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Diaspididae on *Citrus* spp. (Rutaceae) from Colombia: New records and a taxonomic key to their identification

Diaspididae en *Citrus* spp. (Rutaceae) de Colombia: Nuevos registros y una clave taxonómica para su identificación

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ABSTRACT

In this manuscript *Aonidiella comperei* is reported for the first time in Colombia; the specimens were found associated with branches, leaves and fruits of *Citrus* x *latifolia* (Rutaceae) in the department of Tolima. Also we obtained physical evidence of the association of *Parlatoria ziziphi* and *Citrus* x *limonia* (Rutaceae) in Colombia from a sample collected in the field; until this paper the only record of *P. ziziphi* in the country came from specimens intercepted in a quarantine inspection at a port of entry in the United States. Field and slide-mounted characteristics are provided for *A. comperei*. Also a taxonomic key to species of Diaspididae present on *Citrus* spp. in Colombia is given.

Key words:
Coccomorpha
Invasive species
Neotropical region
New host
Pest

RESUMEN

En este manuscrito se registra por primera vez para Colombia a *Aonidiella comperei*; los especímenes se encontraron asociados a ramas, hojas y frutos de *Citrus* x *latifolia* (Rutaceae) en el departamento del Tolima. Además, se verifica la asociación *Parlatoria ziziphi* y *Citrus* x *limonia* (Rutaceae), a partir de recolecciones en campo; hasta la fecha, su único registro para el país provenía de especímenes interceptados en puertos de entrada en Estados Unidos. Se provee información de características en campo y en montaje en lámina para *A. comperei*, al igual que una clave taxonómica de especies de Diaspididae presentes en *Citrus* spp. de Colombia.

Palabras claves:
Coccomorpha
Especies invasivas
Región neotropical
Nuevos hospedantes
Plaga

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The Diaspididae (Hemiptera: Coccomorpha), commonly known as "armored scale insects", is one of the most speciose families in that infraorder, and it is composed of 2650 species in 400 genera (García *et al*., 2016). Armored scales occur on a wide variety of host plants encompassing more than 1,380 plant genera in 182 plant families (Miller and Davidson, 2005). This family is particularly important in agriculture and wild vegetation (Zamudio and Claps, 2005) because it includes numerous highly prolific species that can reach high populations and become serious pests of several crops (Claps and Teran, 2001).

On *Citrus* spp. (Rutaceae) there are records of 112 species of Diaspididae (García *et al*., 2016), of which 19 have been recorded in Colombia (Balachowsky, 1959, 1959a; Figueroa, 1946, 1952, 1977; Gallego and Vélez, 1992; Kondo, 2001; Kondo *et al*., 2012; Mosquera, 1979; Posada, 1989).

The genus *Aonidiella* Berlese and Leonardi 1896 has 32 species described around the world, and includes pest species such as *Aonidiella aurantii* (Maskell), it is considered as the most injurious pest of citrus crops around the world (Miller and Davison 1990), *Aonidiella citrina* (Coquillett) in citrus (EFSA PLH Panel, 2014); *Aonidiella eremocitri* McKenzie on oil palm and coconut (Mariau, 1998); *Aonidiella gracilis* (Balachowsky) on cacao (Liegeois, 1944); *Aonidiella inornata* (McKenzie) on papaya (Lee and Wen, 1977) and mango (Chua and Wood, 1990); *Aonidiella orientalis* (Newstead) recorded as a pest of several agricultural crops such as citrus (Rose, 1990), tea (Nagarkatti and Sankaran, 1990), date palm (Rajagopal and Krishnamoorty, 1996), palms and ornamentals (Dekle, 1976), papaya (Elder *et al*., 1998) and mango (Swirski *et al*., 2002); and *Aonidiella taxus* Leonardi recorded causing damage to *Taxus* sp. and *Podocarpus* sp. trees (Miller and Davidson, 1990). In Colombia, only *A. orientalis* has been hitherto recorded (Kondo, 2001; Posada, 1989).

Before this study, *Aonidella comperei* McKenzie was recorded in 22 countries in the Neotropical and Oriental regions (García *et al*., 2016). In the Neotropics, *A. comperei* has been recorded in Brazil (Culik *et al*., 2008; Martins *et al*., 2004), Dominica (McKenzie, 1946), Guadeloupe (Balachowsky, 1957), Guatemala (McKenzie, 1946), Haiti (McKenzie, 1946) Martinique (Balachowsky, 1957), Puerto Rico (Martorell, 1976), Saint Martin (Matile and Etienne, 2006) and the U.S. Virgin Islands (Nakahara, 1983).

Aonidiella comperei is considered an important pest species of papaya, *Carica papaya* L. (Caricaceae) in Brazil because it has a widespread distribution and frequent occurrence; it causes cosmetic damage to fruit and weakens it host plant, and is also of concern as a pest of quarantine significance (Martins *et al*., 2014). It is a polyphagous species, affecting 14 plant species belonging to 12 families: *Annona muricata* L. (Annonaceae) (Martorell, 1976), *Cocos nucifera* L. (Arecaceae) (McKenzie, 1946), *Pluchea odorata* (L.) (Asteraceae) (Williams and Watson, 1988), *Carica papaya* (Martins *et al*., 2004), *Cucurbita maxima* Duchesne (Cucurbitaceae) (Velasquez, 1971), *Diospyros* sp. (Ebenaceae) (Williams and Watson, 1988), *Annesijoa* sp. (Euphorbiaceae) (Williams and Watson 1988), *Ficus* sp. (Moraceae) (Williams and Watson, 1988), *Musa* sp. (Musaceae) (Williams and Watson, 1988), *Morinda citrifolia* L. (Rubiaceae) (Williams and Watson, 1988), *Citrus aurantifolia* Swingle (McKenzie, 1946), *Citrus maxima* (Burm.) (McKenzie, 1946), *Citrus* sp. (Rutaceae) (McKenzie, 1937) and *Vitis* sp. (Vitaceae) (McKenzie, 1946).

Parlatoria ziziphi (Lucas) is a cosmopolitan species (Garcia *et al*., 2016), known to occur in Africa, Asia, Central and South America, Europe, Oceania, and the West Indies (Miller and Davidson, 2005). The species is considered to have a very limited host range, probably *Citrus* spp., *Murraya* spp., *Poncirus* spp., and *Severinia* spp., with *Citrus* spp. being the predominant host (Miller and Davidson, 2005). In Colombia this species was recorded by Blackburn and Miller (1984) based on information from the United States Department of Agriculture, without information about its hosts.

Parlatoria ziziphi is known as "the black parlatoria scale" and it has long been considered one of the major pests of citrus in certain areas (Miller and Davidson, 2005). Heavy infestations of this scale cause chlorosis and premature leaf drop, dieback of twigs and branches, stunting and distortion of fruit, and premature fruit drop and perhaps the most characteristic damage is the virtually unremovable scale cover on the fruit (Miller and Davidson, 2005). Beardsley and González (1975) and

Miller and Davidson (1990) considered this species as a serious world pest.

The purpose of this paper is to provide new biological information of *Aonidiella comperei* and *Parlatoria ziziphi*. We report for the first time *A. comperei* and *P. ziziphi* on *Citrus* spp. in Colombia. Brief diagnoses of the adult females are given for both species. An updated list and a taxonomic key of all species of Diaspididae recorded on *Citrus* spp. (Rutaceae) from Colombia is provided.

MATERIALS AND METHODS

Samples of scales insects were collected on fruits and leaves of Key lime, *Citrus* x *latifolia* Tanaka ex Q. Jiménez (Rutaceae) from commercial crops in the department of Tolima, by the first author as part of plant health surveillance activities conducted by the Colombian Agricultural Institute (ICA) and on leaves of *Citrus* x *limonia* (L.) Osbeck (Rutaceae) in the department of Atlántico by entomologist Oscar Dix.

Slide-mounted specimens were prepared according to the protocol by Siresena *et al*. (2013); however, the exposure time to which the specimens were subjected to the chemical reagents was modified. The specimens are deposited at the "Universidad Nacional Agronomía Bogotá" UNAB entomological museum, Facultad de Ciencias Agrarias, Universidad Nacional de Colombia, Sede Bogotá, Bogotá, Cundinamarca, Colombia. Imaging analysis was done under a phase contrast microscope Nikon Eclipse E600 and the software Image Pro Insight v 8.0.

