 m, 9.ii.2009, coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (UVCO), 1 (MECP).

**Distribution.** Cosmopolitan (Ben-Dov et al. 2015).

**Remarks.** The latania scale, *H. lataniae* is a highly polyphagous cosmopolitan species. It has been recorded on 278 genera in 78 plant families (Borchsenius 1966). In the present study we found this species only on twigs of the 'Lorena' cultivar.

### ***Hemiberlesia palmae* (Cockerell)**

**Material studied.** Colombia. Valle del Cauca: Alcalá: Finca Los Alpes, 04°42'24.8"N, 75°49'01.0"W, 1194 m, 02.xii.2008, *ex* avocado cv. 'Lorena', coll. J. Muñoz, 1 (UVCO); Same data except 04°17'56"N, 75°53'00"W, 1376 m, 28.x.2008, coll. J. Muñoz, *ex* avocado cv. 'Booth', 1 (UVCO); Same data except, coordinates and altitude not given, 9.xii.2008, *ex* avocado 'Booth' 8, 1 (UVCO); **Caicedonia:** Finca El Palmar, 04°17'56"N, 75°53'00"W, 1376 m, 28.x.2008, coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (UVCO), 2 (MECP); Same data, except 4.xi.2008, 1 (MECP); **El Cerrito:** Finca La Alvecia, 03°38'51.1"N, 76°06'14.7"W, 1925 m, 19.xii.2008, coll. A. Arias, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (MECP).

**Distribution.** Cosmopolitan (Ben-Dov et al. 2015).

**Remarks.** We found *H. palmae* on the twigs of 'Lorena' and 'Booth 8' cultivars. Originally described from Jamaica and reported from many tropical countries on numerous host plants (Williams and Watson 1988a). This diaspidid species has been considered a pest of oil palm and banana in Malaysia where it can be found in large numbers on the leaves of these plants (Borchsenius 1966).

### ***Hemiberlesia rapax* (Comstock)**

**Material studied.** Colombia. Valle del Cauca: **Caicedonia:** Finca El Palmar, 04°17'56"N, 75°53'00"W, 1376 m, 28.x.2008, coll. J. Muñoz, *ex* avocado cv. 'Booth 8', 1 (MECP); Same data except 31.x.2008, 1 (UVCO).

**Distribution.** Cosmopolitan (Ben-Dov et al. 2015).

**Remarks.** *Hemiberlesia rapax* was found on the leaves of the 'Booth 8' cultivar. This species has been recorded on 117 species in 60 plant families (Borchsenius 1966) and is considered one of the 43 most damaging diaspidid species to agriculture (Beardsley and González 1975).

### ***Howardia biclavis* (Comstock)**

**Material studied.** Colombia: Valle del Cauca: **Caicedonia:** Finca El Palmar, 04°17'56.0"N, 75°53'00.0"W, 1376 m, 28.x.2008, coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (MECP); Same data except, 31.x.2008, 2 (UVCO), 1 (MECP).

**Distribution.** This species occurs in tropical areas around the world (Miller and Davidson 2005).

**Remarks.** In the present study, *H. biclavis* was found on twigs of the 'Lorena' cultivar. The mining scale, *H. biclavis* is highly polyphagous and has been recorded on 41 plant families (Borchsenius 1966).

### ***Lindingaspis rossi* (Maskell)**

**Material studied.** Colombia. Valle del Cauca: Alcalá: Finca Santacruz, 04°39'47.1"N, 75°48'20.7"W, 1223 m, 27.iv.2009, coll. T. Kondo, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (UVCO), 1 (MECP); **Caicedonia:** Finca La Cabaña, 04°17'43.8"N, 75°50'39.4"W, 1705 m, 09.ii.2009, coll. J. Muñoz, *ex* avocado cv.

‘Papelillo’ (‘Lorena’), 1 (UVCO), 1 (MECP); **Palmira:** Rozo, Finca Brasil, 03°36’36.0”N, 76°25’08.5”W, 967 m, 10.xii.2008, coll. A. Arias, J. Muñoz, *ex* avocado cv. ‘Papelillo’ (‘Lorena’), 1 (UVCO), 1 (MECP); Same data except 03°38’51.1”N, 76°06’14.7”W, 1925 m, 19.xii.2008, coll. J. Muñoz, 2 (UVCO), 1 (MECP). **Distribution.** **Afrotropical:** Angola, Cameroon, Guinea, Mauritius, Mozambique, Reunion, Sierra Leone, South Africa, Tanzania, Togo, Zimbabwe. **Australasian:** Australia, Hawaii, New Caledonia, New Zealand, Norfolk Island, Western Samoa. **Nearctic:** Mexico, USA. **Neotropical:** Argentina, Brazil, Chile, Peru. **Oriental:** India, Philippines, Sri Lanka, Taiwan. **Palearctic:** Azores, China, Egypt, Japan, Madeira Islands, Portugal, Sicily, Spain (Ben-Dov et al. 2015). The araucaria black scale, *L. rossi* was originally described on araucaria in Australia, but since then it has been recorded from many tropical countries and temperate regions (Williams and Watson 1988a).

**Remarks.** *Lindingaspis rossi* was found on the underside of leaves of the ‘Lorena’ variety. This species has been recorded on a wide range of plants, often causing chlorosis and in some cases defoliation (Williams and Watson 1988a). This is the first record of *L. rossi* from Colombia.

### *Mycetaspis personata* (Comstock)

**Material studied.** **Colombia. Valle del Cauca: Palmira:** Rozo, Finca Brasil, 03°36’36.0”N, 76°25’08.5”W, 967 m, 10.xii.2008, coll. A. Arias, J. Muñoz, *ex* avocado cv. ‘Papelillo’ (‘Lorena’), 1 (UVCO), 1 (MECP); Same data except 19.xii.2008, coll. J. Muñoz, *ex* avocado cv. ‘Papelillo’ (‘Lorena’), 2 (UVCO). **Distribution.** Cosmopolitan (Ben-Dov et al. 2015).

**Remarks.** We found *M. personata* on the upper surface of avocado leaves of the ‘Lorena’ cultivar. This species is very small, only measuring about 1 mm in diameter (Evans et al. 2009). The species is fairly polyphagous and has been recorded on 17 plant families (Ben-Dov et al. 2015). In Colombia, *M. personata* is commonly found on the leaves of mango and *Ficus* spp., but in small numbers and it is not considered of economic importance in Colombia (T. Kondo, personal observation).

### *Pseudaonidia trilobitiformis* (Green)

**Material studied.** **Colombia. Valle del Cauca: Alcalá:** Finca La Porra, 04°40’13.1”N, 75°44’34.3”W, 1395 m, 10.xii.2008, coll. J. Muñoz, *ex* avocado cv. ‘Booth’, 1 (UVCO), 1 (MECP).

**Distribution.** Cosmopolitan (Ben-Dov et al. 2015). Its origin is probably southern Asia where it is common, but it has spread onto Africa, the Malagasian area and tropical America (Williams and Watson 1988a).

**Remarks.** We found *P. trilobitiformis* on the underside of the main vein of the leaf of the ‘Booth’ cultivar. It has been found in great numbers on plants; however, they seem to cause little damage (Williams and Watson 1988a).

### *Pseudoparlatoria parlatorioides* (Comstock) (Fig. 1C)

**Material studied.** **Colombia. Valle del Cauca: Alcalá:** Finca Campoalegre, 04°38’26.6”N, 75°47’27.1”W, 1257 m, 23.ii.2009, coll. A. Arias, *ex* avocado cv. ‘Booth’, 1 (UVCO), 3 (MECP); Finca La Esmeralda, 04°39’58.4”N, 75°48’27.4”W, 1223 m, 16.ii.2009, coll. J. Muñoz, *ex* avocado cv. ‘Papelillo’ (‘Lorena’), 2 (UVCO); Finca La Giralda, 04°17’44.2”N, 75°50’32.8”W, 1717 m, 09.ii.2009, coll. A. Arias, *ex* avocado cv. ‘Papelillo’ (‘Lorena’), 1 (UVCO), 3 (MECP); Finca Santacruz, 04°39’47.1”N, 75°48’20.7”W, 1223 m, 27.iv.2009, coll. T. Kondo, *ex* avocado cv. ‘Papelillo’ (‘Lorena’), 1 (UVCO), 3 (MECP); Finca La Porra, 04°40’13.1”N, 75°44’34.3”W, 1395 m, 10.xi.2009, coll. J. Muñoz, *ex* avocado cv. ‘Papelillo’ (‘Lorena’), 1 (UVCO), 7 (MECP); Finca El Edén, 04°39’38.4”N, 75°44’33.1”W, 1421 m, 31.x.2008, coll. T. Kondo, *ex* avocado cv. ‘Trinidad’, 2 (UVCO), 2 (MECP); Finca Los Alpes, 04°42’24.8”N, 75°49’01.0”W, 1194 m, 02.xii.2008, coll. A. Arias, J. Muñoz, *ex* avocado cultivar not determined, 2 (MECP); Finca Villa del Sol, 04°42’06.1”N, 75°50’00.5”W, 1215 m, 02.xii.2008, coll. A. Arias, J. Muñoz, *ex* avocado cultivar not determined, 2 (MECP); **Caicedonia:** Finca El Palmar, 04°17’56.0”N, 75°53’00.0”W, 1376 m, 28.x.2008, Coll. J. Muñoz, *ex* avocado cv. ‘Booth 8’, 1 (UVCO), 3 (MECP); Finca El Jardín, 04°18’18.4”N, 75°51’00.0”W, 1622 m, 16.ii.2009, coll. J. Muñoz, *ex* avocado cultivar not determined, 3 (MECP); Finca Linares, 04°17’53.2”N, 75°51’50.9”W, 1490 m, 02.iii.2009, coll. A. Arias, *ex* avocado cv. ‘Papelillo’ (‘Lorena’), 1 (UVCO), 3 (MECP); Finca Corinto, 04°17’04.2”N, 75°51’53.9”W, 1650 m, 20.iv.2009, coll. A. Arias, T. Kondo, J. Muñoz, *ex* avocado cultivar not determined, 2 (MECP); Finca Las Margaritas, 04°17’37.1”N, 75°53’18.0”W, 1352 m, 26.v.2009, coll. T. Kondo, *ex* avocado cv. ‘Trinidad’, 3 (MECP); **Cali:** Portada:

