

## Research Article

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# A taxonomic key to mealybugs (Hemiptera: Coccoomorpha: Pseudococcidae) of Florida, United States

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**Abstract:** Many mealybug species (Hemiptera: Coccoomorpha: Pseudococcidae) are notably invasive and economically significant. They directly harm plants by extracting sap from the phloem, which diminishes plant vigor, induces chlorosis, and causes defoliation. Their excretion of honeydew promotes the growth of black sooty mold, reducing the aesthetic value of plants and obstructing photosynthesis. Additionally, mealybugs serve as vectors for plant viruses and toxins. Conversely, many native mealybug species may not be pests and can provide important resources for other insects. Existing taxonomic keys for mealybug identification are limited and not comprehensive for all species in Florida, United States. This study presents the first definitive identification key for the 79 mealybug species established in landscapes or commonly collected in nurseries in Florida. The key utilizes morphological characters of slide-mounted adult females. Our key will enable researchers, extension agents, identifiers, and regulators to make accurate identifications, which are crucial for comprehending the ecology, economic impact, control strategies, and significance of mealybugs. This, in turn, facilitates timely and effective management and regulatory measures to safeguard the United States agricultural industry.

**Keywords:** identification; insect pests; invasive species; scale insects; Southern United States

**Resumen:** Muchas especies de cochinillas (Hemiptera: Coccoomorpha: Pseudococcidae) son notablemente invasivas y de gran importancia económica. Dañan directamente a las plantas al extraer savia del floema, lo que disminuye el vigor de la planta, induce clorosis y causa defoliación. Su excreción de melaza promueve el crecimiento de fumagina, lo que reduce el valor estético de las plantas y obstruye la fotosíntesis. Además, las cochinillas sirven como vectores de virus y toxinas vegetales. Por otro lado, muchas especies nativas de cochinillas pueden no ser plagas y pueden proporcionar recursos importantes para otros insectos. Las claves taxonómicas existentes para la identificación de la cochinilla, en Florida, Estados Unidos, son limitadas y no son exhaustivas para todas las especies. Este estudio presenta la primera clave de identificación definitiva para las 79 especies de cochinillas establecidas en paisajes o comúnmente recolectadas en viveros en Florida. La clave utiliza caracteres morfológicos de hembras adultas en portaobjetos. Nuestra clave permitirá a investigadores, extensionistas, identificadores y reguladores realizar identificaciones precisas, y cruciales para comprender la ecología, el impacto económico, las estrategias de control y la importancia de las cochinillas harinosas. Esto, a su vez, facilita la implementación oportuna y eficaz de medidas de gestión y regulación para proteger la industria agrícola estadounidense.

**Palabras clave:** identificación; plagas de insectos; especies invasoras; cochinillas; sur de Estados Unidos

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## 1 Introduction

Among plant sap-sucking insects, scale insects (Hemiptera: Coccoomorpha) are recognized as some of the most notorious invasive species globally (Miller et al. 2005). These diminutive insects, particularly in the mobile first instar (crawler stage), often reside in concealed parts of their host plants (Ahmed et al. 2021). They are disseminated worldwide

through the movement of plant material, including fruits and ornamental plants (Miller et al. 2002). Although scale insects constitute only 1% of the total insect fauna in the United States (US), they represent 13% of the adventive insect fauna in the US (Miller et al. 2005). On average, one new invasive scale insect species becomes established as a pest in the US annually (Miller et al. 2005). Overall, scale insects cause billions of dollars in damage annually (Kosztarab 1990). Florida hosts nearly 400 species of scale insects, making it the state with the second-highest diversity of scale insects in the country, following California, which has 540 species (Ahmed 2023; García Morales et al. 2016).

Among scale insects, female mealybugs (Pseudococcidae) are characterized by their small, soft-bodied, wingless form and the white, powdery, meal-like wax covering their bodies (Ahmed 2023; McKenzie 1967). These insects can be found feeding on all parts of plants, both above and below ground (McKenzie 1967; Powell et al. 2024). Mealybugs reproduce both sexually and asexually and sometimes have multiple overlapping generations within a short period (Diepenbrock and Ahmed 2020). Similar to some other hemipterans, they feed exclusively on phloem sap (Douglas 2006), causing direct damage to plants by extracting sap from the phloem. This feeding behavior reduces plant vigor, induces chlorosis, and leads to defoliation (Diepenbrock and Ahmed 2020). Mealybugs excrete honeydew, which promotes the development of black sooty mold, thereby reducing the aesthetic value of plants and obstructing photosynthesis (Ahmed 2023). Additionally, mealybugs are capable of transmitting plant viruses and toxins (Ahmed 2023).

Globally, approximately 2,000 species of mealybugs have been described, with 320 species present in the US and 70 to 80 species documented in Florida (Ahmed 2023; García Morales et al. 2016). Over the past 25 years, numerous pest mealybugs have been introduced and have become established in Florida (Powell et al. 2024). Among the notable recently invasive species are the giant bamboo mealybug, *Chaetococcus bambusae* (Maskell), the pink hibiscus mealybug, *Maconellicoccus hirsutus* (Green), the Lebeck mealybug, *Nipaeococcus viridis* (Newstead), the agave mealybug, *Paracoccus gilliana* von Ellenrieder & Stocks, the papaya mealybug, *Paracoccus marginatus* Williams & Granara de Willink, the bamboo mealybug, *Palmicultor lumpurensis* (Takahashi), Ehrhorn's palm mealybug, *Palmicultor palmarum* (Ehrhorn), the passion-vine mealybug, *Planococcus minor* (Maskell), *Phenacoccus multicercarii* Granara de Willink, and *Phenacoccus miruku* Tanaka & Choi (Ahmed 2023; García Morales et al. 2016; Hodges 2002; Hodges and Hodges 2004; Powell et al. 2024; Stocks 2012; Stocks and Hodges 2010; Stocks and Roda 2011).

