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Hibiscus Mealybug (Hemiptera: Pseudococcidae) – Biology, Host Plants, Current Management Practices, and a Field Guide for North America

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Abstract

Hibiscus mealybug, *Nipaecoccus viridis* (Newstead), is an invasive, highly polyphagous pest that has recently established in Florida. This pest is historically known to heavily effect citrus production in other citrus-producing regions and has similarly negatively impacted citrus groves in several counties. Hibiscus mealybug was first found infesting citrus in one county in 2019 and has rapidly spread across counties and onto additional hosts in only a few years. Here we review the known distribution and biology of hibiscus mealybug, including a description of life stages, known host plants in Florida, and management options. Additionally, a field diagnostics guide is presented to assist in early detection and prevent the spread of *N. viridis* in other regions. We anticipate that information shared here will help in slowing its spread in the United States.

Key words: invasive species, hibiscus mealybug, *Nipaecoccus viridis*

Hibiscus mealybug, *Nipaecoccus viridis* (Newstead) (Hemiptera: Pseudococcidae), is an invasive pest of a wide variety of agricultural, horticultural, and ornamental plants in tropical and subtropical regions of the world (Sharaf and Meyerdirk 1987). Hibiscus mealybug is a major pest of concern for citrus production worldwide, and more recently in Florida (Diepenbrock and Ahmed 2021). This pest has also been documented on 144 genera of plants (scalenet.info/catalogue/Nipaecoccus viridis/), many of which are grown commercially in Florida and neighboring states in the southeastern United States.

Distribution

Hibiscus mealybug is native to Asia (Evans and Dooley 2013) and is widespread in at least 63 countries in the tropical, subtropical, and Mediterranean regions of the world (Levi-Zada et al. 2019, CABI 2021) (Fig. 1). Hibiscus mealybug is exotic to the United States and was first documented developing on dodder plants in Palm Beach County, Florida in November 2009 (Stocks and Hodges 2010). This mealybug pest has since been found infesting citrus trees in several commercial groves in southern and central Florida (Diepenbrock and Ahmed 2021). Based on suitable environmental conditions (temperature and relative humidity) and availability of susceptible hosts, hibiscus mealybug has high potential for invading additional states in the southeastern United States (Thomas and Leppla 2008).

Records of *N. viridis* in the Florida Department of Agriculture and Consumer Services, Division of Plant Industry (DPI) database, and identifications from slides in Florida State Collection of Arthropods (FSCA) were incorporated to provide a summary of their geographical locations and host plants in Table 1 and Fig. 2.

Description and Life History

Hibiscus mealybugs reproduce both sexually and parthenogenetically, and can reproduce continuously throughout the year, though more slowly in cooler winter months, resulting in multiple overlapping generations (reviewed in Sharaf and Meyerdirk 1987).

Hibiscus mealybugs lay eggs in batches within a hemispherical ovisac composed of densely interwoven mealy wax secretions beneath the adult female body. Freshly laid eggs are oval, brownish white to orange, and turning brownish-red or purplish prior to hatching (Fig. 3). An adult female can lay from 400 to more than 1,000 eggs in her lifetime and eggs hatch into dark-red or purplish nymphs (crawlers) in 5–10 d.