Specimens were identified by checking the morphological descriptions of McKenzie (1937), Beardsley (1966), Miller and Davidson (2005) and by using the keys by Beardsley (1966), Williams and Watson (1988) and Miller and Davidson (2005). The taxonomic key of species of Diaspididae of *Citrus* spp. for Colombia is based on morphological external features of the adult female. The species included in the key correspond to those recorded on *Citrus* spp. from Colombia by Balachowsky (1959), Figueroa (1946, 1952, 1977), Gallego and Vélez (1992), Kondo (2001) and Posada (1989).

RESULTS AND DISCUSSION

Aonidiella comperei McKenzie 1937, 327. Type data: INDIA: Bombay, Calaba, on *Citrus* sp.
Chrysomphalus comperei Lindinger 1957: 545

Figure 1. Fruit (left) and branch (right) of *Citrus* x *latifolia* infested with *Aonidiella comperei*.

Field characteristics

The female scale is circular, smooth, flat, light brown in the center, surrounded by a white halo (Figure 2A). The insect is reniform, membranous and yellow when it is young (Figure 2B) and it turns orange and sclerotized at maturity (Figure 2C). The female has two nymphal instars, all of them slightly darker than the adult female (Figure 2D).

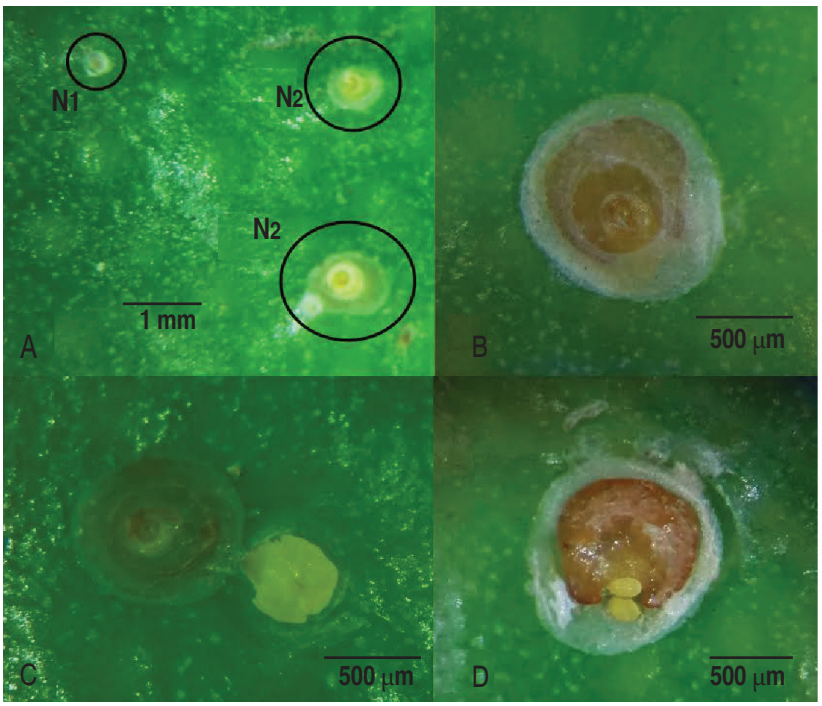

Figure 2. Live specimens of *Aonidiella comperei*. A**.** Two stages of development, N1: first-instar nymph, N2: second-instar nymph B. Adult female cover. C. Young adult female separated from its scale; D. Mature adult female after removal of scale.

Slide-mounted characters

The adult female is reniform, highly sclerotized at maturity (Figure 3A). The following features are given by McKenzie (1937): pygidium not heavily sclerotized; three pairs of lobes present, the median pair only slightly larger than the second pair (Figure 3B); paraphyses small, short, and slender; tubular ducts broad and conspicuous (Figure 3C); anal opening large; venter with a few small ducts, situated close to the margin of the pygidium; perivulvar pores present, in two groups only, of apparently no more than two pores in each group (Figure 3D). The differences between *A. comperei* and *A. orientalis* are listed in Table 1.

Table 1. Morphological differences between *Aonidiella orientalis* and *A. comperei*, showed as attributes. Character states taken from Beardsley (1966), Mckenzie (1937) and Williams and Watson (1988).

Character states	Attribute for *Aonidiella orientalis*	Attribute for *Aonidiella comperei*
Grade of development of prosomatic lobes	Weakly developed	Well developed (Figure 3E)
Number of rows or clusters of dorsal ducts on either side of abdominal submargin	One to three	None
Presence/absence of conspicuous groups of ducts on lateral margin of dorsum of each three prepygidial abdominal segments	Present	Absent
Form of the plates lateral to third lobe	Not fringed, each with one long fleshy process	Fringed (Figure 3F)
Number of distinguishable perivulvar pore cluster	Five	Two

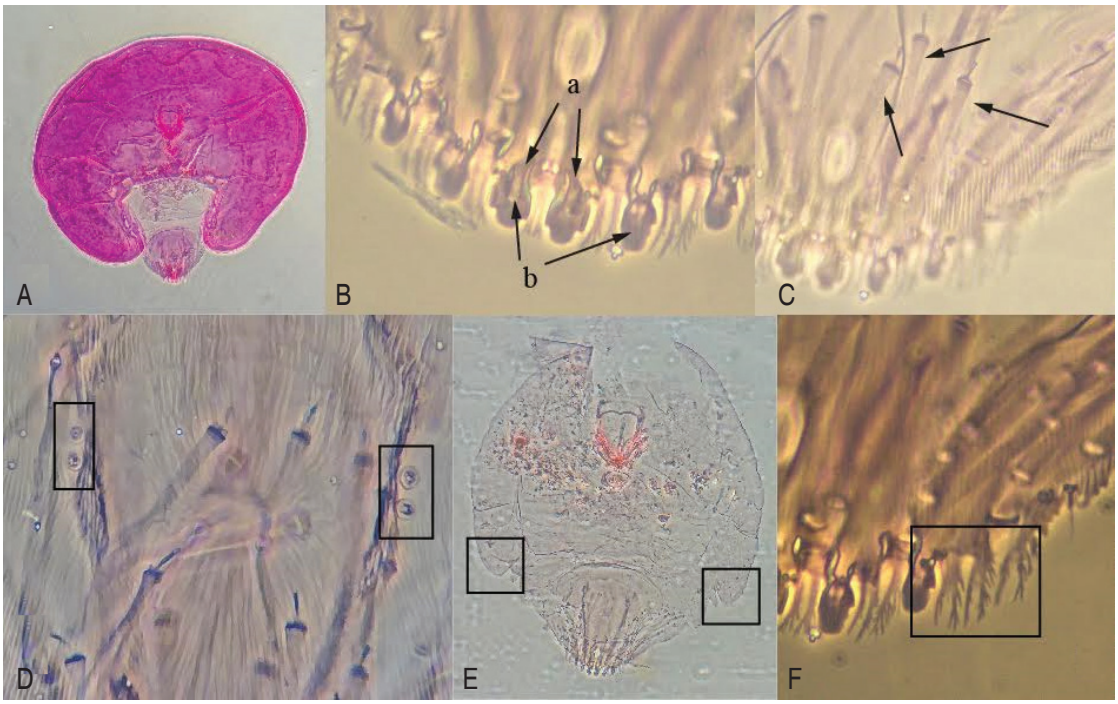

Figure 3. Slide-mounted features of *Aonidiella comperei*: A. Reniform and highly sclerotized mature adult female. B. Three pairs of lobes present on the pygidium, the median pair (a) only slightly larger than the second pair (b). C. Tubular ducts. D. Perivulvar pores in two groups, each with two pores. E. Prosomatic lobes well developed. F. Fringed plates lateral to third lobe.