Protecting the US agricultural industry from these new mealybug species requires, first and foremost, accurate identification. This enables decision-makers to access crucial information about species of regulatory concern (Ahmed and Deeter 2022; Ahmed et al. 2015a,b, 2023). There has been significant taxonomic literature published on mealybug species in the US in the last century. Examples include Rau (1938), Ferris (1953, 1955), McKenzie (1960), Beardsley (1965), McKenzie (1967), Williams (1969), Miller and McKenzie (1971, 1973), Miller (1973, 1974, 1975), Howell and Miller (1976), Miller and Denno (1977), Miller (1983), Miller et al. (1984), Miller and Williams (1985), Gimpel and Miller (1996), Kosztarab (1996), Miller and Polavarapu (1997), Miller and Williams (1997), Miller (1999), Miller et al. (1999), Miller and Miller (2002a,b), von Ellenrieder and Stocks (2014), von Ellenrieder et al. (2018), and Powell et al. (2024). These publications contain identification keys for several species and genera of mealybugs. Most of these keys are either taxonomically or geographically limited; none focus on the mealybugs of Florida. For the first time, our study provides a taxonomic key for the slide-mounted adult females of the 79 mealybug species established in landscapes or commonly collected in nurseries in Florida.

## 2 Materials and methods

The first step in developing this key was to prepare a list of mealybugs established in landscapes or commonly collected in nurseries in Florida. We reviewed slide-mounted specimens deposited in the Florida State Collection of Arthropods (FSCA), the database of the Florida Department of Agriculture and Consumer Services, Division of Plant Industry (FDACS-DPI 2025), ScaleNet (García Morales et al. 2016) and published literature to confirm the species established in Florida. The second step was to confirm the species' identities. We used the following published taxonomic treatments for this purpose: Rau (1938), Ferris (1955), McKenzie (1960), Beardsley (1965), De Lotto (1967) (South Africa), McKenzie (1967), Williams (1969), Miller and McKenzie (1970, 1971, 1973), Miller (1973, 1974, 1975), Howell and Miller (1976), Miller and Denno (1977), Miller (1983), Miller et al. (1984), Miller and Williams (1985), Williams and Watson (1988) (South Pacific region), Cox 1989; Williams and Granara de Willink (1992) (Central and South America), Gimpel and Miller (1996), Kosztarab (1996), Miller and Polavarapu (1997), Miller and Williams (1997), Miller (1999), Miller et al. (1999), Miller and Miller (2002a,b), Williams (2004) (South Asia), Granara de Willink and Szumik (2007) (Central and South America), Miller and

Giliomee (2011) (Africa), Kaydan and Gullan (2012), Granara de Willink and González (2018) (Central and South America), von Ellenrieder et al. (2018), and Powell et al. (2024).

Multiple genera had specimens that we have determined are undescribed species, including the grass-infesting genera *Distichlicoccus* Ferris and *Tridiscus* Ferris. Other grass-infesting genera, e.g., *Trionymus* Berg and *Pseudantonina* Green, require revision and consequently only come out to genus in the key.

After confirming their identities, we utilized descriptions, illustrations, slide-mounted specimens, and existing taxonomic keys to develop a comprehensive taxonomic key. Wherever possible, at least ten slide-mounted specimens were examined for each species. Specific measurements used in the key were derived from original species descriptions and our own examination of at least ten slide-mounted specimens. Terminology follows that of Miller et al. (2014), an expert system for determining species commonly intercepted at US ports-of-entry. It provides visual and textual information on commonly used terms in scale insect taxonomic keys, including mealybugs. We also provide an illustration (Figure 1) that depicts morphological characters.