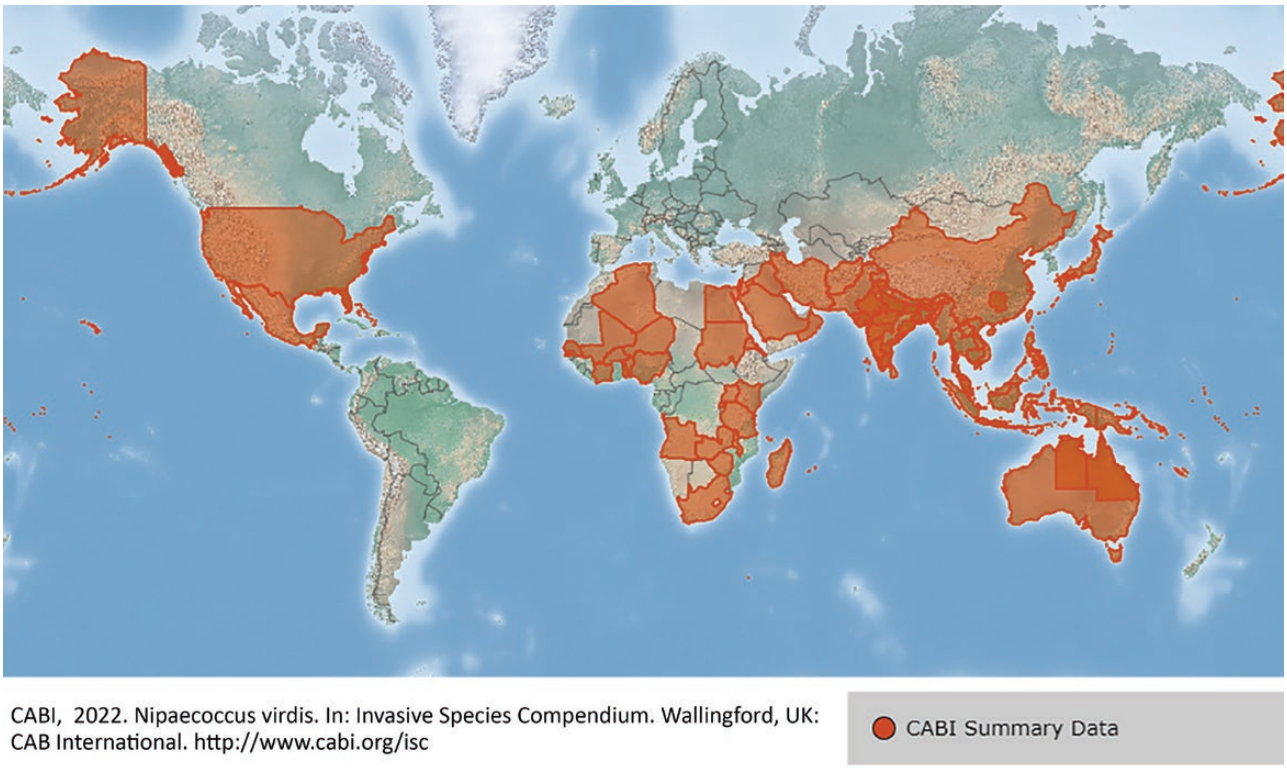

Fig. 1. Geographical distribution of hibiscus mealybugs, *Nipaecoccus viridis* (Newstead) worldwide. Orange overlay indicates countries where hibiscus mealybug has been reported. Reprinted with permission from: https://www.cabi.org/isc/datasheet/36335#toDistributionMaps.

The first nymphal stage of hibiscus mealybugs is called crawlers. Crawlers are the dispersal stage, thought to move primarily through accidental human-mediated transport (Middleton and Diepenbrock 2022). Crawlers are approximately 0.4–0.5 mm long and 0.19–0.25 mm wide and move around the natal ovisac for a short period of time before descending onto the host plant in search of suitable feeding sites near the mother colony (Sharaf and Meyerdirk 1987) (Fig. 4a and b).

Immature females are oval and purplish or dark red, resembling adult females with less waxy covering. Immature males are light brown, slightly longer, and more slender than immature females. The sex of immature hibiscus mealybugs can be distinguished at the third instar stage (Fig. 5a and b). Female hibiscus mealybugs develop through three nymphal instars before emergence of adult females. Males undergo a form of metamorphosis that includes two nymphal instars, a pre-pupal, and a pupal stage (Fig. 6), before the emergence of short-lived, winged male adults (Fig. 7) (Sharaf and Meyerdirk 1987, Gullan 2000).

Adult females have an oval, dorsoventrally flattened, and soft body. Adult females are ~4 mm long and ~3 mm wide and are dark purple to dark brown, with a pair of seven-segmented antennae (Sharaf and Meyerdirk 1987). Their body is dorsally covered by a thick layer of white or yellowish-white wax that often extends laterally to form a series of short filaments (Peri and Kapranas 2012) (Fig. 8).

Hosts

Hibiscus mealybugs have been reported to feed on plant species in about 140 genera in 53 plant families (García et al. 2016). Hosts include many economically important agricultural and horticultural crops and ornamentals such as citrus, pomegranate, avocados, coffee, soybean, potato, grapevine, eggplants, roses, mulberry, hibiscus, and gardenia (García et al. 2016, Diepenbrock and Ahmed 2021). In Florida, hibiscus mealybug has been collected feeding on a wide range of hosts including various fruit trees, ornamental plants, and weeds (Table 1; Deeter and Ahmed, 2023).