Material studied

Aonidiella comperei McKenzie. Colombia, Tolima, Chicoral, vereda Las Mercedes, finca El Diamante, 318 m.a.s.l., 04°13′41.34″ N, 75°00′11.1636″ W, 18th november 2015, coll. A. Ramos ex. leaves, branches and fruits of key lime, *Citrus* x *latifolia* (Rutaceae), 32♀♀, Catalogue No. UNAB 1837; Tolima, Espinal, vereda La Morena, Citriexpinal, 331 m.a.s.l., 04°13'59.62" N, 74°54'23.96" W, 2nd march 2016, coll. A. Ramos, ex. stored fruits of key lime, *Citrus* x *latifolia* (Rutaceae). 10♀♀, Catalogue No. UNAB 1837.

NOTE: The scale insects were found in high populations (Figure 1).

***Parlatoria ziziphi* (Lucas)**

Coccus ziziphi Lucas, 1853: xxix. Type data: FRANCE: on *Ziziphus pinnachristi*. Syntypes, female. Described: female.
Chermes aurantii Boisduval, 1867: 338-339. [Synonymized by McKenzie, 1945: 54].
Parlatoria lucassi Targioni Tozzetti, 1868: 735. Nomen nudum.
Parlatoria (*Websteriella*) *ziziphus* (Lucas); Ramakrishna Ayyar, 1919: 26. Change of combination.
Apteronidia ziziphi (Lucas); Lindinger, 1934: 62. Change of combination.
Diaspis ziziphus (Lucas); Lindinger, 1934: 62. Change of combination.
Parlatoreopsis ziziphi (Lucas); Kawai, 1972: 23. Change of combination.

Field characters

According to Miller and Davidson (2005) the adult female cover is flat, broadly elongate oval, black with narrow white fringe, with two or three longitudinal ridges, shed skins marginal, black, primary component of cover second shed skin; white; body of newly matured adult female yellow brown, margin of body lateral of mouthparts with a small lobe; normally on leaves, also on branches and fruit.

Slide-mounted characters

The description and character states that differentiates *P. ziziphi* from others species of *Parlatoria* agrees well with those proposed by Miller and Davidson (2005): body

oval, length usually less than two times the greatest width; presence of perivulvar pores; marginal macroducts barrel shaped, length of ducts usually less than three times width of inner end of duct; a barrel shaped macroduct present between median lobes; plates or gland spines in space between median and second lobes with at least two apical fimbriations, usually more; with conspicuous ear-like lobes on body margin laterad of mouthparts.

The differences between *P. ziziphi* and others species of *Parlatoria* present on *Citrus* spp. in Colombia are given in the key.

Material studied

Parlatoria ziziphi (Lucas). Colombia, Atlántico, Sabanagrande, Vda Los Caracoles, 9 m of altitude, 10°47'16.3" N, 74°46'07.2" W, 8th december 2015, coll. O. Dix; E. Palacino ex. *Citrus x limonia* (Rutaceae), 23♀♀, Catal. UNAB 1885.

Updated list of species of Diaspididae on *Citrus* spp. from Colombia. Author(s) after the colon (:) correspond to whom recorded each species.

Acutaspis scutiformis (Cockerell, 1893): Figueroa (1977).
Aonidiella comperei (McKenzie, 1937): Present study.
Aspidiotus nerii (Costa, 1829): Gallego and Vélez (1992), Kondo *et al.* (2012), Posada (1989).
Aulacaspis tubercularis (Newstead, 1906): Kondo *et al.* (2012), Posada (1989).
Chrysomphalus aonidum (Linnaeus, 1758): Balachowsky (1959), Figueroa (1946, 1952, 1977), Gallego and Vélez (1992), Kondo *et al.* (2012), Mosquera (1979), Posada (1989).
Chrysomphalus dictyospermi (Morgan, 1889): Figueroa (1946, 1952, 1977), Gallego and Vélez (1992), Kondo *et al.* (2012), Mosquera (1979), Posada (1989).
Hemiberlesia lataniae (Signoret, 1869): Kondo *et al.* (2012), Posada (1989).
Hemiberlesia palmae (Cockerell, 1892): Kondo *et al.* (2012), Posada (1989).
Ischnaspis longirostris (Signoret, 1882): Balachowsky (1959), Gallego and Vélez (1992) Kondo *et al.* (2012), Mosquera (1979), Posada (1989).
Lepidosaphes beckii (Boisduval, 1868): Balachowsky (1959), Figueroa (1952, 1977), Gallego and Vélez (1992), Mosquera (1979), Kondo (2001), Kondo *et al.* (2012).
Lepidosaphes gloverii (Packard, 1869): Balachowsky (1959), Figueroa (1952, 1977), Kondo (2001), Kondo *et al.* (2012), Mosquera (1979), Posada (1989).
Lopholeucaspis sp.: Mosquera (1979), Posada (1989).
Parlatoria cinerea (Hadden in Doane and Hadden, 1909): Kondo (2001), Kondo *et al.* (2012), Mosquera (1979), Posada (1989).
Parlatoria pergandii (Comstock, 1881): Kondo (2001), Kondo *et al.* (2012), Mosquera (1979), Posada (1989).
Parlatoria ziziphi (Lucas, 1853): Blackburn and Miller (1984)
Pinnaspis aspidistrae (Signoret, 1869): Figueroa (1952, 1977), Kondo *et al.* (2012), Mosquera (1979), Posada (1989).
Pinnaspis strachani (Cooley, 1898): Balachowsky (1959), Kondo *et al.* (2012), Mosquera (1979), Posada (1989).
Pseudaonidia trilobitiformis (Green, 1896): Kondo *et al.* (2012), Mosquera (1979), Posada (1989).
Selenaspidus articulatus (Morgan, 1889): Balachowsky (1959), Kondo *et al.* (2012), Mosquera (1979), Posada (1989).
Unaspis citri (Comstock, 1881): Balachowsky (1959), Figueroa (1952, 1977), Gallego and Vélez (1992), Kondo (2001), Kondo *et al.* (2012), Mosquera (1979), Posada (1989).

Key to subfamilies, genera and species of Diaspididae on *Citrus* spp. from Colombia (Compiled from Beardsley (1966), Claps and Wolff (2003), Kosztarab (1996), McKenzie (1946), Miller (2005), Miller and Davidson (2005) and Watson (2016)).

1. Macroducts normally of the "one-barred type", length of each one at least six times the width; second pygidial lobes unilobulate; anterior spiracles usually without associated pores; antennae of adult female usually bearing only one seta; pygidial plates present in second instar if not in adult; gland spines absent; duct tubercles absent; body circular or pyriform (Figure. 4A) .... **Aspidiotinae** …….12
1'. Macroducts of the "two barred" type, length of each one rarely longer than three times their width; second pygidial lobes uni-or bilobulate; anterior spiracles usually with associated pores; antennae of adult female often bearing more than one seta; pygidial plates or gland spines often present in second instar if not in the adult; gland spines present or absent; duct tubercles may be present; body usually elongate

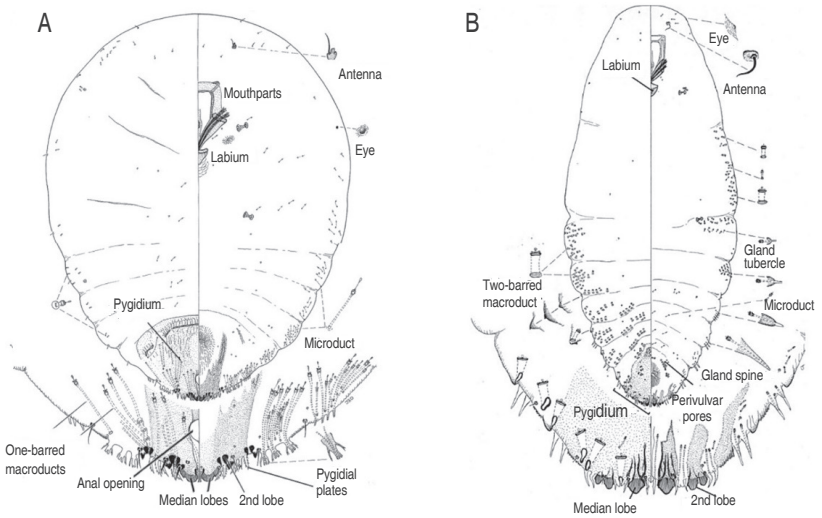

Figure 4. Habitus with magnified structures of two main subfamilies of Diaspididae. A. Aspidiotinae (Illustration from Miller and Davidson 1998); B. Diaspidinae. Illustration by Davidson (Miller, 2005).