03°27'16.1"N, 76°33'06.5"W, 1068 m, 31.xii.2008, coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 5 (MECP); **El Cerrito:** Finca La Alvecia, 03°38'51.1"N, 76°06'14.7"W, 1925 m, 19.xii.2008, coll. A. Arias, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (UVCO), 3 (MECP); **Palmira:** Roza, Finca Brasil, 03°36'36.0"N, 76°25'08.5"W, 967 m, 10.xii.2008, coll. A. Arias, J. Muñoz, *ex* avocado cultivar not determined, 2 (MECP); **Ulloa:** Finca La Catalina, 04°41'38.8"N, 75°45'10.4"W, 1301 m, 04.v.2009, coll. A. Arias, *ex* avocado cv. 'Choquette', 1 (UVCO); Same data except, *ex* avocado cv. 'Santana', 2 (MECP).

**Distribution.** **Afrotropical:** Tanzania. **Australasian:** Hawaiian Islands (Oahu), New Zealand (North Island). **Nearctic:** Mexico, USA. **Neotropical:** Argentina, Bahamas, Bermuda, Brazil, Colombia, Cuba, Ecuador, Guatemala, Honduras, Jamaica, Panama, Puerto Rico, U.S. Virgin Islands. **Oriental:** India, Sri Lanka. **Palaeartic:** Belgium (in greenhouses.), Czechoslovakia, France, Germany, Italy, Madeira Islands, Netherlands, Spain, Sweden, United Kingdom (England) (Ben-Dov et al. 2015).

**Remarks.** *Pseudoparlatoria parlatorioides* commonly known as the false parlatoria scale is probably native to tropical America (Miller and Davidson 2008). We found it at different altitudes ranging between 967 to 1925 m, on avocados of the following cultivars: 'Booth 8', 'Choquette', 'Santana' and 'Trinidad'. This species is found on the underside of the leaves and live crowded in large groups up to 600 individuals per leaf, and in this situation it causes chlorosis symptoms (J. Muñoz, personal observation).

### *Pseudischnaspis acephala* Ferris

**Material studied.** **Colombia. Valle del Cauca: Palmira:** Roza, Finca Brasil, 03°36'36.0"N, 76°25'08.5"W, 967 m, 10.xii.2008, coll. J. Muñoz, *ex* avocado cv. 'Lorena', 1 (UVCO); same data except *ex* avocado cv. 'Trinidad', 1 (MECP); Same data except 19.xii.2008, coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (UVCO).

**Distribution.** **Nearctic:** Mexico. **Neotropical:** Colombia, El Salvador, Guatemala, Nicaragua, Panama, Peru (Ben-Dov et al. 2015).

**Remarks.** We found the species near the main veins on the upper leaf surface of leaves of the 'Lorena' and 'Trinidad' cultivars.

### *Pseudischnaspis bowreyi* (Cockerell)

**Material studied.** **Colombia. Valle del Cauca: Alcalá:** Finca La Esmeralda, 04°39'58.4"N, 75°48'27.4"W, 1223 m, 16.ii.2009, coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (UVCO); Caicedonia, Finca La Cabaña, 04°17'43.8"N, 75°50'39.4"W, 1705 m, 09.ii.2009, coll. J. Muñoz, *ex* avocado cv. 'Trinidad', 1 (UVCO).

**Distribution.** **Nearctic:** Mexico, USA. **Neotropical:** Argentina, Barbados, Belize, Bermuda, Bolivia, Brazil, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Peru, Puerto Rico, Trinidad, U.S. Virgin Islands, Venezuela (Ben-Dov et al. 2015).

**Remarks.** The species was found on the upper surface of leaves of the 'Lorena' and 'Trinidad' cultivars. It is similar to *P. acephala* but it has a broader pygidium and a less pointed apex (Evans et al. 2009).

### *Selenaspidus articulatus* (Morgan)

**Material studied.** **Colombia. Valle del Cauca: Alcalá:** Finca La Pastora, 04°39'41.6"N, 75°47'46.6"W, 1240 m, 27.iv.2009, coll. J. Muñoz, 4 (UVCO), 3 (MECP); **Ulloa:** Finca La Catalina, 04°41'38.8"N, 75°45'10.4"W, 1301 m, 16.ii.2009, coll. J. Muñoz, *ex* avocado cv. 'Santana', 1 (UVCO), 1 (MECP).

**Distribution.** Cosmopolitan (Ben-Dov et al. 2015).

**Remarks.** *Selenaspidus articulatus* is a tropicopolitan species (Williams and Watson 1988a). This species was found on the upper surface of leaves of the 'Lorena' and 'Santana' cultivars.

## Family Coccidae

### *Bombacoccus aguacatae* Kondo

**Material studied.** **Colombia. Valle del Cauca: Alcalá:** Finca La Porra, 04°40'13.1"N, 75°44'34.3"W, 1395 m, 10.xi.2008, coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (UVCO), 1 (MECP); **Caicedonia:** Finca El Jardín, 04°18'18.4"N, 75°51'00.0"W, 1622 m, 16.ii.2009, coll. T. Kondo, *ex* avocado cv.

'Papelillo' ('Lorena'), 1 (UVCO).

**Distribution.** Only known from Colombia (Kondo 2010).

**Remarks.** The Cottony avocado scale, *B. aguacatae* was originally collected in Anserma, department of Caldas, Colombia, on 'Booth 8' and 'Hass' cultivars (Kondo 2010). In the present study we additionally collected the species from the 'Lorena' cultivar in the department of Valle del Cauca. The insects have been found on tree branches and twigs of three avocado cultivars. Tiny parasitic wasps have been found emerging from the body of old females and the larvae of a species of syrphid fly (Diptera: Syrphidae) have been found feeding on the coccid nymphs (Kondo 2010). The ant *Pheidole* sp. (Hymenoptera: Formicidae) has been found tending the soft scale, and sooty moulds regularly grow on their produced honeydew covering branches, leaves and fruit (Kondo 2010).

### *Ceroplastes floridensis* Comstock

**Material studied. Colombia: Valle del Cauca: Alcalá:** Finca La Porra, 04°40'13.1"N, 75°44'34.3"W, 1395 m, 10.xi.2008, coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 2 (UVCO), 2 (MECP); Finca Los Alpes, 04°42'24.8"N, 75°49'01.0"W, 1194 m, 02.xii.2008, coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (UVCO), 2 (MECP); Finca Los Alpes, 04°17'56.0"N, 75°53'00.0"W, 1376 m, 28.x.2008, coll. A. Arias, *ex* avocado cv. 'Booth 8', 1 (UVCO); Finca Villa del Sol, 04°42'06.1"N, 75°50'00.5"W, 1215 m, 02.xii.2009, coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 2 (UVCO), 3 (MECP).