Economic Importance

Hibiscus mealybug attacks several citrus species causing considerable damage in orchards in citrus-growing regions worldwide (Griffiths and Derksen 2010). Hibiscus mealybugs have been found infesting mature groves and young replanted trees of commercial citrus in Florida (Diepenbrock and Ahmed 2021). Because hibiscus mealybug is a recent invader, there have been no studies to estimate the impact hibiscus mealybug could have on the Florida citrus industry. However, due to the associated premature fruit drop and death of young replanted citrus trees, the economic impact of hibiscus mealybug on the Florida citrus industry could be significant. In southern Africa, as high as 50% yield loss was reported in some heavily infested navel orange orchards (Cilliers and Bedford 1978). Heavy and repeated infestation could result in total loss of citrus trees as observed in citrus-growing areas in Jordan where orchards were burnt to eradicate hibiscus mealybugs (Stocks 2013).

Damage to Citrus

Hibiscus mealybug is a major pest of many citrus species including lemon, citron, lime, sweet orange, grapefruit, and tangerine (Sharaf

Table 1. Host plants of *Nipaecoccus viridis* recorded from Florida between 2010 and 2021

Genus	Species	Common names	Family
A.Flowering plants[a]			
Cannabis	*sativa*	hemp	Cannabaceae
Clerodendrum	*paniculatum*	pagoda flower	Lamiaceae
Cuscuta	*exaltata*	dodder	Acanthaceae
Dodonaea	*viscosa*	varnish leaf	Sapindaceae
Gardenia	*jasminoides*	gardenia	Rubiaceae
Jatropha	*integerrima*	spicy jatropha	Euphorbiaceae
Portulaca	*oleracea*	common purslane	Portulacaceae
Schefflera	*arboricola*	dwarf umbrella tree	Araliaceae
Syzygium	*paniculatum*	magenta cherry	Myrtaceae
Trachelospermum	*jasminoides*	star jasmine	Apocynaceae
B.Flowering shrubs or trees[a]			
Acalypha	*wilkesiana*	copperleaf	Euphorbiaceae
Couroupita	*guianensis*	cannonball tree	Lecythidaceae
Cupaniopsis	*Anacardioides*	carrotwood	Sapindaceae
Radermachera	sp.	NA	Bignoniaceae
Uncarina	*grandidieri*	succulent sesame	Pedaliaceae
Nerium	*oleander*	oleander	Apocynaceae
Nyctanthes	*arbor-tristis*	night-flowering jasmine	Oleaceae
Polyscias	*racemosa*	false ‘ohe	Araliaceae
C.Fruit trees or shrubs[a]			
Alibertia	sp.	NA	Rubiaceae
Annona	*muricata*	soursop	Annonaceae
Annona	*squamosa*	sugar apples	Annonaceae
Artocarpus	*heterophyllus*	jackfruit	Moraceae
Citrus	*aurantifolia*	key lime	Rutaceae
Citrus	*limettioides*	sweet lime	Rutaceae
Citrus	*limon*	lemon	Rutaceae
Citrus	*maxima*	pomelo	Rutaceae
Citrus	×*paradisi*	grapefruit	Rutaceae
Citrus	*sinensis*	sweet oranges	Rutaceae
Citrus	×*tangelo*	tangelo	Rutaceae
Dimocarpus	*longan*	longan	Sapindaceae
Ficus	*carica*	common fig	Moraceae
Ficus	*microcarpa*	Chinese banyan	Moraceae
Fortunella	*japonica*	kumquats	Rutaceae
Litchi	*chinensis*	lychee	Sapindaceae
Mangifera	*indica*	mango	Anacardiaceae
Murraya	*koenigii*	curry tree	Rutaceae
Persea	*americana*	avocado	Lauraceae
Persea	*borbonia*	redbay	Lauraceae
Punica	*granatum*	pomegranate	Lythraceae
Swinglea	*glutinosa*	tabog	Rutaceae
Tamarindus	*indica*	tamarind	Fabaceae
Vaccinium	sp.	blueberry	Ericaceae
Vitis	*rotundifolia*	muscadine grape	Vitaceae
Ximenia	*americana*	sea lemon	Olacaceae
Ziziphus	*mauritiana*	Indian jujube	Rhamnaceae
Ziziphus	*jujuba*	Chinese jujube	Rhamnaceae
D.Other plants or shrubs or weeds[a]			
Ambrosia	*artemisiifolia*	ragweed	Asteraceae
Bidens	*alba*	Spanish needles	Asteraceae
Croton	*glandulosus*	tropic croton	Euphorbiaceae
Cupaniopsis	*anacardioides*	tuckeroo	Sapindaceae
Hyophorbe	*lagenicaulis*	bottle palm	Arecaceae
Portulacaria	*afra*	elephant bush	Didiereaceae
Quercus	*myrtifolia*	myrtle oak	Fagaceae