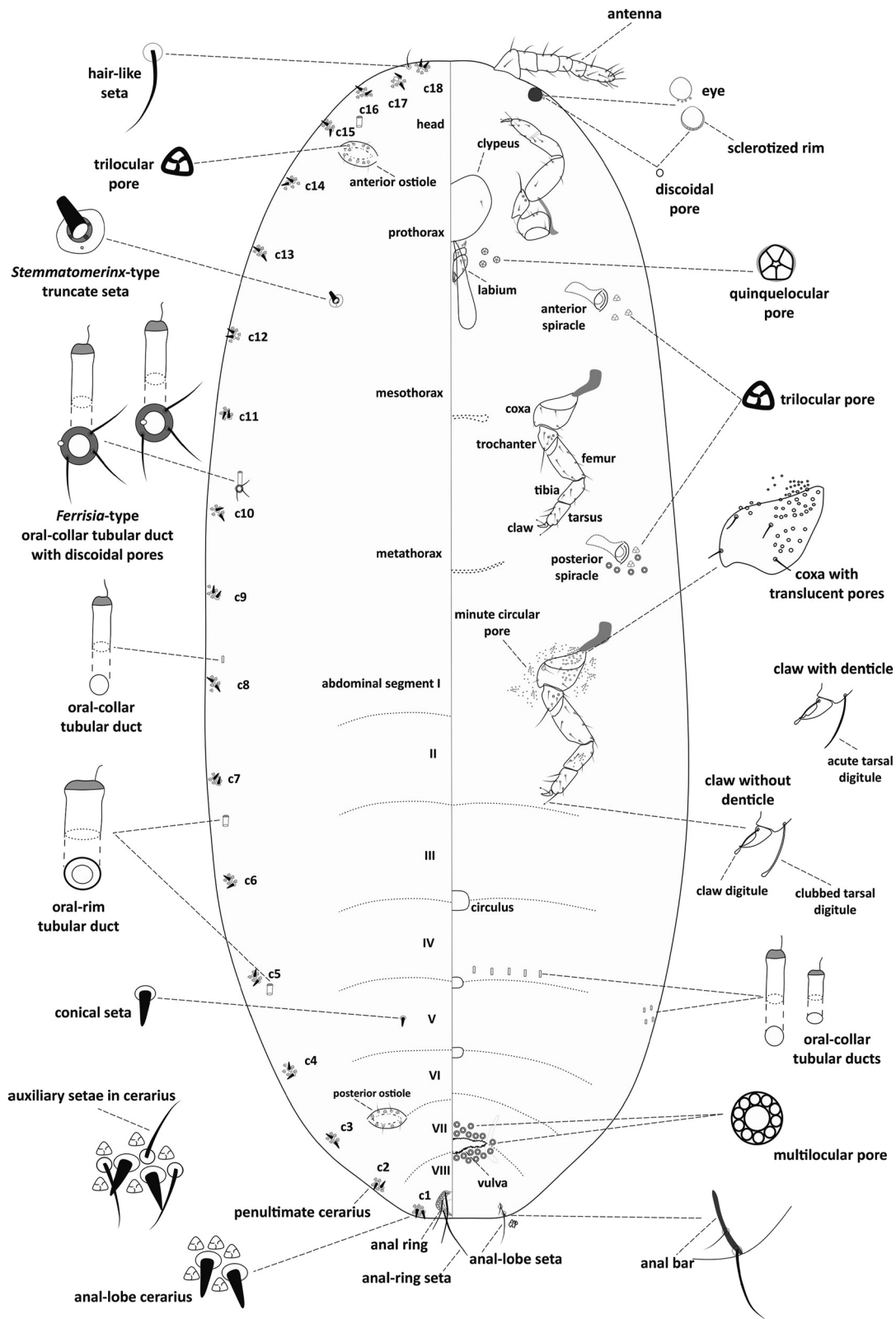
## 3 Results

### 3.1 List of Florida mealybugs

We conclude that 79 mealybug species are established in landscapes or commonly collected in nurseries in Florida. \*There are undescribed species for these four genera found in Florida.

\*\*These 12 species and three genera key out at two places in the key.

1. *Antonina graminis* (Maskell, 1897)
2. *Antonina pretiosa* Ferris, 1953
3. *Antoninoides nortoni* (Parrott & Cockerell in Parrott, 1899)
4. *Antoninoides parrotti* (Cockerell, 1903)
5. *Brevennia rehi* (Lindinger, 1943)
6. *Chaetococcus bambusae* (Maskell, 1893)
7. *Chnaurococcus trifolii* (Forbes, 1885)
8. *Chorizococcus rostellum* (Lobdell, 1930)
9. *Crisicoccus taxodii* Kosztarab, 1996
10. *Delottococcus confusus* (De Lotto, 1977)\*\*
11. *Distichlicoccus* species Ferris, 1950\*
12. *Dysmicoccus boninsis* (Kuwana, 1909)
13. *Dysmicoccus brevipes* (Cockerell, 1893)\*\*
14. *Dysmicoccus difficilis* (Lobdell, 1930)\*\*
15. *Dysmicoccus diodium* (McConnell, 1941)
16. *Dysmicoccus grassii* (Leonardi, 1913)
17. *Dysmicoccus mackenziei* Beardsley, 1965
18. *Dysmicoccus milleri* Kosztarab, 1996
19. *Dysmicoccus neobrevipes* Beardsley, 1959
20. *Dysmicoccus radinovskiyi* Miller & Miller, 2002
21. *Dysmicoccus texensis* (Tinsley, 1900)
22. *Ferrisia dasylirii* (Cockerell, 1896)
23. *Ferrisia gilli* Gullan, 2003
24. *Ferrisia malvastra* (McDaniel, 1962)
25. *Ferrisia quaintancii* (Tinsley, 1898)\*\*
26. *Ferrisia uzinuri* Kaydan & Gullan, 2012
27. *Ferrisia virgata* (Cockerell, 1893)
28. *Heterococcus raui* Miller, 1975
29. *Hypogeococcus hamoni* Miller, 1983
30. *Hypogeococcus margaretae* Miller, 1983
31. *Hypogeococcus pungens* Granara de Willink, 1981
32. *Leptococcus eugeniae* (Miller & Denno, 1977)
33. *Maconellicoccus hirsutus* (Green, 1908)
34. *Miscanthicoccus miscanthi* (Takahashi, 1928)
35. *Nipaecoccus floridensis* Beardsley, 2001\*\*
36. *Nipaecoccus nipae* (Maskell, 1893)\*\*
37. *Nipaecoccus viridis* (Newstead, 1894)
38. *Oracella acuta* (Lobdell, 1930)
39. *Palmicultor browni* (Williams, 1960)
40. *Palmicultor lumpurensis* (Takahashi, 1951)\*\*
41. *Palmicultor palmarum* (Ehrhorn, 1916)
42. *Paracoccus gilliana* von Ellenrieder & Stocks, 2014\*\*
43. *Paracoccus herreni* Williams & Granara de Willink, 1992
44. *Paracoccus juniperi* (Ehrhorn, 1906)\*\*
45. *Paracoccus lycopersici* Ezzat & McConnell, 1956
46. *Paracoccus marginatus* Williams & Granara de Willink, 1992
47. *Paradoxococcus mcdanieli* McKenzie, 1962
48. *Paraputo olivaceus* (Cockerell, 1896)
49. *Phenacoccus madeirensis* Green, 1923
50. *Phenacoccus miruku* Tanaka & Choi, 2022\*\*
51. *Phenacoccus multicerarii* Granara de Willink, 2007
52. *Phenacoccus parvus* Morrison, 1924
53. *Phenacoccus solani* Ferris, 1918
54. *Phenacoccus solenopsis* Tinsley, 1898
55. *Planococcus citri* (Risso, 1813)\*\*
56. *Planococcus minor* (Maskell, 1897)
57. *Pseudantonina* species Green, 1922\*\*\*
58. *Pseudococcus bryberia* Gimpel & Miller, 1996
59. *Pseudococcus dendrobiorum* Williams, 1985
60. *Pseudococcus dolichomelos* Gimpel & Miller, 1996
61. *Pseudococcus elisae* Borchsenius, 1947
62. *Pseudococcus importatus* McKenzie, 1960
63. *Pseudococcus jackbeardsleyi* Gimpel & Miller, 1996



**Figure 1:** Generalized diagrammatic illustration depicting the morphological structures of the mealybug family, Pseudococcidae. In the figure, c = cerarius.