spindle-shaped, rarely pyriform (Figure 4B) ..... **Diaspidinae** 2

2. Adult female with second lobes bilobulate (Figure 5A); gland spines usually present, occasionally replaced by plates; pores often associated with anterior and posterior spiracles; marginal macroducts usually with the long axis of each orifice perpendicular to margin; antennae each usually with two or more setae 6

2'.Adult female with second lobes unilobulate (Figure 5B); gland spines absent, plates usually present; spiracular pores associated with anterior spiracles only; marginal macroducts often with the long axis of each orifice oriented parallel to margin; antenna with one or more setae 3

3. Antenna with two to six setae; adult female pupillarial; body more or less elongate; plates, if present, confined to pygidium; marginal pygidial ducts not enlarged; abdominal disc pores sometimes present on some prepygidial segments ..... ***Lopholeucaspis* sp.**

3' Antenna with one seta; adult female usually not pupillarial; body oval to circular (elongate if pupillarial); plates often

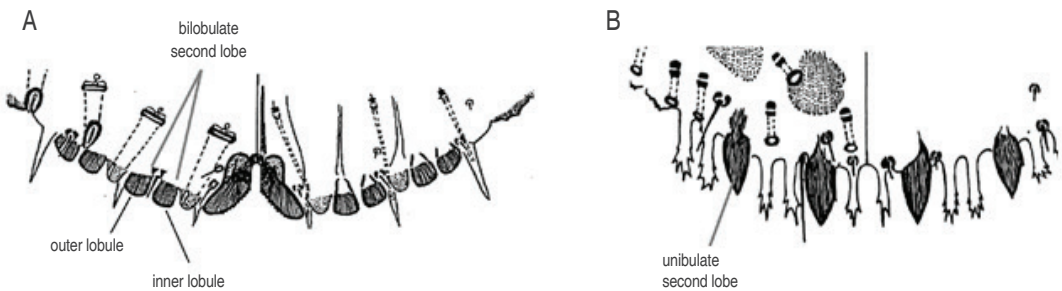

Figure 5. A**.** Pigydium with second lobe bilobulate; B**.** Pigydium with second lobe unilobulate. Illustrations taken from Miller and Davidson (2005).

present on pre pygidium and pygidium; marginal pygidial ducts often enlarged; abdominal disc pores never present on some prepygidial segments..... ***Parlatoria*** (Targioni Tozzetti) 4

4. With a large, conspicuous, lateral and membranous lobe on each side of head, marginal to each anterior spiracle; female scale composed principally of a large black second exuvium ***..... Parlatoria ziziphi*** (Lucas) (Figure 6).

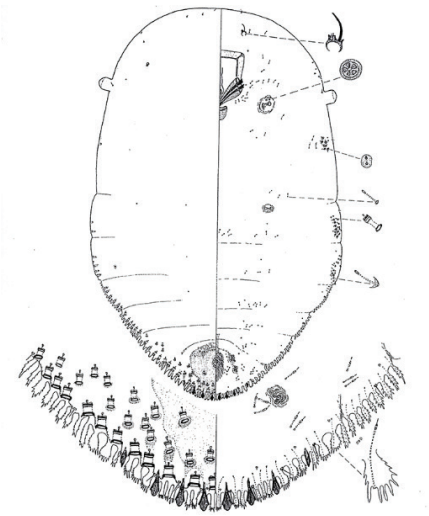

Figure 6. Habitus of *Parlatoria ziziphi* (Lucas) with magnified structures. Illustration taken from Miller and Davidson (2005).

4' Without such a membranous lobe on each side of head; female scale cover not largely black 5

5. Dorsum of pygidium with two longitudinal rows of macroducts on each side of pygidium on abdominal segments six and seven, extending cephalad to well anterior of anal opening; three plates between third and fourth lobs ..... ***Parlatoria cinerea*** (Hadden in Doane and Hadden) (Figure 7A)

5'. Dorsum of pygidium without such rows of macroducts; macroducts not found anterior to anal opening on these segments; four plates between third and fourth lobes ..... ***Parlatoria pergandii*** (Comstock) (Figure 7B)

6. Median lobes zygotic (Figure 8A) ..... 7.

6'. Median lobes not zygotic (although crowding or secondary sclerotization may make this difficult to see) (Figure 8B) 9

7. Gland spines and macroducts absent from area anterior to abdominal segment 1; body of characteristic shape, with head, prothorax, and mesothorax swollen and rectangular; lateral margin side of prothorax on older females with 1

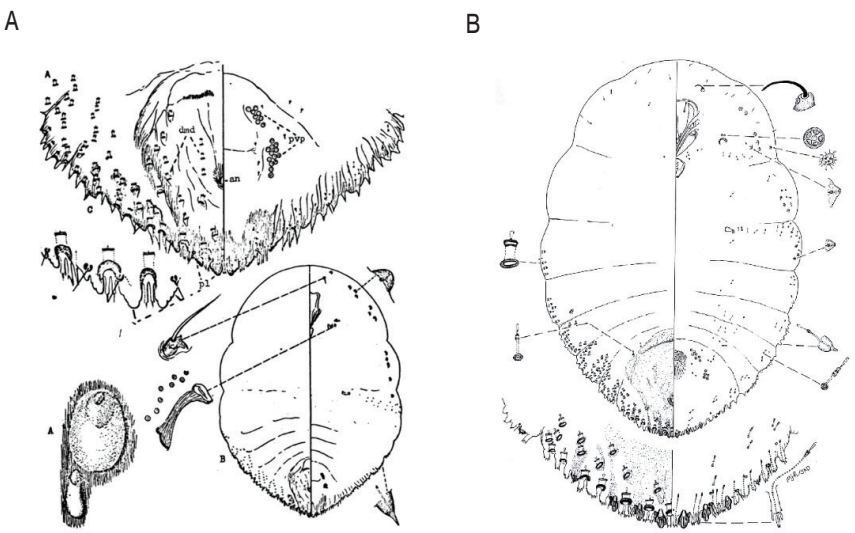

Figure 7. Habitus with magnified structures of: A**.** *Parlatoria cinerea* (Hadden in Doane & Hadden) (Illustration taken from Gerson 1977); B. *Parlatoria pergandii* (Comstock). Illustration taken from Miller and Davidson (2005).

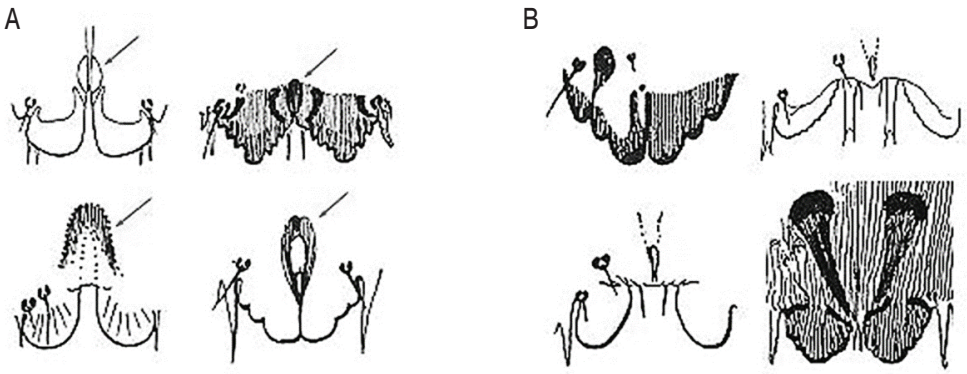

Figure 8. A. Median lobes zygotic; B. Median lobes not zygotic. Illustrations taken from Watson (2016).

swollen tubercle on each side of body; labium set in groove, with sclerotized areas on each side…….. ***Aulacaspis tubercularis*** (Newstead) (Figure 9).