[a]Categories are based on their common usages in Floridian landscape.

and Meyerdirk 1987, Diepenbrock and Ahmed 2021). Nymphs and adult females feed on sap from all parts of citrus hosts except for roots. They preferentially feed under and close to the calyx of developing citrus fruit, which can cause premature abortion of fruit, reducing crop yield (Sharaf and Meyerdirk 1987, Abdul-Rassoul 2014) (Fig. 8). Mealybug feeding stunts growth of young citrus trees (Hattingh et al. 1998) and under heavy infestation, can cause chlorosis, wilting and death of young citrus trees (L.D., personal

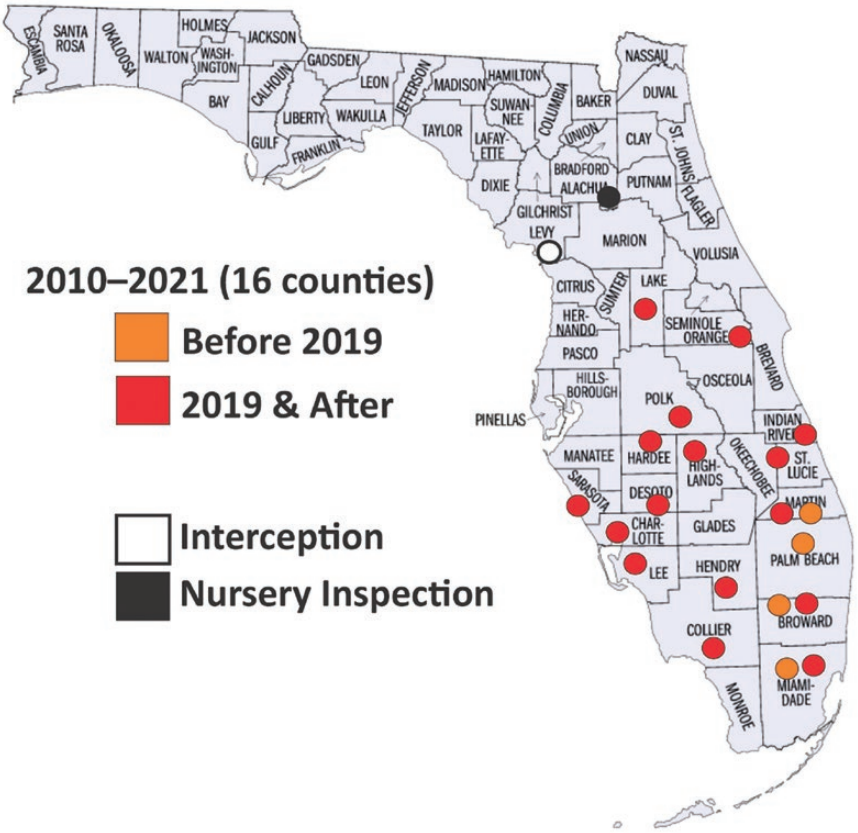

Fig. 2. Distribution of *Nipaecoccus viridis* in Florida between 2010 and 2021 (Florida Department of Agriculture and Consumer Services-Division of Plant Industry, data retrieved by request).