**Distribution.** Cosmopolitan (Ben-Dov et al. 2015).

**Remarks.** *Ceroplastes floridensis* was found on the upper surface of leaves of 'Booth 8' and 'Lorena' cultivars.

### *Ceroplastes rubens* Maskell (Fig. 1D)

**Material studied. Colombia. Valle del Cauca: Alcalá:** Finca La Porra, 04°40'13.1"N, 75°44'34.3"W, 1395 m, 10.xi.2008, coll. A. Arias, *ex* avocado 'Booth 8', 1 (UVCO), 3 (MECP); Same data except cv. 'Booth 7', 1 (UVCO); same data except coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (UVCO); Finca Los Alpes, 04°42'24.8"N, 75°49'01.0"W, 1194 m, 02.xii.2008, coll. A. Arias, J. Muñoz, 1 (UVCO), 3 (MECP); Finca Los Alpes, 04°17'56.0"N, 75°53'00.0"W, 1376 m, 28.x.2008, coll. A. Arias, *ex* avocado cv. 'Booth 8', 1 (UVCO); Same data, except coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (MECP); Finca Villa del Sol, 04°42'06.1"N, 75°50'00.5"W, 1215 m, 02.xii.2009, coll. A. Arias, J. Muñoz, *ex* avocado cv. 'Booth 8', 1 (UVCO), 2 (MECP); Same data, except avocado cv. 'Trinidad', 1 (UVCO), 2 (MECP); Finca La Pastora, 04°39'41.6"N, 75°47'46.6"W, 1240 m, 27.iv.2009, coll. A. Arias, T. Kondo, J. Muñoz, 2 (UVCO), 3 (MECP); Finca La Esmeralda, 04°39'58.4"N, 75°48'27.4"W, 1223 m, 02.xii.2009, coll. J. Muñoz, 1 (UVCO), 2 (MECP); **Caicedonia:** Finca Corinto, 04°17'04.2"N, 75°51'53.9"W, 1650 m, 20.iv.2009, coll. A. Arias, T. Kondo, J. Muñoz, 1 (UVCO), 2 (MECP); Finca Las Margaritas, 04°17'37.1"N, 75°53'18.0"W, 1352 m, 26.v.2009, coll. J. Muñoz, *ex* avocado cv. 'Booth', 1 (UVCO), 2 (MECP); same data except coll. avocado cv. 'Papelillo' ('Lorena'); **Palmira:** Roza, Finca Brasil, 03°36'36.0"N, 76°25'08.5"W, 967 m, 10.xii.2008, coll. A. Arias, 2 (UVCO), 3 (MECP); Same data except 19.xii.2008, coll. J. Muñoz, 1 (UVCO); **Ulloa:** Finca La Catalina, 04°41'38.8"N, 75°45'10.4"W, 1301 m, 04.v.2009, coll., T. Kondo, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (UVCO), 2 (MECP).

**Distribution. Afrotropical:** Kenya, Reunion, Seychelles, South Africa, Tanzania, Zanzibar. **Australasian:** Australia, Cook Islands, Fiji, French Polynesia (Tahiti), Guam, Hawaiian Islands (Hawaii), Indonesia (Java), Kiribati; New Caledonia, Norfolk Island, Northern Mariana Islands, Palau; Papua New Guinea, Solomon Islands, Vanuatu, Western Samoa. **Nearctic:** USA. **Neotropical:** Colombia, Guadeloupe, Haiti, Martinique, Puerto Rico. **Oriental:** China, India, Malaysia, Maldives, Philippines, Ryukyu Islands, Sri Lanka, Taiwan, Vietnam. **Palaeartic:** China, Egypt, Hungary, Japan, South Korea (Ben-Dov et al. 2015).

**Remarks.** We found the red wax scale, *C. rubens* on the upper surface of leaves of 'Booth 7', 'Booth 8', 'Choquette', 'Lorena' and 'Trinidad' cultivars. This species was recorded for the first time in Colombia on leaves of the ornamental plants *Philodendron* sp. and *Aglaonema* sp. (Araliaceae) (Kondo 2008).

### *Coccus hesperidum* L. (Fig. 1E)

**Material studied. Colombia. Valle del Cauca: Alcalá:** Finca La Porra, 04°40'13.1"N, 75°44'34.3"W, 1395 m, 10.xi.2008, coll. J. Muñoz, *ex* avocado cv. 'Booth', 1 (UVCO), Same data except, *ex* avocado



cv. 'Papelillo' ('Lorena'), 1 (MECP); 3 (MECP); Finca Los Alpes, 04°42'24.8"N, 75°49'01.0"W, 1194 m, 02.xii.2008, coll. A. Arias, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (UVCO), 2 (MECP); **Caicedonia:** Finca Corinto, 04°17'04.2"N, 75°51'53.9"W, 1650 m, 20.iv.2009, coll. A. Arias, T. Kondo, J. Muñoz, 1 (UVCO), 2 (MECP); Finca Las Margaritas, 04°17'37.1"N, 75°53'18.0"W, 1352 m, 26.v.2009, coll. A. Arias, T. Kondo, J. Muñoz, 1 (UVCO), 2 (MECP).

**Distribution.** Cosmopolitan (Ben-Dov et al. 2015).

**Remarks.** A tropicopolitan species commonly found on leaves and twigs (Hamon and Williams 1984). We found this species on the underside of leaves of 'Booth', 'Hass' and 'Lorena' cultivars.

### *Coccus longulus* (Douglas)

**Material studied.** Colombia. Valle del Cauca: **Caicedonia:** Finca Linares, 04°17'53.2"N, 75°51'50.9"W, 1490 m, 02.iii.2009, coll. J. Ramos, 1 (UVCO), 1 (MECP).

**Distribution.** **Afrotropical:** Agalega Islands, Angola, Cape Verde, Kenya, Madagascar, Mauritius, Saint Helena, Sao Tome, Senegal, Seychelles, South Africa, Uganda, Zimbabwe. **Australasian:** American Samoa, Australia, Bonin Islands, Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, Guam, Hawaiian Islands (Hawaii); Kiribati, Marshall Islands, New Caledonia, New Zealand, Northern Mariana Islands, Palau, Papua New Guinea, Solomon Islands, Tonga, Vanuatu, Western Samoa. **Nearctic:** Mexico, USA. **Neotropical:** Bermuda, Brazil, Colombia, Cuba, Ecuador, Galapagos Islands, Guadeloupe, Guatemala, Honduras, Panama, Puerto Rico, U.S. Virgin Islands. **Oriental:** Hong Kong, India, Indonesia, Philippines, Sri Lanka, Taiwan, Thailand. **Palaeartic:** Canary Islands; China, Cyprus, Egypt, France, Germany, Israel, Japan, Lebanon, Netherlands, Saudi Arabia; United Kingdom (England) (Ben-Dov et al. 2015).

**Remarks.** Of tropicopolitan distribution. *Coccus longulus* was found on the underside of the leaves of avocado alongside the secondary veins on avocado of the 'Booth' cultivar.

### *Protopulvinaria pyriformis* (Cockerell) (Fig. 1F)

**Material studied.** Colombia. Valle del Cauca: **Alcalá:** Finca El Edén, 04°39'38.4"N, 75°44'33.1"W, 1421 m, 31.x.2008, coll. T. Kondo, 2 (UVCO), 3 (MECP); Finca La Polonia, 04°40'09.8"N, 75°45'14.1"W, 1369 m, 31.x.2008, coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (MECP); Finca La Porra, 04°40'13.1"N, 75°44'34.3"W, 1395 m, 10.xii.2008, coll. A. Arias, J. Muñoz, 2 (UVCO), 2 (MECP); Finca Los Alpes, 04°42'24.8"N, 75°49'01.0"W, 1194 m, 02.xii.2008, coll. A. Arias, J. Muñoz, 2 (UVCO), 3 (MECP); Finca Villa del Sol, 04°42'06.1"N, 75°50'00.5"W, 1215 m, 02.xii.2008, coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (MECP). **Caicedonia:** Finca El Palmar, 04°17'55.9"N, 75°53'00.2"W, 1376 m, 28.x.2008, coll. A. Arias, T. Kondo, J. Muñoz, 2 (UVCO), 3 (MECP); Finca La Cabaña, 04°17'43.8"N, 75°50'39.4"W, 1705 m, 09.ii.2009, coll. J. Muñoz, 2 (UVCO), 4 (MECP); Finca El Jardín, 04°18'18.4"N, 75°51'00.0"W, 1622 m, 16.ii.2009, coll. A. Arias, T. Kondo, J. Muñoz, 2 (UVCO), 2 (MECP); Finca La Giralda, 04°17'44.2"N, 75°50'32.8"W, 1717 m, 09.ii.2009, coll. A. Arias, J. Muñoz, 2 (UVCO), 3 (MECP); Finca Corinto, 04°17'04.2"N, 75°51'53.9"W, 1650 m, 20.iv.2009, coll. A. Arias, T. Kondo, J. Muñoz, 2 (UVCO), 4 (MECP); Finca Las Margaritas, 04°17'37.1"N, 75°53'18.0"W, 1352 m, 26.v.2009, coll. A. Arias, T. Kondo, J. Muñoz, 3 (UVCO), 4 (MECP); **Palmira:** Roza, Finca Brasil, 03°36'36.0"N, 76°25'08.5"W, 967 m, 10.xii.2008, coll. A. Arias, 1 (UVCO), 3 (MECP). **Ulloa:** Finca La Catalina, 04°41'38.8"N, 75°45'10.4"W, 1301 m, 04.v.2009, coll. J. Muñoz, H. Rodríguez, *ex* avocado cv. 'Santana', 2 (UVCO), 1 (MECP).