7'.Gland spines and macroducts present anterior to abdominal segment 1; head, prothorax, and mesothorax not swollen; without lateral tubercles on lateral margin side of prothorax on older females; labium set not in groove, without sclerotized areas on each side…....……***Pinnaspis*** (Cockerell).....8

8. Preanal sclerosis lacking or represented by light sclerotized patch; median lobes protrude less than or about same distance as second lobes; posterior spiracles each

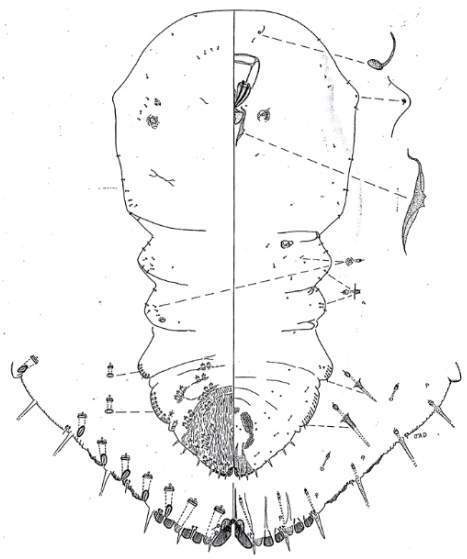

Figure 9. Habitus with magnified structures of *Aulacaspis tubercularis* (Newstead). Illustration taken from Miller and Davidson (2005).

with one to 12 pores, four pores on average ……..…. ***Pinnaspis aspidistrae*** (Signoret) (Figure 10A)

8'. Preanal sclerosis represented by sclerotized bar; median lobes protrude beyond or about same distance as second lobes; posterior spiracles each with 0 to four pores, two pores on average …….…….. ***Pinnaspis strachani*** (Cooley) (Figure 10B)

9. Median lobes with only a pair of marginal setae between their bases ……11

9'. Median lobes with only a pair of gland spines between their bases …..…… ***Lepidosaphes*** (Schlectendal) 10

10. Mature female without sclerotized pattern on thorax; without sclerotized dermal pockets on thorax; macroducts

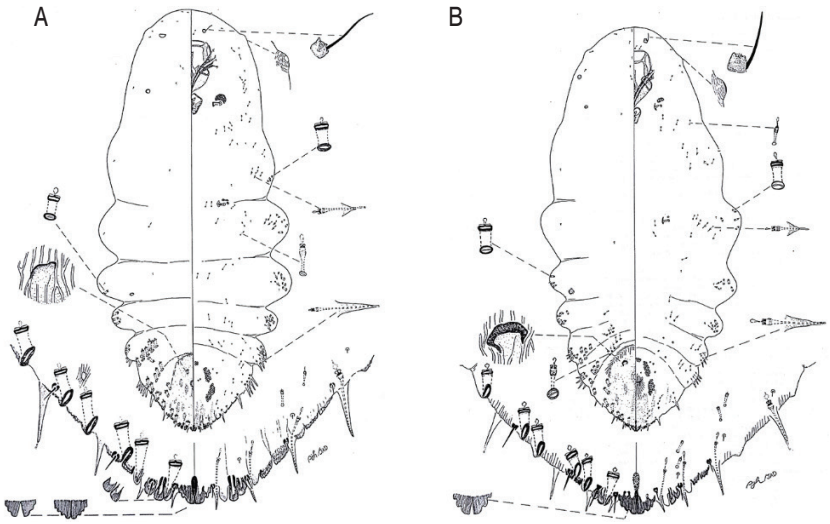

Figure 10. Habitus with magnified structures of: A. *Pinnaspis aspidistrae* (Signoret) B. *Pinnaspis strachani* (Cooley). Illustrations taken from Miller and Davidson (2005).

on dorsal margin of prothorax present ……***Lepidosaphes beckii*** (Boisduval) (Figure 11A)

10'. Mature female with distinctive pattern of punctures on dorsum of thorax extending to ventral margin; with sclerotized dermal pockets on pro- and mesothorax; macroducts on dorsal margin of prothorax absent …….. ..... ***Lepidosaphes gloverii*** (Packard) (Figure 11B)

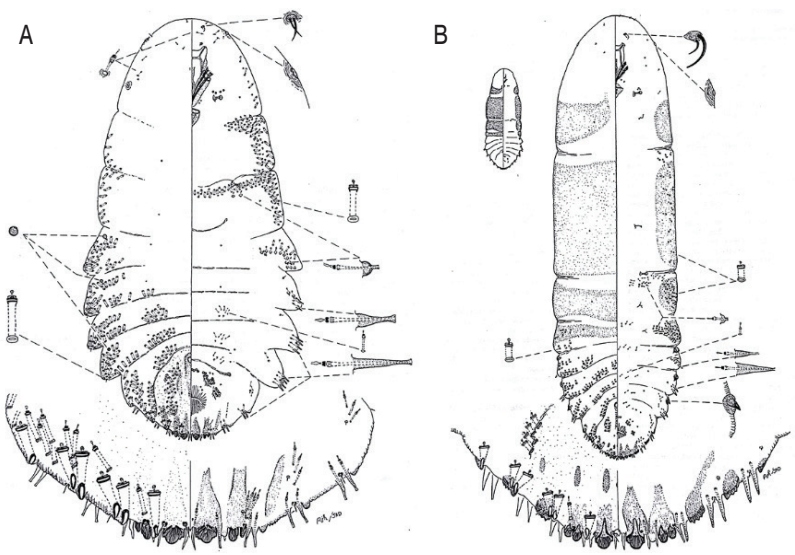

Figure 11. Habitus with magnified structures of: A. Lepid*osaphes beckii* (Boisduval); B. *Lepidosaphes gloverii* (Packard). Illustrations taken from Miller and Davidson (2005).

11. Dorsum of pygidium with a coarse 'lattice-work' sclerotized pattern ……..…. ***Ischnaspis longirostris*** (Signoret) (Figure 12A)

11'. Dorsum of pygidium without such a sclerotized pattern; with four or fewer perivulvar pores on each side of body ..…..... ***Unaspis citri*** (Comstock) (Figure 12B)

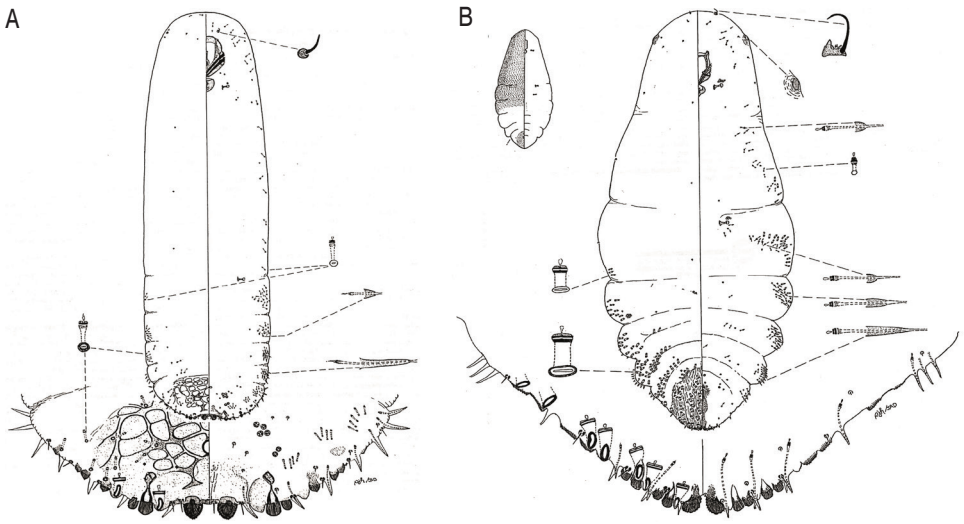

Figure 12. Habitus with magnified structures of: A. *Ischnaspis longirostris* (Signoret); B. *Unaspis citri* (Comstock). Illustrations taken from Miller and Davidson (2005).