- 64. *Pseudococcus landoi* (Balachowsky, 1959)
- 65. *Pseudococcus longispinus* (Targioni Tozzetti, 1867)
- 66. *Pseudococcus maritimus* (Ehrhorn, 1900)
- 67. *Pseudococcus microcirculus* McKenzie, 1960
- 68. *Pseudococcus nakaharai* Gimpel & Miller, 1996
- 69. *Pseudococcus odermatti* Miller & Williams, 1997
- 70. *Pseudococcus sorghiellus* (Forbes, 1885)
- 71. *Pseudococcus spanocera* Gimpel & Miller, 1996
- 72. *Pseudococcus viburni* (Signoret, 1875)
- 73. *Pseudoferrisia floridana* (Ferris, 1953)
- 74. *Saccharicoccus sacchari* (Cockerell, 1895)
- 75. *Spilococcus mamillariae* (Bouché, 1844)\*\*
- 76. *Stemmatomerinx acircula* Howell & Miller, 1976
- 77. *Stemmatomerinx adenticulata* Howell & Miller, 1976
- 78. *Symmococcus spirapunctus* (Lobdell, 1930)
- 79. *Tridiscus* species Ferris, 1950\*\*\*
- 80. *Trionymus* species Berg, 1899\*\*\*
- 81. *Vryburgia amaryllidis* (Bouché, 1837)
- 82. *Vryburgia brevicurvis* (McKenzie, 1960)
- 83. *Vryburgia trionymoides* (De Lotto, 1961)

**3.2 Taxonomic key to Florida  
Pseudococcidae (slide-mounted adult  
females) (Figure 1)**

- 1. Cerarii present.....10
- Cerarii absent.....2
- 2(1). Antennae 1–2 segmented.....3
- Antennae 4–7 segmented.....6
- 3(2). Abdomen without sclerotized plates.....4
- Abdomen with sclerotized plates.....
- .....*Antonina pretiosa* Ferris
- 4(3). Anal ring invaginated, dorsal multilocular pores absent.....5
- Anal ring not invaginated, dorsal multilocular pores present.....*Antoninoides nortoni* (Parrott & Cockerell)
- 5(4). Without compact group of duct-like pores behind posterior spiracles; ventral multilocular pores present on all abdominal segments.....*Antonina graminis* (Maskell)
- With compact group of duct-like pores behind posterior spiracles; ventral multilocular pores restricted to posterior 2 or 3 abdominal segments.....
- .....*Chaetococcus bambusae* (Maskell)
- 6(2). Antennae geniculate; often with tri- or bitubular cerores (i.e., tri- or bitubular pores or ducts).....
- .....Rhizoecidae<sup>#</sup>

- Antennae not geniculate; without tri- or bitubular cerores (i.e., tri- or bitubular pores or ducts).....
- .....7 (Pseudococcidae)
- 7(6). Without circulus.....8
- With circulus.....9
- 8(7). Coxa not enlarged, without translucent pores.....
- .....*Antoninoides parrotti* (Cockerell)
- Coxa enlarged, with translucent pores.....
- .....*Pseudantonina* Green (in part)
- 9(7). With pores in spiracular atrium.....
- .....*Symmococcus spirapuncta* (Lobdell)
- Without pores in spiracular atrium.....
- .....*Tridiscus* Ferris (in part)
- 10(1). Number of cerarii fewer than 10 pairs.....11
- Number of cerarii 10 pairs or more.....46
- 11(10). With oral-rim tubular ducts (excluding *Ferrisia*-type oral-collar tubular ducts).....12
- Without oral-rim tubular ducts.....22
- 12(11). Antennae 9 segmented.....13
- Antennae with fewer than 9 segments.....14
- 13(12). With denticle on claw; with 2 pairs of cerarii.....
- .....*Vryburgia trionymoides* (De Lotto)
- Without denticle on claw; with more than 2 pairs of cerarii.....*Maconellicoccus hirsutus* (Green)
- 14(12). With more than 5 multilocular pores on venter.....15
- Without or with less than 5 multilocular pores on venter.....21
- 15(14). Translucent pores present on hind coxa.....16
- Translucent pores absent from hind coxa.....20
- 16(15). With translucent pores on hind tibia.....17
- Without translucent pores on hind tibia.....
- .....*Chorizococcus rostellum* (Lobdell)
- 17(16). Claw denticle absent; translucent pores scattered on hind tibia.....18
- Claw denticle present; translucent pores in tight cluster on hind tibia.....
- .....*Spilococcus mamillariae* (Bouché) (in part)
- 18(17). With fewer than 10 ventral oral-rim tubular ducts in medial and mediolateral area of thorax.....19
- With 10 or more ventral oral-rim tubular ducts in medial and mediolateral area of thorax.....
- .....*Paracoccus gilliana* von Ellenrieder & Stocks (in part)
- 19(18). With oral-rim tubular ducts on dorsum.....
- .....*Paracoccus lycopersici* Ezzat & McConnell
- Without oral-rim tubular ducts on dorsum.....
- .....*Paracoccus juniperi* (Ehrhorn) (in part)
- 20(15). Dorsal multilocular pores present; legs comparatively short and stout.....*Vryburgia brevicurvis* (McKenzie)