**Distribution.** **Afrotropical:** Comoros, Mauritius, Reunion, South Africa, Zimbabwe. **Nearctic:** USA. **Neotropical:** Argentina, Bermuda, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Grenada, Guadeloupe, Guatemala, Guyana, Haiti, Jamaica, Martinique, Mexico, Peru, Puerto Rico, Saint Lucia, Trinidad, U.S. Virgin Islands. **Oriental:** Taiwan, Vietnam. **Palaeartic:** Azores, Canary Islands, Crete, France, Greece, Israel, Italy, Japan, Madeira Islands, Malta, Portugal, Spain (Ben-Dov et al. 2015).

**Remarks.** The species was found on the underside of leaves of 'Booth 8', 'Lorena', 'Santana' and 'Trinidad' cultivars. *Protopulvinaria pyriformis* was one of the most common soft scales on avocado in the studied area. It was found associated with sootymolds in trees with high populations of the insect. In the field, larvae of a species of Syrphidae were observed feeding on the soft scales.

### *Pulvinaria psidii* Maskell (Fig. 1G)

**Material studied.** Colombia. Valle del Cauca: **Alcalá:** Finca La Porra, 04°40'13.1"N, 75°44'34.3"W,

1395 m, 10.xi.2008, coll. J. Muñoz, 1 (UVCO), *ex* avocado cv. 'Booth', 2 (MECP); Same data, except, *ex* avocado cv. 'Papelillo' ('Lorena'), 3 (UVCO), 1 (MECP); Same data except avocado cultivar not given, 1 (MECP); Finca Los Alpes, 04°42'24.8"N, 75°49'01.0"W, 1194 m, 02.xii.2008, coll. A. Arias, J. Muñoz, 1 (UVCO), 2 (MECP); Finca La Pastora, 04°39'41.6"N, 75°47'46.6"W, 1240 m, 27.iv.2009, coll. J. Muñoz, 1 (MECP); **Caicedonia:** Finca La Cabaña, 04°17'43.8"N, 75°50'39.4"W, 1705 m, 09.ii.2009, coll. J. Muñoz, *ex* avocado cv. 'Booth', 1 (UVCO); Finca Corinto, 04°17'04.2"N, 75°51'53.9"W, 1650 m, 20.iv.2009, coll. J. Muñoz, *ex* avocado cv. 'Booth 8', 1 (UVCO); Finca Las Margaritas, 04°17'37.1"N, 75°53'18.0"W, 1352 m, 26.v.2009, coll. A. Arias, 1 (MECP).

**Distribution.** Cosmopolitan (Ben-Dov et al. 2015).

**Remarks.** The species was found on the underside of avocado leaves of 'Booth', 'Lorena' and 'Trinidad' cultivars.

### *Saissetia coffeae* (Walker)

**Material studied.** **Colombia. Valle del Cauca: Alcalá:** Finca La Porra, 04°40'13.1"N, 75°44'34.3"W, 1395 m, 10.xi.2008, coll. A. Arias, J. Muñoz, 1 (UVCO), 2 (MECP); Finca Los Alpes, 04°17'56"N, 75°53'00"W, 1376 m, 28.x.2008, coll. J. Muñoz, *ex* avocado cv. 'Booth 8', 1 (UVCO); Hacienda La Polonia, 04°40'09.8"N, 75°45'14.1"W, 1369 m, 31.x.2008, coll. T. Kondo, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (MECP); **Caicedonia:** Finca La Cabaña, 04°17'43.8"N, 75°50'39.4"W, 1705 m, 09.ii.2009, coll. J. Muñoz, *ex* avocado cv. 'Booth', 2 (UVCO), 1 (MECP); Finca Corinto, 04°17'04.2"N, 75°51'53.9"W, 1650 m, 20.iv.2009, coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 2 (UVCO), 2 (MECP); Finca Las Margaritas, 04°17'37.1"N, 75°53'18.0"W, 1352 m, 26.v.2009, coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), (2 (UVCO), 3 (MECP).

**Distribution.** Cosmopolitan (Ben-Dov et al. 2015).

**Remarks.** The hemispherical scale, *S. coffeae* was found on both leaf surfaces of avocados of 'Booth' and 'Lorena' cultivars.

### *Saissetia neglecta* De Lotto (Fig. 1H)

**Material studied.** **Colombia. Valle del Cauca: Alcalá:** Finca La Porra, 04°40'13.1"N, 75°44'34.3"W, 1395 m, 10.xi.2008, coll. A. Arias, J. Muñoz, 1 (UVCO), 1 (MECP); Finca Los Alpes, 04°42'24.8"N, 75°49'01.0"W, 1194 m, 02.xii.2008, coll. A. Arias, J. Muñoz, 1 (UVCO), 2 (MECP); Finca Villa del Sol, 04°42'06.1"N, 75°50'00.5"W, 1215 m, 02.xii.2008, coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 2 (UVCO), 3 (MECP); Finca La Pastora, 04°39'41.6"N, 75°47'46.6"W, 1240 m, 27.iv.2009, coll. J. Muñoz, 1 (UVCO), 1 (MECP). **Caicedonia:** Finca La Cabaña, 04°17'43.8"N, 75°50'39.4"W, 1705 m, 09.ii.2009, coll. T. Kondo, *ex* avocado cv. 'Papelillo' ('Lorena'), 2 (UVCO), 1 (MECP); Finca Corinto, 04°17'04.2"N, 75°51'53.9"W, 1650 m, 20.iv.2009, coll. J. Muñoz, 1 (UVCO), 1 (MECP); Finca El Chaquiro, 04°17'00.0"N, 75°51'24.7"W, 1651 m; Finca Las Margaritas, 04°17'37.1"N, 75°53'18.0"W, 1352 m, coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (UVCO). **Palmira:** Roza, Finca Brasil, 03°36'36.0"N, 76°25'08.5"W, 967 m, 10.xii.2008, coll. A. Arias, 1 (MECP). **Ulloa:** Finca La Catalina, 04°41'38.8"N, 75°45'10.4"W, 1301 m, 04.v.2009, coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (UVCO).

**Distribution.** **Australasian:** Vanuatu. **Nearctic:** Mexico, USA. **Neotropical:** Argentina, Belize, Bermuda, Colombia, Costa Rica, Cuba, El Salvador, Galapagos Islands, Guadeloupe, Guatemala, Honduras, Panama, Puerto Rico, Saint Lucia, U.S. Virgin Islands, Venezuela. **Oriental:** Hong Kong (Ben-Dov et al. 2015).

**Remarks.** In the present study, the Caribbean black scale, *S. neglecta* was commonly found on twigs of 'Booth 8', 'Lorena', 'Santana' and 'Trinidad' cultivars.

## Family Pseudococcidae

### *Dysmicoccus brevipes* (Cockerell)

**Material studied.** **Colombia. Valle del Cauca: Alcalá:** Finca Santacruz, 04°39'47.1"N, 75°48'20.7"W, 1223 m, 27.iv.2009, coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 2 (UVCO), 1 (MECP). **Caicedonia:** Finca El Palmar, 04°17'55.9"N, 75°53'00.2"W, 1376 m, 28.x.2008, coll. T. Kondo, 1 (UVCO).

**Distribution.** Tropicopolitan (Ben-Dov et al. 2015).

**Remarks.** The pineapple mealybug, *D. brevipes* is a polyphagous species. In the present study, it was found on the leaves of the 'Lorena' cultivar.

***Ferrisia kondoi* Kaydan and Gullan**

**Material studied.** Colombia. Valle del Cauca: Cali: Portada al mar, 03°27'16.1"N, 76°33'06.5"W, 1068 m, 31.xii.2008, coll. J. Muñoz, ex Leaf of avocado cv. 'Papelillo' ('Lorena'), 2 (UVCO), 1 (MECP).

**Distribution.** The species occurs in Colombia, Brazil, Costa Rica, Guyana, Honduras, Mexico and Peru (Kaydan and Gullan 2012).

**Remarks.** This polyphagous mealybug was recently described by Kaydan and Gullan (2012). *Ferrisia kondoi* is usually found on the leaves of its host.