12. Dorsal surface of pygidium with a conspicuous mosaic or areolate appearance ……. ***Pseudaonidia trilobitiformis*** (Green) (Figure 13A)

12'. Dorsal surface of pygidium without mosaic areolate pattern …… 13

13. Pygidial margin with paraphyses present, these sometimes small (arising from bases of lobes or from the margin itself); paraphyses sometimes present lateral to the outer lobes ……..14

13'. Pygidial margin without paraphyses ……. 19

14. Pygidial apex acute, forming an angle of 90° or less, although basal half of pygidium may be broad (Figure 13B); pygidial margins tending to be concave and sclerotized; plates confined to interlobular spaces …… ***Acutaspis scutiformis*** (Cockerell)

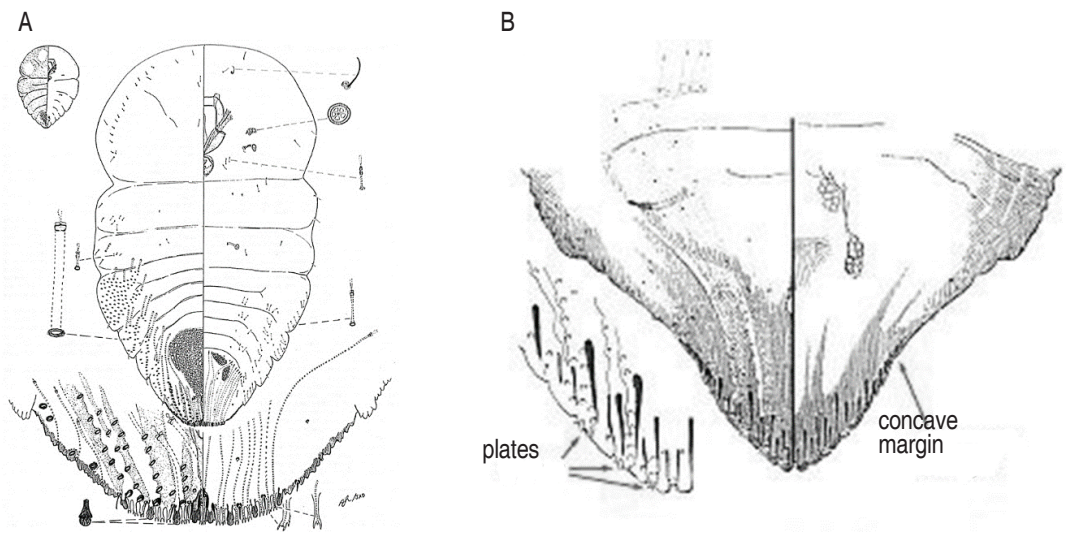

Figure 13. A. Habitus with magnified structures of *Pseudaonidia trilobitiformis* (Green). Illustration from Miller and Davidson (2005); B. Pygidial apex acute, forming an angle of 90° or less of *Acutaspis scutiformis* (Cockerell). Illustration taken from Watson (2016).

14'. Pygidial apex more or less broad, forming an angle greater than 90°; pygidial margins convex or straight, with or without sclerotization; plates often present lateral to third lobes ……..…… 15

15. Mature specimens with prosoma very enlarged and sclerotized, usually reniform so its lateral lobes more or less enclose the pygidium. If prosoma not reniform at maturity (*A. orientalis*), then paraphyses between second and third lobes never longer than the lobes.....……. ***..... Aonidiella comperei*** McKenzie (Figure 14)

15'. Mature specimens with prosoma membranous or sclerotized, not expanded sufficiently to become reniform; paraphyses between second and third lobes shorter or longer than the lobes ……..……..... 16

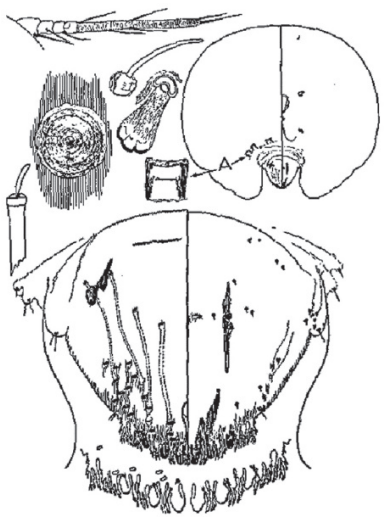

Figure 14. Habitus with magnified structures of *Aonidiella comperei* McKenzie. Illustration taken from McKenzie (1937).

16. Paraphyses obviously longer than median lobes (Figure 15A) …… ***Chrysomphalus*** (Ashmead)….....17

16' Paraphyses same length or shorter than median lobes (Figure 15B) ……..……..…… ***Hemiberlesia*** (Berlese and Leonardi) .....….....18

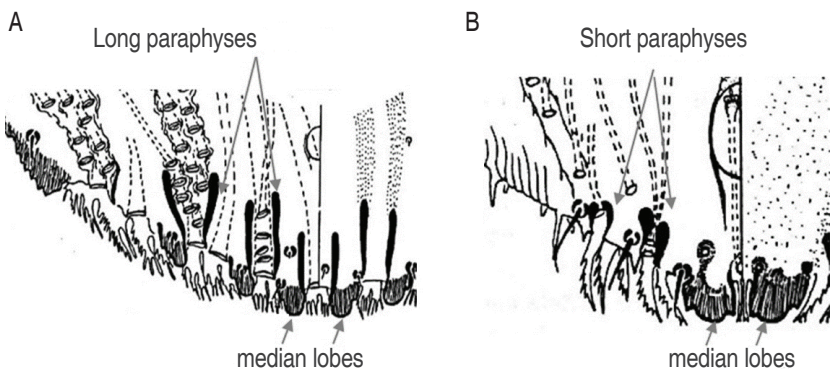

Figure 15. A. Paraphyses obviously longer than median lobes; B. Paraphyses same length or shorter than median lobes. Illustrations taken from Miller and Davidson (2005).

17. With one cluster of macroducts on submarginal areas of prepygidial segments; plates just lateral to third lobes fringed; nine to 13 prevulvar pores on each side of pygidium ……. ***..... Chrysomphalus aonidum*** (Linnaeus) (Figure 16A)

17'. Without clusters of macroducts on submarginal areas of prepygidial segments; plates just lateral to third lobes clavate; five or six prevulvar pores on each side of pygidium ..... ***Chrysomphalus dictyospermi*** (Morgan) (Figure 16B).

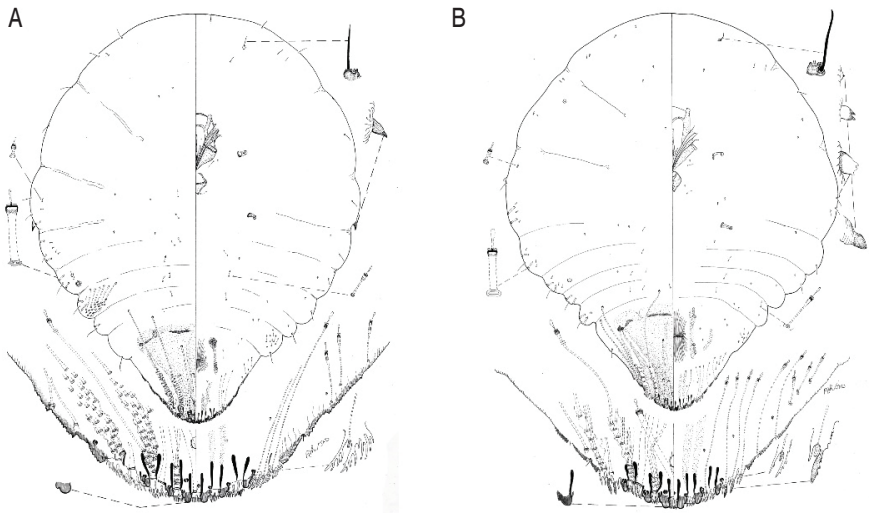

Figure 16. Habitus with magnified structures of: A. *Chrysomphalus aonidum* (Linnaeus); B. *Chrysomphalus dictyospermi* (Morgan). Illustrations taken from Miller and Davidson (2005).