- Dorsal multilocular pores absent; legs comparatively large.....*Vryburgia amaryllidis* (Bouché) 21(14). *Ferrisia*-type oral-collar tubular ducts present; anal-lobe cerarius with more than 2 conical setae.....*Pseudoferrisia floridana* (Ferris)
- Ferrisia*-type oral-collar tubular ducts absent; anal-lobe cerarius with 2 conical setae.....*Distichlicoccus* Ferris 22(11). With 4 or fewer pairs of cerarii.....23
- With more than 4 pairs of cerarii.....39
- 23(22). With *Ferrisia*-type oral-collar tubular ducts.....24
- Without *Ferrisia*-type oral-collar tubular ducts.....28
- 24(23). Anterior ostiole absent.....25
- Anterior ostiole present.....26
- 25(24). Less than 10 *Ferrisia*-type oral-collar tubular ducts; without oral-collar tubular ducts along ventral margin.....*Ferrisia quaintancii* (Tinsley) (in part)
- More than 10 *Ferrisia*-type oral-collar tubular ducts; with oral-collar tubular ducts along ventral margin.....*Ferrisia gilli* Gullan 26(24). Multilocular pores present on abdominal segment VI.....27
- Multilocular pores absent from abdominal segment VI.....*Ferrisia malvastra* (McDaniel) 27(26). *Ferrisia*-type oral-collar tubular ducts with discoidal pores touching orifice of duct opening; non-*Ferrisia* type oral-collar tubular ducts often with discoidal pores associated with opening.....*Ferrisia uzinuri* Kaydan & Gullan
- With the following combinations of characters:

<i>Ferrisia dasylii</i> (Cockerell)	<i>Ferrisia virgata</i> (Cockerell)
Discoidal pores, when present, protruding from sclerotized margin of <i>Ferrisia</i> -type oral-collar tubular ducts (see Figure 1 for the position of discoidal pores)	Discoidal pores, when present, not protruding from margin of <i>Ferrisia</i> -type oral-collar tubular ducts; usually not touching margin of duct or edge of sclerotization around <i>Ferrisia</i> -type oral-collar tubular duct but in mid area of sclerotization
Usually less than 15 multilocular pores on abdominal segment VI	Usually more than 15 multilocular pores on abdominal segment VI
Translucent pores absent from hind coxa	Translucent pores usually present on hind coxa

- 28(23). With circulus.....29
- Without circulus.....34
- 29(28). With 1 circulus.....31
- With more than 1 circulus.....30
- 30(29). Spiracles narrow and elongate.....*Tridiscus* Ferris (in part)

- Spiracles broadly oval.....*Miscanthicoccus miscanthi* (Takahashi) 31(29). With minute circular pores on derm surrounding each hind coxa.....32
- Without minute circular pores on derm surrounding each hind coxa.....33
- 32(31). With 1 pair of cerarii.....*Saccharicoccus sacchari* (Cockerell)
- With 2 or more pairs of cerarii.....*Palmicultor lumpurensis* (Takahashi) (in part) 33(31). Anterior pair of ostioles absent; body rotund; typically on *Rhus* L. (Anacardiaceae).....*Ferrisia quaintancii* (Tinsley) (in part)
- Anterior pair of ostioles present; body usually elongate; typically on grasses.....*Trionymus* Berg (in part) 34(28). With quinquelocular pores.....35
- Without quinquelocular pores.....36
- 35(34). Translucent pores absent from hind coxa; antennae 6 or 7 segmented.....*Brevennia rehi* (Lindinger)
- Translucent pores present on hind coxa; antennae 9 segmented.....*Heterococcus rauii* Miller 36(34). Without anal bar.....37
- With anal bar.....*Crisicoccus taxodii* Kosztarab 37(36). Coxa typical or slightly enlarged; without pores in atrium of spiracles.....38
- With one or both of the following character states: coxa greatly enlarged, with pores in atrium of spiracle.....*Pseudantonina* Green (in part) 38(37). Body elongate; typically on grasses.....*Trionymus* Berg (in part)
- Body rotund; typically not on grasses.....*Chnaurococcus trifolii* (Forbes) 39(22). Without trilocular pores.....*Hypogeococcus* 40
- With trilocular pores.....42
- 40(39). With 1 circulus.....41
- With 2 or 3 circuli.....*Hypogeococcus pungens* Granara de Willink 41(40). Setae on hind femur conical; some dorsal setae enlarged.....*Hypogeococcus margaretae* Miller
- Setae on hind femur hair like; dorsal setae not enlarged.....*Hypogeococcus hamoni* Miller 42(39). Without conspicuous row of large ventral oral-collar tubular ducts on abdominal segment V; with circulus.....43
- With conspicuous row of large ventral oral-collar tubular ducts on abdominal segment V; without circulus.....*Paradoxococcus mcdanieli* McKenzie 43(42). Dorsal oral-collar tubular ducts absent.....44
- Dorsal oral-collar tubular ducts present.....45