***Ferrisia williamsi* Kaydan and Gullan (Fig. 1D)**

**Material studied.** Colombia. Valle del Cauca: Alcalá: Finca La Polonia, 04°40'09.8"N, 75°45'14.1"W, 1369 m, 31.x.2008, coll. J. Muñoz, ex Avocado cv. 'Papelillo' ('Lorena'), 3 (UVCO); Finca La Porra, 04°40'13.1"N, 75°44'34.3"W, 1395 m, 10.xi.2008, coll. A. Arias, J. Muñoz, ex Leaves of avocado cv. 'Booth 8', 2 (UVCO), 1 (MECP); Finca Villa del Sol, 04°42'06.1"N, 75°50'00.5"W, 1215 m, 02.xii.2008, coll. A. Arias, J. Muñoz, ex avocado cv. 'Papelillo' ('Lorena'), 3 (UVCO), 1 (MECP); Finca Santacruz, 04°39'47.1"N, 75°48'20.7"W, 1223 m, 27.iv.2009, coll. J. Muñoz, ex avocado cv. 'Papelillo' ('Lorena'), 1 (UVCO), 1 (MECP); Finca La Pastora, 04°39'41.6"N, 75°47'46.6"W, 1240 m, 27.iv.2009, coll. T. Kondo, J. Muñoz, 1 (UVCO), 2 (MECP); Caicedonia: Finca Corinto, 04°17'04.2"N, 75°51'53.9"W, 1650 m, 20.iv.2009, coll. J. Muñoz, ex Avocado cv. 'Choquette', 1 (UVCO), 1 (MECP); Finca La Cabaña, 04°17'43.8"N, 75°50'39.4"W, 1705 m, 09.xii.2009, coll. J. Muñoz, ex avocado cv. 'Papelillo' ('Lorena'), 1 (UVCO), 3 (MECP); Finca El Palmar, 04°17'55.9"N, 75°53'00.2"W, 1376 m, 28.x.2008, coll. T. Kondo, 1 (UVCO), 2 (MECP); Varsovia: Hacienda La Polonia, 04°40'09.8"N, 75°45'14.1"W, 1369 m, 31.x.2008, coll. J. Muñoz, 1 (MECP).

**Distribution.** Colombia (Kaydan and Gullan 2012).

**Remarks.** *Ferrisia williamsi* was recently described by Kaydan and Gullan (2012) and is the most common mealybug found on avocado leaves, branches, twigs and flowers in the present study.

***Nipaecoccus nipae* (Maskell)**

**Material studied.** Colombia. Valle del Cauca: Caicedonia: Finca El Chaquiro, 04°17'00.0"N, 75°51'24.7"W, 1651 m, 02.iii.2009, coll. T. Kondo, J. Muñoz, ex avocado cv. 'Booth', 1 (UVCO), 1 (MECP); Finca Corinto, 04°17'04.2"N, 75°51'53.9"W, 1650 m, 20.iv.2009, coll. J. Muñoz, 2 (UVCO), 2 (MECP); Finca El Jardín, 04°18'18.4"N, 75°51'00.0"W, 1622 m, 16.ii.2009, coll. A. Arias, ex avocado cv. 'Papelillo' ('Lorena'), 7 (UVCO), 2 (MECP).

**Distribution.** Cosmopolitan (Ben-Dov et al. 2015).

**Remarks.** *Nipaecoccus nipae* was found on the underside of leaves of 'Booth' and 'Lorena' cultivars.

***Pseudococcus jackbeardsleyi* Gimpel and Miller**

**Material studied.** Colombia. Valle del Cauca: Alcalá: Finca El Edén, 04°39'38.4"N, 75°44'33.1"W, 1421 m, 31.x.2008, coll. A. Arias, 1 (UVCO), 1 (MECP); Finca La Pastora, 04°39'41.6"N, 75°47'46.6"W, 1240 m, 27.iv.2009, coll. T. Kondo, 1 (UVCO); Finca Santacruz, 04°39'47.1"N, 75°48'20.7"W, 1223 m, 27.iv.2009, coll. T. Kondo, 1 (UVCO), 1 (MECP); Caicedonia: Finca El Chaquiro, 04°17'00.0"N, 75°51'24.7"W, 1651 m, 02.iii.2009, coll. J. Muñoz, 1 (UVCO).

**Distribution.** Afrotropical: Ivory Coast, Reunion, Seychelles. Australasian: Federated States of Micronesia, Hawaiian Islands (Hawaii). Australasian: Indonesia. Australasian: Kiribati, Papua New Guinea, Tuvalu. Nearctic: Canada, Mexico, USA. Neotropical: Aruba, Bahamas, Barbados, Belize, Brazil, Colombia, Costa Rica, Cuba, Dominican Republic, El Salvador, Galapagos Islands, Guatemala, Haiti, Honduras, Jamaica, Martinique, Panama, Puerto Rico, Saint Martin, Trinidad and Tobago; U.S. Virgin Islands, Venezuela. Oriental: Brunei, India, Cambodia, Malaysia, Maldives, Philippines, Singapore, Sri Lanka, Taiwan, Thailand, Vietnam (Ben-Dov et al. 2015).

**Remarks.** The species was collected on leaves of the 'Hass' cultivar.

***Pseudococcus landoi* (Balachowsky)**

**Material studied.** Colombia. Valle del Cauca: Alcalá: Finca Santacruz, 04°39'47.1"N, 75°48'20.7"W,

1223 m, 27.iv.2009, coll. T. Kondo, J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 6 (UVCO), 1 (MECP); **Caicedonia:** Finca El Chaquiro, 04°17'00.0"N, 75°51'24.7"W, 1651 m, 02.iii.2009, coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (UVCO).

**Distribution.** **Nearctic:** Mexico. **Neotropical:** Barbuda, Brazil, Colombia, Costa Rica, Cuba, Ecuador, Guatemala, Guyana, Honduras, Nicaragua, Panama, Trinidad (Ben-Dov et al. 2015).

**Remarks.** *Pseudococcus landoi* was found on the main vein of an avocado leaf of the 'Lorena' cultivar (commonly known as 'Papelillo').

## Family Kerriidae

### *Austrotachardiella colombiana* Kondo and Gullan

**Material studied.** **Colombia, Valle del Cauca: Alcalá:** Finca La Pastora, 04°39'41.6"N, 75°47'46.6"W, 1240 m, 27.iv.2009, coll. J. Muñoz, *ex* avocado cv. 'Papelillo' ('Lorena'), 1 (UVCO).

**Distribution.** Colombia (Kondo and Gullan 2005).

**Remarks.** We found a single specimen of *A. colombiana* on the twig of a tree of the 'Lorena' cultivar. *Austrotachardiella colombiana* was originally described by Kondo and Gullan (2005) based on specimens collected on two cultivars of guava, *Psidium guajava* L. (Myrtaceae). This is the first record of this species on avocado worldwide. It is not considered a species of economic importance on avocados.

## Family Putoidae

### *Puto barberi* (Cockerell)

**Material studied.** **Colombia, Valle del Cauca: Palmira:** 03°32'18.9"N, 76°18'04.2"W, 1022 m, 17.iv.2009, coll. T. Kondo, *ex* avocado cv. 'Papelillo' ('Lorena'), 3 (UVCO), 4 (MECP).

**Distribution.** **Neotropical:** Antigua, Bahamas, Colombia, Dominican Republic, Grenada, Guadeloupe, Haiti, Jamaica, Montserrat, Puerto Rico, Saint Kitts, Saint Lucia, Trinidad and Tobago, U.S. Virgin Islands, Venezuela (Ben-Dov et al. 2015).

**Remarks.** *Puto barberi* was found in the city of Palmira, on leaves and twigs of an avocado tree planted along a sidewalk. This is the first report of *P. barberi* on avocado in Colombia.

## Family Margarodidae

### *Eurhizococcus colombianus* Jakubski

**Material studied.** **Colombia, Antioquia:** Rionegro, Corpoica, Centro de Investigación La Selva, 17.ix.2008, coll. T. Kondo, *ex* avocado cv. 'Papelillo' ('Lorena'), 3 (MECP).

**Distribution.** **Neotropical:** Colombia (Jakubski 1965; Kondo and Gómez 2008).

**Remarks.** This is the first record of the species on avocado.

## Family Monophlebidae

### *Laurencella colombiana* Foldi and Watson

**Material studied.** **Colombia, Valle del Cauca:** Caicedonia, Finca Corinto, 04°17'04.2"N, 75°51'53.9"W, 1650 m, 20.iv.2009, coll. T. Kondo, *ex* avocado cv. Papelillo (Lorena), 4 (BME); Finca La Cabaña, 04°17'43.8"N, 75°50'39.4"W, 1705 m, 09.ii.2009, coll. T. Kondo, *ex* avocado cv. 'Papelillo' ('Lorena'), 3 (BME).

**Distribution.** **Neotropical:** Colombia (Foldi and Watson 2001).

**Remarks.** Specimens were kindly identified by Dr. Penny Gullan (The Australian National University, Australia) as *Laurencella colombiana* based on immature specimens, which were compared to immature specimens of *L. colombiana* collected from the type locality and collector of the type material (P. Gullan, personal communication).