18 Medial notch, first and second space of pygidium with band of fringe plates less strongly developed; plates in third space, if present, reduced in size, not forming such a dense uniform fringe; median lobes very close together, almost in touch; ..... ***Hemiberlesia lataniae*** (Signoret) (Figure 17a)

18'. Medial notch, first, second and third space of pygidium with a band of broad apically fringed plates of nearly uniform; plates in third space always present in a dense, nearly uniform fringe; median lobes separated, at least in the half of the width of each median lobe .... ***Hemiberlesia palmae*** (Cockerell) (Figure 17b)

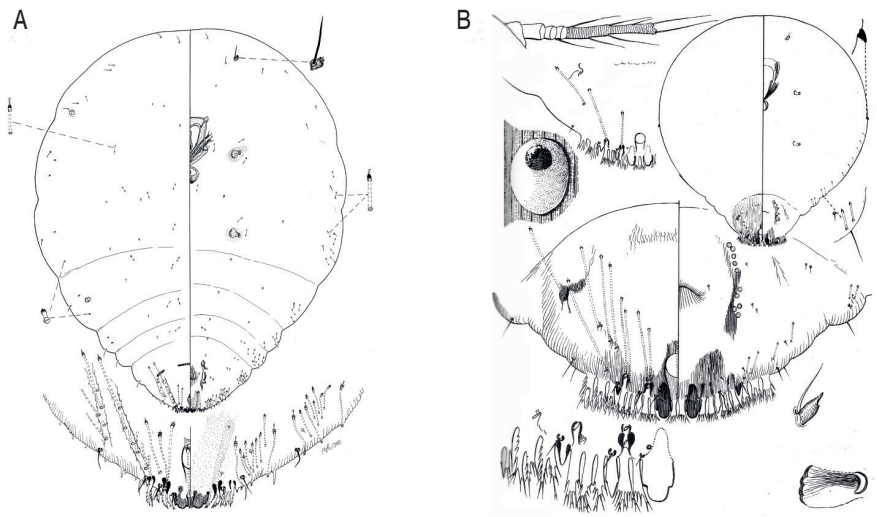

Figure 17. Habitus with magnified structures of A. *Hemiberlesia lataniae* (Signoret). Illustrations taken from Miller and Davidson (2005); B. *Hemiberlesia palmae* (Cockerell). Illustrations taken from Ferris (1938).

19. Prosoma strongly constricted between meso- and metathorax, and sclerotized; third lobe represented by an elongate, acute, sclerotized spine.....…….....…… .....***Selenaspidus articulatus*** (Morgan) (Figure 18a)

19'. Prosoma without strong constriction between meso- and metathorax, and usually membranous; third lobe short, either rounded or pointed, or absent…….. ……..... ***Aspidiotus nerii*** (Costa) (Figure 18b)

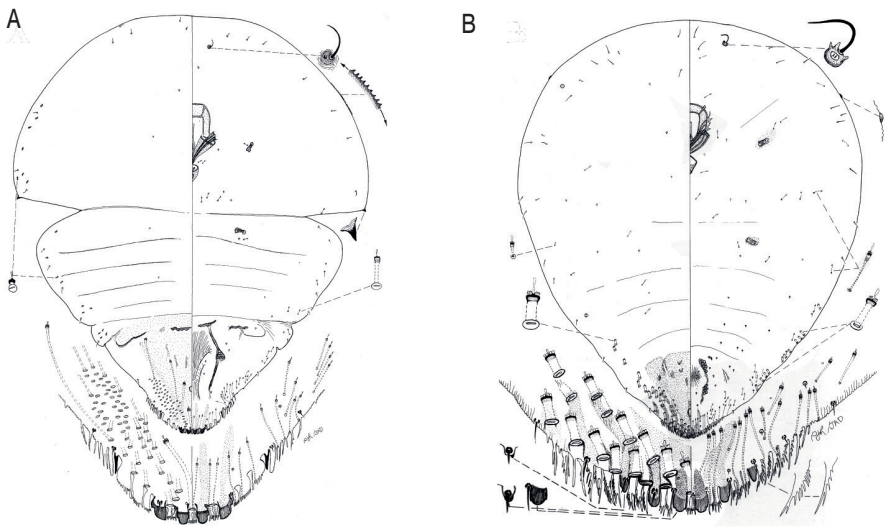

Figure 18. Habitus with magnified structures of: A. *Selenaspidus articulatus* (Morgan); B. *Aspidiotus nerii* (Costa). Illustrations taken from Miller and Davidson (2005).

CONCLUSIONS

The identity of *Aonidella comperei*, the species that is causing damage on fruits, branches and leaves of *Citrus aurantifolia* in Tolima, Colombia, was determined. This basic information will be useful to start studies about its biology and ecology in order to define management strategies. The knowledge about species of Diaspididae on *Citrus* spp. in Colombia is improved and the number of species recorded on this host and their geographical distribution is updated.

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REFERENCES

Balachowsky AS. 1957. Les cochenilles de la Guadeloupe et de la Martinique (première liste). Revue de Pathologie Végétale et d'Entomologie Agricole de France 36: 198-208.

Balachowsky AS. 1958. Les cochenilles du continent Africain Noir. v. 2 Aspidiotini (2me partie), Odonaspidini and Parlatorini. Annales du Musée Royal du Congo Belge (Sciences Zoologiques). Tervuren 4: 149-356.

Balachowsky AS. 1959. Nuevas cochinillas de Colombia. Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales 10: 337-361.

Balachowsky AS. 1959a. Otras cochinillas nuevas de Colombia. Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales 10: 362-366.

Beardsley JW and Gonzalez HR. 1975. The biology and ecology of armored scales. Annual Review of Entomology 20: 47-73. doi: 10.1146/annurev.en.20.010175.000403

Beardsley JW. 1966. Insects of Micronesia (Homoptera: Coccoidea). Insects of Micronesia 6: 377-562.

Blackburn,VL and Miller DR. 1984. Pests not known to occur in the United States or of limited distribution, No. 44: Black parlatoria scale. United States Department of Agriculture, Plant Protection and Quarantine, Animal and Plant Health Inspection Service 81-45: 1-13.

Chua TH, Wood BJ. 1990. Armored scale insects, their biology, natural enemies and control. pp. 543-552. In: Rosen D. (ed.). Other tropical fruit trees and shrubs. v. 4B. World Crop Pests. Elsevier Amsterdam, the Netherlands. 688 p.

Claps LE and Terán A. 2001. Diaspididae (Hemiptera: Coccoidea) asociadas a cítricos en la provincia de Tucumán (República Argentina). Neotropical Entomology 30(3): 391-402. doi: 10.1590/S1519-566X2001000300009

Claps LE and Wolff VS. 2003. Cochinillas Diaspididae (Hemiptera: Coccoidea) frecuentes en plantas de importancia económica de la Argentina y Brasil. Publicación Especial de la Sociedad Entomológica Argentina (3): 58 p.

Culik MP, Martins DS, Ventura JA and Wolff VS. 2008. Diaspididae (Hemiptera: Coccoidea) of Espírito Santo, Brazil. Journal of Insect Science 8(17): 1-6. doi: 10.1673/031.008.1701

Dekle GW. 1976. Florida armored scale insects. pp. 139-178. In*:* Delucchi V (ed.). Arthropods of Florida and neighboring land areas. Florida Department of Agriculture and Consumer Services Division of Plant Industry 3: 1-345.

EFSA PLH Panel (European Food Safety Authority Panel on Plant Health). 2014. Scientific opinion on the pest categorization of *Aonidiella citrina*. EFSA Journal 12(12): 3929-, 23 p. doi: 10.2903/j.efsa.2014.3929

Elder RJ, Smith D, Bell KL. 1998. Successful parasitoid control of *Aonidiella orientalis* (Newstead) (Hemiptera: Diaspididae) on *Carica papaya* L. Australian Journal of Entomology 37: 74-79.

Ferris GF. 1938. Atlas of the scale insects of North America. Series 3. Stanford University Press Palo Alto, California

Figueroa A. 1946. Catalogación inicial de las cochinillas del Valle del Cauca (Homoptera-Coccoidea). Revista Facultad Nacional de Agronomía 6(23): 220.

Figueroa A. 1952. Catálogo de los artrópodos de las clases Arachnida e Insecta, encontrados en el hombre, los animales y las plantas de la República de Colombia. Acta Agronómica 2(4): 199-223.