- 44(43). Multilocular pores absent from dorsum; more than 2 conical setae in cerarii.....  
 .....*Dysmicoccus difficilis* (Lobdell) (in part)  
 —Multilocular pores present on dorsum; 2 conical setae in cerarii.....*Oracella acuta* (Lobdell)
- 45(43). With minute circular pores on derm surrounding each hind coxa.....  
 .....*Palmicultor lumpurensis* (Takahashi) (in part)  
 —Without minute circular pores on derm surrounding each hind coxa.....*Dysmicoccus boninsis* (Kuwana)
- 46(10). Without minute circular pores on derm surrounding each hind coxa.....47  
 —With minute circular pores on derm surrounding each hind coxa.....48
- 47(46). With auxiliary setae in cerarii anterior to anal-lobe cerarius.....49  
 —Without auxiliary setae in cerarii anterior to anal-lobe cerarius.....76
- 48(46). Usually more than 3 conical setae in anal-lobe cerarius; antennae usually 6 segmented, rarely 7 segmented.....*Palmicultor palmarum* (Ehrhorn)  
 —Usually 2, rarely 3, conical setae in anal-lobe cerarius; antennae 7 or 8 segmented.....  
 .....*Palmicultor browni* (Williams)
- 49(47). With oral-rim tubular ducts.....50  
 —Without oral-rim tubular ducts.....65
- 50(49). Antennae with less than 9 segments; never with 16 pairs of cerarii.....51  
 —Antennae 9 segmented; with 16 pairs of cerarii.....*Leptococcus eugeniae* (Miller & Denno)
- 51(50). Multilocular pores restricted to vulvar area.....52  
 —Multilocular pores not restricted to vulvar area.....53
- 52(51). With more than 1 oral-rim tubular duct associated with each abdominal cerarius; anal-lobe and penultimate cerarii heavily sclerotized.....  
 .....*Pseudococcus longispinus* (Targioni Tozzetti)  
 —With 0–1 oral-rim tubular duct associated with each abdominal cerarius; anal-lobe cerarius heavily sclerotized, penultimate cerarius not heavily sclerotized.....*Pseudococcus dendrobiorum* Williams
- 53(51). Translucent pores present on hind coxa.....54  
 —Translucent pores absent from hind coxa.....56
- 54(53). With 17 pairs of cerarii; oral-rim tubular ducts on dorsal submargin between cerarii 15 and 16 present or absent; dorsal oral-rim tubular ducts usually present near cerarii, mediolaterally and medially on abdominal segments (3–34 oral-rim tubular ducts on dorsum).....55  
 —With fewer than 17 pairs of cerarii; oral-rim tubular ducts on dorsal submargin between cerarii 15 and 16 (or their positions) absent; dorsal oral-rim tubular ducts usually present near cerarii, restricted to submargin, rarely present mediolaterally and medially on abdominal segments (0–13 oral-rim tubular ducts on dorsum).....*Pseudococcus spanocera* Gimpel & Miller
- 55(54). Total length of hind femur, tibia and tarsus less than 485  $\mu\text{m}$ ; antennae less than 365  $\mu\text{m}$  in length; with relatively smaller circulus (31–87  $\mu\text{m}$  in width).....  
 .....*Pseudococcus sorghiellus* (Forbes)  
 —Total length of hind femur, tibia and tarsus more than 485  $\mu\text{m}$ ; antennae more than 365  $\mu\text{m}$  in length; with relatively larger circulus (59–111  $\mu\text{m}$  in width).....  
 .....*Pseudococcus dolichomelos* Gimpel & Miller
- 56(53). Translucent pores present on hind tibia, absent from hind femur.....57  
 —Translucent pores present on hind tibia and femur.....60
- 57(56). Dorsal oral-collar tubular ducts absent; dorsal multilocular pores absent; hind tibia not swollen mesally; circulus  $\leq 126 \mu\text{m}$  wide.....58  
 —Dorsal oral-collar tubular ducts present; dorsal multilocular pores usually present (numbering 0–5); hind tibia swollen mesally; circulus  $\geq 148 \mu\text{m}$  wide.....  
 .....*Pseudococcus nakaharai* Gimpel & Miller
- 58(57). Circulus large (75–126  $\mu\text{m}$  wide); 4–21 ventral oral-collar tubular ducts mesad of cerarius 12.....59  
 —Circulus small (22–74  $\mu\text{m}$  wide); 0–3 ventral oral-collar tubular ducts mesad of cerarius 12.....  
 .....*Pseudococcus microcirculus* McKenzie
- 59(58). Oral-rim tubular duct(s) present near frontal cerarius (c17); with 0–5 discoidal pores in membranous area around each eye.....  
 .....*Pseudococcus importatus* McKenzie  
 —Oral-rim tubular duct(s) absent near frontal cerarius (c17); with 6–11 discoidal pores in sclerotized rim around each eye.....*Pseudococcus landoi* (Balachowsky)
- 60(56). Discoidal pores present near eye, with discoidal pores associated with eye in sclerotized rim.....61  
 —Discoidal pores absent near eye, or with discoidal pores associated with eye not in sclerotized rim.....62
- 61(60). With combination of at least two of following characters: with 1–13 dorsal oral-rim tubular ducts on abdomen; more than 20 multilocular pores on abdominal segment IV; small rim associated with marginal oral-collar tubular ducts on thorax.....  
 .....*Pseudococcus elisae* Borchsenius  
 —With combination of at least two of following characters: with 14–27 dorsal oral-rim tubular ducts on abdomen; less than 15 multilocular pores on abdominal segment IV; no rim associated with marginal oral-collar tubular ducts on thorax.....  
 .....*Pseudococcus jackbeardsleyi* Gimpel & Miller