## Scale insects on avocado in Colombia and the world

According to the literature, there are 128 species of scale insects (Hemiptera: Coccoidea) hitherto recorded on avocado worldwide (Ben-Dov et al. 2015; Peña and Wysoki 2008; Evans et al. 2009; Kondo et al. 2011, Posada-Ochoa 1989; Renato and Larral 2008). Thirty-four scale insect species in seven families were collected on avocado tree in Colombia in the present study, of which nine are new records on avocado trees worldwide (Table 2). The new worldwide records are namely: *Lindingaspis rossi*, *Pseudischnaspis bowreyi* (Diaspididae), *Pulvinaria psidii*, *Saissetia neglecta* (Coccidae), *Ferrisia kondoi*, *Pseudococcus jackbeardsleyi*, *Ps. landoi* (Pseudococcidae), *Eurhizococcus colombianus* (Margarodidae) and *Austrotachardiella colombiana* (Kerriidae). There are records of *P. psidii* and *P. bowreyi* on *Persea* sp. in the scale insect database, ScaleNet (Ben-Dov et al. 2015), and such records may well belong to *P. americana*. The list of scale insects on avocado worldwide is increased to 137 species in 9 families, including only those species identified to the species level (Table 1).

Most of the scale insects collected during the present study were found in small numbers, and in the case of *A. colombiana*, only one specimen was collected on a branch of an avocado tree of the 'Lorena' variety. *Austrotachardiella colombiana* has only been hitherto reported on guava (Kondo and Gullan 2005). The ground pearl, *E. colombianus* is a well-known pest of *Rubus glaucus* (Blackberry) (Rosaceae) and *Arracacia xanthorrhiza* (Peruvian carrot) (Apiaceae) in Colombia (Jakubski 1965). In this study, *E. colombianus* was collected on the roots of an undetermined native variety of avocado, in Rio Negro, Antioquia, in an area that used to be a blackberry orchard. The tree appeared to tolerate the presence of *E. colombianus* and no particular symptoms were observed. Four species of wax scales of the genus *Ceroplastes* Gray were collected, namely: *C. floridensis*, *C. rubens*, plus two undetermined species. *Ceroplastes rubens* which was recently reported in Colombia on *Aglaonema* sp. and *Philodendron* sp. (Araliaceae) (Kondo 2008 b) was commonly found on avocado leaves, but generally in small numbers. However, in a farm in the municipality of Montenegro, in the state of Antioquia, moderate numbers of *C. rubens* were observed on the 'Booth 8' variety, but most of the specimens showed symptoms of parasitism, and many had exit holes on their waxy test.

Kondo and Muñoz (2009) reported *A. tubercularis* Newstead on *Persea* sp., a plant locally known as aguacatillo, in Cali, and on *Cucurbita pepo* L. (Cucurbitaceae) in Palmira, Valle del Cauca. According to Kondo and Muñoz (2009), *A. tubercularis* was not collected on avocado during seven months of a faunistic survey of scale insects on avocado. However, the first author (T. Kondo) found several 'Hass' avocado fruits infested with *A. tubercularis*, which came from a farm located at Amagá, in the State of Antioquia. According to Kondo and Muñoz (2009), 15 out of the 40 host plants recorded for *A. tubercularis* belong to the plant family Lauraceae to which avocado belongs (Ben-Dov et al. 2015). However, *A. tubercularis* is not a common species on avocados in Colombia, since it was collected only once in twelve months of study.

In the Americas, Colombia has the greatest scale insect diversity with 44 species, followed by U.S.A. with 37 species, Mexico with 35 species, Chile with 14 species and Peru with 11 reported species (Table 1). Species commonly collected on avocado in Colombia include *Hemiberlesia cyanophylli*, *Pseudoparlatoria parlatoroides* (Diaspididae), *Ceroplastes rubens*, *Coccus hesperidum*, *Protopulvinaria pyriformis*, *Pulvinaria psidii*, *Saissetia neglecta* (Coccidae), and *Ferrisia williamsi* (Pseudococcidae). Most of these species, although common, are usually found in small numbers. Occasionally, the pyriform scale, *P. pyriformis* was found in large numbers, especially in urban areas, and often associated with sooty mold; and *P. parlatoroides* was commonly found covering the underside of the leaves of 'Booth', 'Choquette', 'Lorena', 'Trinidad' and other native cultivars (excluding 'Hass'), and causing chlorosis symptoms on the opposite side of the leaves, but the affected trees appear to tolerate large numbers of this scale.

## Scale insects and their affinities with avocado cultivars and plant parts.

A wide range of avocado cultivars are commonly grown in Colombia, e.g., 'Booth', 'Choquette', 'Collinred', 'Fuerte', 'Gwen', 'Hass', 'Lorena', 'Reed', 'Trapica' and 'Trinidad' (Rios-Castaño and Tafur-Reyes 2003). 'Hass' is not a preferred cultivar in Colombia, but it is gaining popularity among entrepreneurs who plan to export avocados abroad in the near future. The scale insects collected in this study were collected on 'Booth', 'Booth 7', 'Booth 8', 'Choquette', 'Hass', 'Lorena', 'Trinidad', 'Santa Ana', 'Reed' and

other undetermined cultivars. The scale insects recorded on each of these cultivars in this study are shown in Table 2. The numbers of species recorded for each of the cultivars are: 'Booth', including 'Booth' 7 and 8 cultivars (20 spp.), 'Choquette' (6 spp.), 'Hass' (5 spp.), 'Lorena' (30 spp.), 'Trinidad' (9 spp.) and undetermined cultivars (10 spp.). Three species, *Aulacaspis tubercularis*, *Hemiberlesia cyanophylli* and *Chrysomphalus dictyospermi* were found on the fruit of 'Hass', but were not found on fruits of other cultivars. This may be because other cultivars have smooth skins, unlike the rough skin texture of the 'Hass' avocado fruit, which provides an excellent habitat for armored scales. In smooth skin avocados, armored scales are usually found around the calyx.

The present list of scale insects on avocados in Colombia includes species collected on the roots, tree trunk, branches, leaves, flowers and fruits (Table 3). Although there are some species that are able to feed on different parts of a plant, the majority of scale insects prefer feeding on a particular site in the plant. For example, the ground pearl, *Eurhizococcus colombianus* only feeds on the roots and is never found feeding on the aerial parts of the plant. Similarly, *Bombacoccus aguacatae* feeds on the branches and twigs, but it's not found on leaves, fruit, or roots.

## Discussion

Colombia has one of the richest biodiversity in the world and is considered as one of 17 megadiverse countries in the world (Mittermeier 1997). With the results of the present study, Colombia has become the country with the most scale insects recorded on avocado worldwide with 44 taxa, followed by the U.S.A. with 37 species and Mexico with 35 species. Of the 44 species collected on avocados in Colombia, five species (11%) are only known from Colombia, namely: *Austrotachardiella colombiana* (Kerriidae), *Bombacoccus aguacatae* (Coccidae), *Eurhizococcus colombianus* (Margarodidae), *Ferrisia kondoi* (Pseudococcidae) and *Laurencella colombiana* (Monophlebidae); the remaining having either a worldwide distribution or being widespread in the Neotropical region (Ben-Dov et al. 2015). The number of species found in the present study probably reflects the true diversity of scale insects in Colombia. Avocados in Colombia are grown from 0 meters up to 2,200 meters above sea level in the Andean mountain range, and many avocado cultivars adapted to each of these altitudes are cultivated (Rios-Castaños and Tafur-Reyes 2003). Many of the scale insects recorded on avocados worldwide are polyphagous and have a cosmopolitan or tropicopolitan distribution. Many species are endemic to each geographical region. For example, *Ceroplastes toddaliae* Hall, *Saissetia zanzibarensis* Williams, *Udinia catori* (Green) and *Parastictococcus gowdeyi* (Newstead) are endemic to the Ethiopian region (Ben-Dov et al. 2015); since *P. americana* is of New World origin, these African species have acquired avocado as a new host.

Although 34 scale insect species were collected on avocados in Colombia in this study, most of these species were found in very low numbers or were rare. Moreover, avocado producers generally did not consider scale insects to be of economic importance. The soft scale, *Akermes colombiensis* that was recorded from an avocado tree at the "El Vinculo" regional natural park, in Buga, Valle del Cauca, by Kondo and Williams (2004) was not found in the present study. The avocado tree where the soft scale was collected at the "El Vinculo" regional natural park had been cut down, and this species has not been collected on avocados since.

Two *Ceroplastes* species were collected in the present study from a farm in the municipality of Rionegro in the department of Antioquia; one species was found on the leaves and the other on the twigs and branches of the host and were sent to Dr. Ana Peronti, a specialist on the group for identification. Another soft scale species was identified as *Toumeyella* sp. collected on branches of a native cultivar appears to be new to science, but was not included in the present study.

The species list of scale insects on avocados in Colombia should become an aide when conducting risk pest analyses of scale insects of quarantine importance. There are international standards for phytosanitary measures, which have been prepared by the Secretariat of the International Plant Protection Convention as part of the United Nations Food and Agriculture Organization's global programme of policy and technical assistance in plant quarantine. These standards for phytosanitary measures include standards, guidelines and recommendations to achieve international harmonization of phytosanitary measures, with the aim to facilitate trade and avoid the use of unjustifiable measures as barriers to

trade (FAO 2001). By understanding the biodiversity of the scale insect fauna on avocado in Colombia, we intend to provide a base for future studies of risk analyses directed at exporting Colombian avocados abroad.