Figueroa A. 1977. Insectos y Acarinos de Colombia. Universidad Nacional de Colombia. Facultad de Ciencias Agropecuarias, Palmira. 685 p.

Gallego FL and Vélez R. 1992. Lista de insectos que afectan los principales cultivos, plantas forestales, animales domésticos y al hombre en Colombia. Universidad Nacional de Colombia. 198 p.

García Morales M, Denno BD, Miller DR, Miller GL, Ben-Dov Y and Hardy, NB. 2016. ScaleNet: A literature-based model of scale insect biology and systematics. Database. In: http://scalenet.info., accessed: May 2016. doi: 10.1093/database/bav118.

Gerson U. 1977. La caspilla *Parlatoria pergandii* Comstock y sus enemigos naturales en Israel. Boletín del Servicio de Plagas 3: 21-53.

Kondo T, Peronti AL, Kozár F and Szita É. 2012. Chapter 7. The scale insects associated with citrus, with emphasis on *Praelongorthezia praelonga* (Douglas) (Hemiptera: Coccoidea: Ortheziidae). pp. 173-189. In: Pássaro Carvalho CP. (ed.). Cítricos: cultivo, poscosecha e industrialización. Editorial Artes y Letras S.A.S., Itagüí, Colombia. 367 p.

Kondo T. 2001. Las cochinillas de Colombia (Hemiptera: Coccoidea). Biota Colombiana 2(1): 31-48.

Kosztarab M. 1996. Scale insects of Northeastern North America. Identification, biology, and distribution. Virginia Museum of Natural History Martinsburg, Virginia. 650 p.

Lee HS, Wen HC. 1977. Seasonal occurrence and control of the papaya red scale, *Aonidiella inornata* McKenzie (Homoptera: Diaspididae). Plant Protection Bulletin 19(3): 196-201.

Liegeois P. 1944. [Cocoa culture in the Belgian Congo]. La culture du cacaoyer au Congo Belge. Bulletin Agricole du Congo Belge 35(1-4): 147-173.

Mariau D. 1998. Hemiptera (Insecta) on oil palm and coconut. Insect Science and its Application 18(4): 269-277.

Martins D, Culik M and Wolff VS. 2004. New Record of Scale Insects (Hemiptera: Coccoidea) as Pests of Papaya in Brazil. Neotropical Entomology 33(5): 655-65. doi: 10.1590/S1519-566X2004000500018

Martins DdosS, Culik MP, Wolff VRdosS. 2004. New record of scale insects (Hemiptera: Coccoidea) as pests of papaya in Brazil. Neotropical Entomology 33(5): 655-657.

Martins MJ, Fornazier MP, Culik JA, Ventura PS, Ferreira F, Zanuncio, JC. 2015. Scale Insect (Hemiptera: Coccoidea) Pests of Papaya (*Carica papaya*) in Brazil. Annals of the Entomologycal Society of America 108(1): 35-43. doi: 10.1093/aesa/sau010.

Martorell LF. 1976. Annotated food plant catalog of the insects of Puerto Rico. Agricultural Experiment Station, University of Puerto Rico, Department of Entomology, Rio Piedras, Puerto Rico. 303 p.

Matile-Ferrero D and Étienne J. 2006. Cochenilles des Antilles françaises et de quelques autres îles Caraïbes [Hemiptera, Coccoidea]. Revue Française d'Entomologie 28(4): 161-190.

McKenzie HL. 1937. Morphological differences distinguishing California red scale, yellow scale, and related species (Homoptera, Diaspididae). University of California. Publications in Entomology. 6: 323-335.

McKenzie HL. 1946. Supplementary notes on the genera *Aonidiella* and *Parlatoria* (Homoptera: Coccoidea: Diaspididae). Microentomology 11: 29-36.

Miller DR and Davidson JA. 1990. A list of armored scale pests. pp 299-306. In: Rosen, D. (ed.). Armored scale insects. Their biology, natural enemies and control. Elsevier, Amsterdam, The Netherlands. Vol. 4B. 688 p.

Miller DR and Davidson JA. 1998. A new species of armored scale (Hemiptera: Coccoidea: Diaspididae) previously confused with *Hemiberlesia diffinis* (Newstead). Proceedings of the Entomological Society of Washington 100: 193-201

Miller DR and Davidson JA. 2005. Armored Scale Insect Pests of Trees and Shrubs. Cornell University Press. Ithaca, New York. 442 p.

Miller DR, Davidson JA. 1990. A List of the Armored Scale Insect Pests. pp. 299–306. In D. Rosen (ed). Armored scale insects, their biology, natural enemies and control. World Crop Pests. Elsevier Amsterdam, The Netherlands. Vol. 4B. 688 p.

Miller DR. 2005. Selected scale insect groups (Hemiptera: Coccoidea) in the southern region of the United States. Florida Entomologist 88(4): 482-500.

Mosquera PF. 1979. Escamas protegidas más frecuentes en Colombia. Boletín Técnico, Ministerio de Agrícola Instituto Colombiano Agropecuario, División de Sanidad Vegetal. Boletín Técnico 38. 103 p.

Nagarkatti S, Sankaran T. 1990. Tea. pp. 553-562 In: Rosen, D. (ed.). Armored scale insects, their biology, natural enemies and control. World Crop Pests. Elsevier Amsterdam, the Netherlands. Vol 4B. 688 p.

Nakahara S. 1983. List of the Coccoidea species (Homoptera) of the United States Virgin Islands. United States Department of Agriculture, Plant Protection and Quarantine, APHIS [Mimeograph] 8142: 1-21.

Posada L. 1989. Lista de Insectos dañinos y otras plagas en Colombia. Cuarta edición. Instituto Colombiano Agropecuario, ICA. División de Disciplinas Agrícolas, Sección Entomología. Boletín Técnico No. 43. 675 p.

Rajagopal D, Krishnamoorthy A. 1996. Bionomics and management of oriental yellow scale, *Aonidiella orientalis* (Newstead) (Homoptera: Diaspididae): an over view. Agricultural Research 17: 139-146.

Rose M. 1990. Citrus. pp. 535-541. In: D. Rosen (ed). Armored scale insects, their biology, natural enemies and control. World Crop Pests. Elsevier Amsterdam, The Netherlands. Vol. 4B. 688 p.

Rosen D, DeBach P. 1978. Diaspididae. Introduced parasites and predators of arthropod pests and weeds: a world review. Agricultural Research Service, United States Department of Agriculture Washington, D.C. 545 p.

Sirisena UGAI, Watson GW, Hemachandra KS, Wijayagunasekara HNP. 2013. A modified technique for the preparation of specimens of Sternorrhyncha for taxonomic studies. Tropical Agricultural Research 24(2): 139-149.

Swirski E, Wysoki M, Izhar Y. 2002. Subtropical fruit pests in Israel. Fruit Board of Israel, Tel Aviv. 284 pp.

Takagi S. 1962. *Aonidiella comperei* McKenzie from Formosa. Insecta Matsumurana 25: 52.

Takagi S. 1970. Diaspididae of Taiwan based on material collected in connection with the Japan-U.S. Cooperative Science Programme, 1965 (Homoptera: Coccoidea). Pt. II. Insecta Matsumurana 33: 1-146.

Velasquez FJ. 1971. Some Philippine armored scale insects of the tribe Aspidiotini (Diaspididae, Homoptera). Philippine Entomologist 2(2): 89-153.

Watson, GW. 2016. Arthropods of economic importance: Diaspididae. S.A. Ulenberg (series editor), http://wbd.etibioinformatics.nl/bis/diaspididae.php?menuentry=sleutel; accessed: May 2016.

Williams DJ and Watson, GW. 1988. The scale insects of the tropical south Pacific region. Pt. 1. The Armoured scales (Diaspididae). CAB International, Wallingford, U.K. 290 p.

Zamudio P and Claps LE. 2005. Diaspididae (Hemiptera: Coccoidea) asociadas a frutales en la Argentina. Neotropical Entomology 34(2): 255-272. doi: 10.1590/S1519-566X2005000200014.