- 62(60). Without oral-rim tubular ducts on submargin between cerarii 15 and 16.....63  
 —With oral-rim tubular ducts on submargin between cerarii 15 and 16.....64
- 63(62). Discoidal pores near eye absent; small dorsal oral-collar tubular ducts present on meso- and/or meta-thorax in medial and mediolateral areas.....  
 .....*Pseudococcus odermatti* Miller & Williams  
 —Discoidal pores near eye present; without dorsal oral-collar tubular ducts.....*Pseudococcus viburni* (Signoret)
- 64(62). With 0–2 ventral oral-collar tubular ducts on each side of head; with 2–11 ventral collar-tubular ducts mesad of cerarius 12.....  
 .....*Pseudococcus bryberia* Gimpel & Miller  
 —With 3–25 ventral oral-collar tubular ducts on each side of head; with 10–25 ventral oral-collar tubular ducts mesad of cerarius 12.....*Pseudococcus maritimus* (Ehrhorn)
- 65(49). Majority of abdominal cerarii with 2 conical setae...  
 .....66  
 —Majority of abdominal cerarii with more than 2 conical setae.....73
- 66(65). Setae on dorsum of abdominal segment VIII about as long as other dorsal setae.....67  
 —Cluster of setae on dorsum of abdominal segment VIII conspicuously longer than other dorsal setae.....  
 .....*Dysmicoccus brevipes* (Cockerell) (in part)
- 67(66). With more than 10 ventral oral-collar tubular ducts on margin and submargin of thorax.....68  
 —Without oral-collar tubular ducts on margin and submargin of thorax or with less than 10.....69
- 68(67). Without circulus, with 16 pairs of cerarii; without translucent pores on hind femur.....  
 .....*Dysmicoccus milleri* Kosztarab  
 —With circulus, with 17 pairs of cerarii; with translucent pores on hind femur.....  
 .....*Dysmicoccus grassii* (Leonardi)
- 69(67). With circulus.....70  
 —Without circulus.....72
- 70(69). Some dorsal seta conical; with less than 17 pairs of cerarii .....71  
 —Dorsal setae hair like; with 17 pairs of cerarii.....  
 .....*Dysmicoccus texensis* (Tinsley)
- 71(70). With 100 or more multilocular pores; cerarian setae separated by less than length of conical seta.....  
 .....*Nipaeococcus floridensis* Beardsley (in part)  
 —With 50 or less multilocular pores; cerarian setae separated by more than length of conical setae.....  
 .....*Nipaeococcus nipae* (Maskell) (in part)
- 72(69). With 9-segmented antennae.....  
 .....*Dysmicoccus radinovskiy* Miller & Miller  
 —With 8 or fewer antennal segments.....  
 .....*Dysmicoccus diodium* (McConnell)
- 73(65). Translucent pores absent from hind coxa.....74  
 —Translucent pores present on hind coxa.....  
 .....*Dysmicoccus mackenziei* Beardsley
- 74(73). With 17 pairs of cerarii.....75  
 —With less than 17 pairs of cerarii.....  
 .....*Dysmicoccus difficilis* (Lobdell) (in part)
- 75(73). Cluster of setae on dorsum of abdominal segment VIII conspicuously longer than other dorsal setae.....  
 .....*Dysmicoccus brevipes* (Cockerell) (in part)  
 —Setae on dorsum of abdominal segment VIII about as long as other dorsal setae.....  
 .....*Dysmicoccus neobrevipes* Beardsley
- 76(47). With *Stemmatomerinx*-type truncate setae on dorsum.....77  
 —Without *Stemmatomerinx*-type truncate setae on dorsum.....78
- 77(76). Without denticle on claw; with circulus.....  
 .....*Stemmatomerinx adenticulata* Howell & Miller  
 —With denticle on claw; without circulus.....  
 .....*Stemmatomerinx acircula* Howell & Miller
- 78(76). With dorsal multilocular pores.....79  
 —Without dorsal multilocular pores.....81
- 79(78). Dorsal multilocular pores in row across some abdominal segments.....80  
 —Dorsal multilocular pores restricted to body margin.....  
 .....*Phenacoccus miruku* Tanaka & Choi (in part)
- 80(79). Quinquelocular pores absent on venter.....  
 .....*Phenacoccus multicerarii* Granara de Willink  
 —Quinquelocular pores present on venter.....  
 .....*Phenacoccus madeirensis* Green
- 81(78). Quinquelocular pores present on venter.....82  
 —Quinquelocular pores absent on venter.....83
- 82(81). Ventral multilocular pores absent from body margin.....  
 .....*Phenacoccus parvus* Morrison  
 —Ventral multilocular pores present near body margin.....  
 .....*Phenacoccus miruku* Tanaka & Choi (in part)
- 83(81). With anal bar.....84  
 —Without anal bar.....91
- 84(83). Oral-rim tubular ducts present near some abdominal cerarii (sometimes ventral only).....85  
 —Oral-rim tubular ducts absent.....90
- 85(84). With translucent pores on hind tibia.....86  
 —Without translucent pores on hind tibia.....  
 .....*Paracoccus marginatus* Williams & Granara de Willink

- 86(85). With translucent pores on hind coxa.....87
- Without translucent pores on hind coxa.....
- .....*Delottococcus confusus* (De Lotto) (in part)
- 87(86). With fewer than 10 ventral oral-rim tubular ducts in medial and mediolateral areas of thorax.....88
- With 10 or more ventral oral-rim tubular ducts in medial and mediolateral area of thorax.....
- .....*Paracoccus gilliana* von Ellenrieder & Stocks, 2014 (in part)
- 88(87). With dorsal oral-rim tubular ducts.....89
- Without dorsal oral-rim tubular ducts.....
- .....*Paracoccus juniperi* (Ehrhorn) (in part)
- 89(88). With less than 5 oral-rim tubular ducts.....
- .....*Planococcus citri* (Risso) (in part)
- With more than 5 oral-rim tubular ducts.....
- .....*Paracoccus herreni* Williams & Granara de Willink
- 90(84). For rapid identification, the following characters will work most of time; more than 4 oral-collar tubular ducts between antennae; more than 5 oral-collar tubular ducts adjacent to middle pair of legs counting both sides of body.....*Planococcus citri* (Risso) (in part)
- For rapid identification, the following characters will work most of time; less than 5 oral-collar tubular ducts between antennae; less than 5 oral-collar tubular ducts adjacent to middle pair of legs counting both sides of body.....*Planococcus minor* (Maskell)
- For more accurate identification, use following table [adapted from Cox (1989)], if score is 0–35 = *Pl. minor* and 36–120 = *Pl. citri*.

Character	Value	Score
Total number of ventral oral-collar tubular ducts on both sides of head	0–3	0
	4–13	10
	14–35	40
Total number of ventral oral-collar tubular ducts laterad of both middle coxae	0–2	0
	3–7	10
	8–30	40
At least 1 ventral oral-collar tubular duct(s) between 16th and 17th cerarius (counting from anal lobe)	No	0
	Yes	10
Total number multilocular pores behind both front coxae	0–6	5
	7–12	0
Ratio length hind = tibia + tarsus to length of trochanter + femur	1.00–1.07	0
	1.08–1.17	5
	1.18–1.30	10
Width of row of ventral multilocular disk pores on posterior margin segment of VI	Single	15
	Intermediate	5
	Double	0

- 91(83). With denticle on claw.....92
- Without denticle on claw.....94
- 92(91). Oral-rim tubular ducts absent; tarsal digitules with acute apex; tibia with translucent pores scattered..... 93