## Conclusions

As a result of the present study, the number of scale insects collected on avocado trees in Colombia is increased to 44 species and to 137 species worldwide. Despite the high number of species of scale insects on avocado trees in Colombia, the species that affect the fruit are only a handful, thus the risk of scale insect species being exported abroad together with produce (fruit) is limited. This species list should be considered preliminary as many more species should be found in the future with more taxonomic studies.

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**Table 1.** An updated list of scale insects on *Persea americana* in the world.

Family Asterolecaniidae (1 sp.)	Chile	Colombia	Mexico	Peru	USA
<i>Bambusaspid bambusae</i> (Boisduval)					
Family Cerococcidae (1 sp.)					
<i>Cerococcus badius</i> Leonardi					
Family Coccidae (43 spp.)					
* <i>Akermes colombiensis</i> Kondo and Williams		X			
<i>Bombacoccus aguacatae</i> Kondo [PS]		X			
<i>Ceroplastes ceriferus</i> (Fabricius)					
* <i>Ceroplastes cirripediformis</i> Comstock	X		X		X
* <i>Ceroplastes cistudiformis</i> Cockerell			X		X
<i>Ceroplastes destructor</i> Newstead					
<i>Ceroplastes floridensis</i> Comstock [NRCA], [PS]		X	X		X
<i>Ceroplastes pseudoceriferus</i> Green					
<i>Ceroplastes reunionensis</i> Ben-Dov and Matile-Ferrero					
<i>Ceroplastes rubens</i> Maskell [NRCA], [PS]		X			
<i>Ceroplastes rusci</i> (Linnaeus)					
<i>Ceroplastes sinensis</i> Del Guercio					
<i>Ceroplastes stellifer</i> (Westwood)					
<i>Ceroplastes toddaliae</i> Hall					
<i>Coccus formicarii</i> (Green)					
<i>Coccus hesperidum</i> L. [NRCA], [PS]	X	X	X		X
<i>Coccus longulus</i> (Douglas) [NRCA], [PS]		X			
<i>Coccus moestus</i> De Lotto					
<i>Coccus viridis</i> (Green)		X		X	
<i>Kilifia acuminata</i> (Signoret)					
<i>Milviscutulus mangiferae</i> (Green)					
<i>Milviscutulus spiculatus</i> Williams and Watson					
<i>Parasaissetia nigra</i> (Nietner)		X		X	
<i>Parthenolecanium persicae</i> (Fabricius)					
<i>Phalacroccoccus howertoni</i> Hodges and Hodgson					
<i>Philephedra lutea</i> (Cockerell)					
<i>Philephedra tuberculosa</i> Nakahara and Gill					
<i>Prococcus acutissimus</i> (Green)					
<i>Protopulvinaria longivalvata</i> Green		X			
<i>Protopulvinaria pyriformis</i> (Cockerell) [PS]	X	X			X
<i>Pseudocribrolecanium andersoni</i> (Newstead)					
<i>Pseudocribrolecanium colae</i> (Green and Laing)					
<i>Pseudokermes vitreus</i> (Cockerell)					
<i>Pulvinaria ficus</i> Hempel					
<i>Pulvinaria mammeae</i> Maskell					
** <i>Pulvinaria psidii</i> Maskell [NRCA], [PS]		X			
* <i>Pulvinaria simulans</i> Cockerell			X		
<i>Saissetia coffeae</i> (Walker) [PS]	X	X	X		X
<i>Saissetia miranda</i> (Cockerell and Parrott)					
** <i>Saissetia neglecta</i> De Lotto [NRCA], [PS]		X			
<i>Saissetia oleae</i> (Olivier)	X	X	X		
<i>Saissetia zanzibarensis</i> Williams					
<i>Udinia catori</i> (Green)					
Family Diaspididae (55 spp.)					
* <i>Acutaspis agavis</i> (Townsend and Cockerell)			X		X
<i>Acutaspis albopicta</i> (Cockerell)			X	X	X
* <i>Acutaspis aliena</i> (Newstead)			X		

<i>Acutaspis perseae</i> (Comstock) [NRCA], [PS]		X		X
<i>Acutaspis scutiformis</i> (Cockerell)		X		
<i>Acutaspis subnigra</i> McKenzie				
<i>Aonidiella aurantii</i> (Maskell)				
<i>Aonidiella citrina</i> (Coquillett)				
* <i>Aonidiella orientalis</i> (Newstead)				X
<i>Aspidiotus destructor</i> Signoret [PS]		X		X
<i>Aspidiotus nerii</i> Bouche				
* <i>Aulacaspis tubercularis</i> Newstead [NRCA], [PS]		X	X	
<i>Chrysomphalus aonidum</i> (Linnaeus)			X	X
<i>Chrysomphalus dictyospermi</i> (Morgan) [PS]	X	X	X	X
<i>Chrysomphalus diversicolor</i> (Green)				
<i>Chrysomphalus pinnulifer</i> (Maskell)				
* <i>Clavaspis herculeana</i> (Cockerell and Hadden)		X		
<i>Clavaspis perseae</i> (Davidson)			X	
<i>Comstockaspis perniciosus</i> (Comstock)			X	X
<i>Davidsonaspis aguacatae</i> (Evans, Watson and Miller)			X	
* <i>Diaspidiotus ancylus</i> (Putnam)	X		X	X
<i>Diaspis boisduvalii</i> Signoret				
* <i>Diaspis coccois</i> Lichtenstein			X	X
<i>Diaspis miranda</i> (Cockerell)			X	
<i>Fiorinia fioriniae</i> (Targioni Tozzetti)	X			X
<i>Hemiberlesia cyanophylli</i> (Signoret) [PS]		X		X
* <i>Hemiberlesia diffinis</i> (Newstead)			X	
<i>Hemiberlesia lataniae</i> (Signoret) [NRCA], [PS]		X	X	X
<i>Hemiberlesia musae</i> Takagi and Yamamoto				X
<i>Hemiberlesia latastei</i> (Cockerell)	X			X
<i>Hemiberlesia palmarum</i> (Cockerell) [PS]	X	X		X
<i>Hemiberlesia rapax</i> (Comstock) [NRCA], [PS]		X	X	X
<i>Howardia biclavis</i> (Comstock) [NRCA], [PS]		X		X
<i>Ischnaspis longirostris</i> (Signoret)				
* <i>Lepidosaphes beckii</i> (Newman)				X
* <i>Lindingaspis floridana</i> Ferris				X
** <i>Lindingaspis rossi</i> (Maskell) [NRCA], [PS]		X		
<i>Lopholeucaspis cockerelli</i> (Grandpré and Charmoy)				
<i>Melanaspis deklei</i> Deitz and Davidson				
<i>Melanaspis nigropunctata</i> (Cockerell)				
<i>Melanaspis squamea</i> Ferris				
* <i>Mycetaspis personata</i> (Comstock) [NRCA], [PS]		X	X	X
<i>Neopinnaspis harperi</i> McKenzie				
<i>Oceanaspis spinosus</i> (Comstock)			X	X
* <i>Parlatoria proteus</i> (Curtis)				X
* <i>Pinnaspis aspidistrae</i> (Signoret)	X			X
<i>Pinnaspis strachani</i> (Cooley)			X	X
* <i>Pseudaonidia duplex</i> (Cockerell)				X
<i>Pseudaonidia trilobitiformis</i> (Green) [PS]		X		X
<i>Pseudaulacaspis cockerelli</i> (Cooley)				
* <i>Pseudischnaspis acephala</i> Ferris [PS]		X		
** <i>Pseudischnaspis bowreyi</i> (Cockerell) [NRCA], [PS]		X		
* <i>Pseudoparlatoria parlatorioides</i> (Comstock)		X		X
<i>Selenaspis articulatus</i> (Morgan) [PS]		X		X
* <i>Velataspis dentata</i> (Hoke)			X	X