- Oral-rim tubular ducts present; tarsal digitules with clubbed apex; distal tibia with conspicuous cluster of translucent pores.....
- .....*Spilococcus mamillariae* (Bouché) (in part)
- 93(92). Ventral multilocular pores on abdominal segment VII present in row along posterior edge only; circulus usually small, rounded; antennae usually 8 segmented.....*Phenacoccus solani* Ferris
- Ventral multilocular pores on abdominal segment VII present between anterior and posterior margins; circulus usually large, more flaccid; antennae usually 9 segmented.....*Phenacoccus solenopsis* Tinsley
- 94(91). Dorsal setae conical.....95
- Dorsal setae hair like.....97
- 95(94). Multilocular pores and oral-collar tubular ducts uncommon in marginal areas of thorax and abdomen.....96
- Multilocular pores and oral-collar tubular ducts in dense band along body margin of thorax and abdomen.....
- .....*Nipaeococcus viridis* (Newstead)
- 96(95). With 100 or more multilocular pores; cerarian setae separated by less than length of conical seta.....
- .....*Nipaeococcus floridensis* Beardsley (in part)
- With 50 or less multilocular pores; cerarian setae separated by more than length of conical setae.....
- .....*Nipaeococcus nipae* (Maskell) (in part)
- 97(94). Anal-lobe cerarii with 2 conical setae.....
- .....*Delottococcus confusus* (De Lotto) (in part)
- Anal-lobe cerarii with more than 3 conical setae.....
- .....*Paraputo olivaceus* (Cockerell)

#Rhizoecidae species from the genera *Geococcus*, *Rhizoecus*, and *Ripersiella* in Florida were previously considered part of the Pseudococcidae and are not included in this key.

## 4 Discussion

Florida’s strategic location, with numerous ports-of-entry on its southern, eastern, and western coasts, coupled with its high tourism influx and extensive agricultural trade in live plant material—particularly ornamental plants—renders the state exceptionally susceptible to invasive species (Frank and McCoy 1995; Frank and Thomas 2004; Skelley et al. 2025). Prior to our study, a definitive list of mealybug species established in Florida was nonexistent. Some species previously reported as occurring in Florida or having representatives in the FSCA were excluded for the following reasons. Upon examination, we identified six slides in the FSCA initially labeled as *Planococcus ficus* (Signoret), all of which were misidentified and actually represented *Pl. citri* (Risso). The single

slide of *Paracoccus solani* Ezzat & McConnell in the FSCA, collected on *Agave* sp. (Asparagaceae), turned out to be the recently described species *Pa. gilliana* von Ellenrieder & Stocks. Williams (1987) reported that numerous records in various publications attributed to *Phenacoccus gossypii* Townsend & Cockerell were, in fact, misidentifications of *Ph. madeirensis* Green. This was further substantiated by Kondo et al. (2002), who confirmed that previous reports of *Ph. gossypii* in Japan were also misidentifications of *Ph. madeirensis*. Consequently, we examined all of the slides labeled as *Ph. gossypii* in the FSCA and verified that they were indeed misidentifications of *Ph. madeirensis*. Therefore, it can be concluded that *Ph. gossypii* does not exist in Florida. McKenzie (1967) cites *Phenacoccus colemani* Ehrhorn as occurring in Florida, though both Ferris (1953) and McKenzie (1967) indicated that earlier identifications were frequently inaccurate. Considering that the species has not been collected in the eastern US, no specimens are present in the FSCA from Florida, and the history of misidentifications, we conclude that this species does not exist in Florida. The only record of *Dysmicoccus lasii* (Cockerell) dates back to 1993 from a single county in north-central Florida, with no subsequent collections. Consequently, we have excluded it from our list. Because it is primarily a subterranean species, it may be present in northern Florida, where additional sampling is needed.

Despite the extensive body of work on mealybug taxonomy, there remains a notable gap: the absence of a current taxonomic key specifically focused on the mealybug species of Florida. For instance, to identify *Pl. minor* (Maskell), a recently established species in Florida, one must rely on taxonomic keys developed for species outside the US, such as those from the South Pacific region (Williams and Watson 1988), China (Zhang and Deng 2023), or Central and South America (Williams and Granara de Willink 1992). No existing US key facilitates the identification of *Pl. minor* alongside other species in Florida or the broader US.

Similarly, *Nipaeococcus viridis* (Newstead) is a recently established species of significant economic importance and regulatory concern in Florida and other US states (Ahmed and Deeter 2022; von Ellenrieder et al. 2018) and is not included in any mealybug key for the US. Consolidating all species into a single key expedites identification, particularly in Florida and the southern US, where new species are being discovered on a regular basis. Timely identification will help in making prompt regulatory and management decisions.

The urgency of addressing this issue is heightened when new invasive mealybug species are intercepted in Florida or when native species are collected in Florida for the first time. For instance, *Dysmicoccus obesus* (Lobdell), which is established in other southeastern states, has not yet been discovered in Florida. Moreover, *Heliococcus summervillei*

Brookes, a significant pest in Asia and Australia, has recently been reported in the Caribbean (Ahmed MZ, personal communication) and Texas (Biles et al. 2025) but remains absent in Florida. The potential for these species to invade or be discovered in Florida in the near future is considerable. Although this key does not encompass these two species, it serves as a valuable tool for identifying the mealybug species currently present in Florida. This, in turn, facilitates a more efficient determination of whether a species being identified is new to Florida.

Given the influx of invasive or newly discovered mealybug species in Florida, this key will assist others in identifying new species records throughout the US, especially in southern US states. This key is developed based on the mealybug species established in Florida as of this year and must be updated to incorporate newly identified species over time. In addition, it focuses on adult female specimens, which must be slide mounted for accurate identification. For other instars, molecular barcoding or allowing immature specimens to mature into adults is required.

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**Research ethics:** Not applicable.

**Informed consent:** Not applicable.

**Author contributions:** MZA and DRM developed the taxonomic key, while ECP created the illustration. All three—MZA, ECP, and DRM—worked together to improve both the key and the illustration. MZA drafted the initial version, and together, MZA, ECP, and DRM reviewed and revised it.

**Use of Large Language Models, AI and Machine Learning**

**Tools:** Not applicable.

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