**Family Kerriidae** (2 spp.)*Paratachardina pseudolobata* Kondo and Gullan**\*\****Austrotachardiella colombiana* Kondo and Gullan X  
[NRCA], [PS]**Family Margarodidae** (1 sp.)**\*\****Eurhizococcus colombianus* Jakubski [NRCA], [PS] X**Family Monophlebidae** (6 spp.)*Crypticerya montserratensis* (Riley and Howard) X*Crypticerya multicatrices* Kondo and Unruh X*Drosicha contrahens* Walker**\****Icerya purchasi* Maskell X X*Icerya seychellarum* (Westwood)*Laurencella colombiana* Foldi and Watson [PS] X**Family Pseudococcidae** (26 spp.)*Dysmicoccus brevipes* (Cockerell) [NRCA], [PS] X X*Dysmicoccus imparilis* Williams*Dysmicoccus nesophilus* Williams and Watson**\*\****Ferrisia kondoi* Kaydan and Gullan [NRCA], [PS] X*Ferrisia malvastra* (McDaniel) X**\****Ferrisia virgata* (Cockerell) X*Ferrisia williamsi* Kaydan and Gullan [PS] X*Formicococcus lindingeri* (Bodenheimer)*Formicococcus njalensis* (Laing)*Maconellicoccus hirsutus* (Green)*Nipaecoccus annonae* Williams and Granara de Willink*Nipaecoccus jonmartini* Williams and Granara de Willink*Nipaecoccus nipae* (Maskell) [NRCA], [PS] X X X*Nipaecoccus viridis* (Newstead)*Paracoccus marginatus* Williams and Granara de Willink**\****Paraputo olivaceus* (Cockerell) X*Planococcus citri* (Risso) X X X*Planococcus ficus* (Signoret)*Planococcus minor* (Maskell)**\****Pseudococcus calceolariae* (Maskell) X*Pseudococcus cryptus* Hempel**\*\****Ps. jackbeardsleyi* Gimpel and Miller [NRCA], [PS] X**\*\****Pseudococcus landoi* (Balachowsky) [NRCA], [PS] X*Pseudococcus longispinus* (Targioni Tozzetti) X X X*Pseudococcus viburni* (Signoret) X*Rastrococcus invadens* Williams**Family Putoidae** (1 sp.)*Puto barberi* (Cockerell) [NRCA], [PS] X**Family Stictococcidae** (1 sp.)*Parastictococcus gowdeyi* (Newstead)**Total: 127 spp.**

**Notes.** Only those species identified to the species level are listed above. Species marked with an asterisk (\*) are those that are not listed in ScaleNet (Ben-Dov et al. 2015), i.e., *A. colombiensis* (Kondo and Williams 2004); *A. aliena*, *D. ancylus*, *D. cocois*, *F. virgata*, *H. diffinis*, *M. personata*, *P. simulans* (Peña and Wysoki, 2008); *A. tubercularis* (Evans et al. 2009); *C. cirripediformis*, *L. beckii*, *P. aspidistrae*, *P. calceolariae* (Renato and Larral 2008); *C. herculeana*, *P. acephala*, and *P. parlatorioides* (Posada-Ochoa 1989); *A. agavis*, *C. cistudiformis*, *I. purchasi*, *P. olivaceus*, *V. dentata* (APHIS 2004); *A. orientalis*, *L. floridana*, *P. proteus*, *P. duplex* (Dekle 1976). Species marked with two asterisks (\*\*) are species that are not listed in ScaleNet (Ben-Dov et al. 2015) that were collected



in the present study. [PS] means collected in the present study. [NRCA] means new record on avocado in Colombia. *Ferrisia virgata*, listed by Posada-Ochoa (1989) for Colombia, was not included in the list because there are two species of *Ferrisia* Fullaway in Colombia, namely *F. williamsi* and *F. kondoi*, which have been hitherto misidentified as *F. virgata*. No voucher specimens studied by Posada-Ochoa (1989) exist, so his identifications cannot be verified.

**Table 2.** Scale insects collected on different avocado cultivars in the present study.

Scale insect family	Avocado cultivar					
	'Booth'	'Choquette'	'Hass'	'Lorena'	'Trinidad'	Not det.
<b>Family Diaspididae</b>						
<i>Acutaspis perseae</i> (Comstock)	X			X		
<i>Aspidiotus destructor</i> Signoret				X		
<i>Chrysomphalus dictyospermi</i> (Morgan)	X		X	X		X
<i>Hemiberlesia cyanophylli</i> (Signoret)	X	X	X	X		
<i>Hemiberlesia lataniae</i> (Signoret)				X		
<i>Hemiberlesia palmae</i> (Cockerell)	X			X		
<i>Hemiberlesia rapax</i> (Comstock)	X					
<i>Howardia biclavis</i> (Comstock)				X		
<i>Lindingaspis rossi</i> (Maskell)	X			X		X
<i>Mycetaspis personata</i> (Comstock)				X		
<i>Pseudaonidia trilobitiformis</i> (Green)	X					
<i>Pseudischnaspis acephala</i> Ferris				X	X	
<i>Pseudischnaspis bowreyi</i> (Cockerell)				X	X	
<i>Pseudoparlatoria parlatorioides</i> (Comstock)	X	X		X	X	X
<i>Selenaspidus articulatus</i> (Morgan)				X		X
<b>Family Coccidae</b>						
<i>Akermes colombiensis</i> Kondo and Williams						X
<i>Ceroplastes floridensis</i> Comstock	X			X		
<i>Ceroplastes rubens</i> (Maskell)	X	X		X	X	
<i>Coccus hesperidum</i> L.	X		X	X		
<i>Coccus longulus</i> (Douglas)	X					
<i>Protopulvinaria pyrifomis</i> (Cockerell)	X	X		X	X	X

<i>Pulvinaria psidii</i> Maskell	X			X	X	
<i>Saissetia coffeae</i> (Walker)	X			X		
<i>Saissetia neglecta</i> De Lotto	X			X	X	X
<b>Family Pseudococcidae</b>						
<i>Dysmicoccus brevipes</i> (Cockerell)				X		
<i>Ferrisia kondoi</i> Kaydan and Gullan	X					
<i>Ferrisia williamsi</i> Kaydan and Gullan	X	X		X	X	X
<i>Nipaecoccus nipae</i> (Maskell)	X			X		
<i>Pseudococcus landoi</i> (Balachowsky)				X		
<i>Pseudococcus jackbeardsleyi</i> Gimpel and Miller			X			
<b>Family Monophlebidae</b>						
<i>Laurencella colombiana</i> Foldi and Watson				X		
<b>Family Margarodidae</b>						
<i>Eurhizococcus colombianus</i> Jakubski				X		
<b>Family Kerriidae</b>						
<i>Austrotachardiella colombiana</i> Kondo and Gullan				X		
<b>Family Putoidae</b>						
<i>Puto barberi</i> (Cockerell)						X

**Table 3.** Scale insects on avocado trees in Colombia and their feeding sites.

Scale insect family	Feeding site on avocado plant					
	branch	twig	leaf	flower	fruit	root
<b>Family Diaspididae</b>						
<i>Acutaspis perseae</i> (Comstock)			X			
<i>Aspidiotus destructor</i> Signoret			X			
<i>Chrysomphalus dictyospermi</i> (Morgan)		X			X	
<i>Hemiberlesia cyanophylli</i> (Signoret)					X	
<i>Hemiberlesia lataniae</i> (Signoret)		X	X			
<i>Hemiberlesia palmarum</i> (Cockerell)		X				
<i>Hemiberlesia rapax</i> (Comstock)			X			
<i>Howardia biclavis</i> (Comstock)		X				
<i>Lindingaspis rossi</i> (Maskell)			X			
<i>Mycetaspis personata</i> (Comstock)			X			
<i>Pseudaonidia trilobitiformis</i> (Green)			X			
<i>Pseudischnaspis acephala</i> Ferris			X			
<i>Pseudischnaspis bowreyi</i> (Cockerell)			X			
<i>Pseudoparlatoria parlatorioides</i> (Comstock)			X			
<i>Selenaspis articulatus</i> (Morgan)			X			
<b>Family Coccidae</b>						

<i>Akermes colombiensis</i> Kondo and Williams		X				
<i>Ceroplastes floridensis</i> Comstock			X			
<i>Ceroplastes rubens</i> (Maskell)			X			
<i>Coccus hesperidum</i> L.		X	X			
<i>Coccus longulus</i> (Douglas)			X			
<i>Protopulvinaria pyrififormis</i> (Cockerell)			X			
<i>Pulvinaria psidii</i> Maskell		X	X			
<i>Saissetia coffeae</i> (Walker)			X			
<i>Saissetia neglecta</i> De Lotto		X				
<b>Family Pseudococcidae</b>						
<i>Dysmicoccus brevipes</i> (Cockerell)			X			
<i>Ferrisia kondoi</i> Kaydan and Gullan			X			
<i>Ferrisia williamsi</i> Kaydan and Gullan		X	X	X		
<i>Nipaecoccus nipae</i> (Maskell)			X			
<i>Pseudococcus landoi</i> (Balachowsky)			X			
<i>Pseudococcus jackbeardsleyi</i> Gimpel and Miller			X		X	
<b>Family Monophlebidae</b>						
<i>Laurencella colombiana</i> Foldi and Watson	X	X				
<b>Family Margarodidae</b>						
<i>Eurhizococcus colombianus</i> Jakubski						X
<b>Family Kerriidae</b>						
<i>Austrotachardiella colombiana</i> Kondo and Gullan		X				
<b>Family Putoidae</b>						
<i>Puto barberi</i> (Cockerell)		X	X			