Fig. 3. Oval, purplish-red eggs of hibiscus mealybug, *Nipaecoccus viridis,* in slightly opened ovisac. Photograph by David Olabiyi, University of Florida.

observation). While feeding, hibiscus mealybug injects saliva into host tissues, causing gall-like outgrowths that distort citrus fruit (Fig. 9) and excretes sticky honeydew that facilitates growth of black sooty mold on the leaf and fruit surfaces, which can reduce host photosynthetic activity (Williams and Granara de Willink 1992), and render fruit commercially undesirable, reducing their fresh market value (Sharaf and Meyerdirk 1987, Franco et al. 2004) (Fig. 10).

Field Identification

Gravid females often aggregate, and their white to cream colored waxy ovisacs appear to merge into one, making them easier to locate than other life stages. The juvenile stages are small and feed in cryptic locations, leading to challenges looking for these lifestages on plants. Infestations in citrus groves can be diagnosed using several specific characteristics of this mealybug species. The presence of a ventrally located ovisac on gravid females (Fig. 11) and gall-like outgrowths on citrus fruit can be used to diagnose likely hibiscus mealybug infestation. Unlike other mealybug species found in Florida citrus, hibiscus mealybugs turn black when submerged in 70% alcohol, and exude dark purple hemolymph when crushed (Diepenbrock and Ahmed 2021) (Fig. 12).

Field Guide

Growers and inspectors should be able to recognize not only adult female infestations, which are often obvious with masses of wax and mold, but also all life stages especially crawlers, which can be small enough to go undetected during scouting. The field guide is designed to help identify *N. viridis* infestations, the different life stages, and their biological control agents (Fig. 13). It will help growers identify infestations early so they can be treated before shipping. The use of this guide, paired with diligent inspection, can slow the spread of this destructive pest, and prevent further economic agricultural damage for the United States.

Management Options

Chemical Control

While chemical control is the most common strategy used in managing mealybug infestations in citrus (Franco et al. 2004), chemical control of hibiscus mealybug has been difficult, and at times counterproductive (Meyerdirk et al. 1988). In the past, outbreaks of mealybugs have likely been exacerbated by the frequent application of nonselective insecticides in citrus, both because mealybug

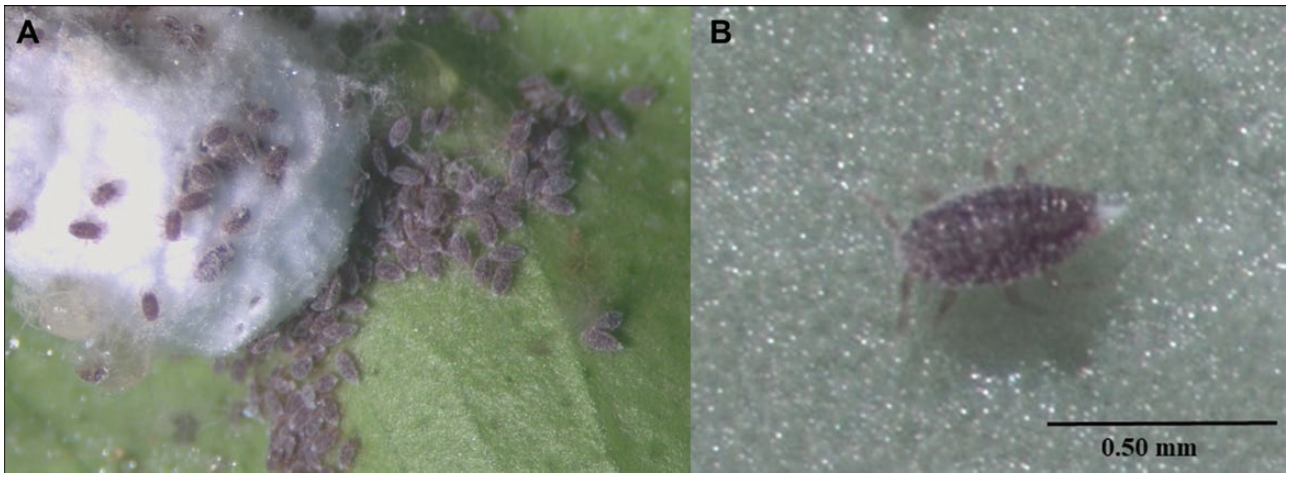

Fig. 4. (a) Hibiscus mealybug, *Nipaecoccus viridis,* first instar (crawlers) around neonatal ovisac. (b) An individual hibiscus mealybug crawler. Photographs by David Olabiyi.

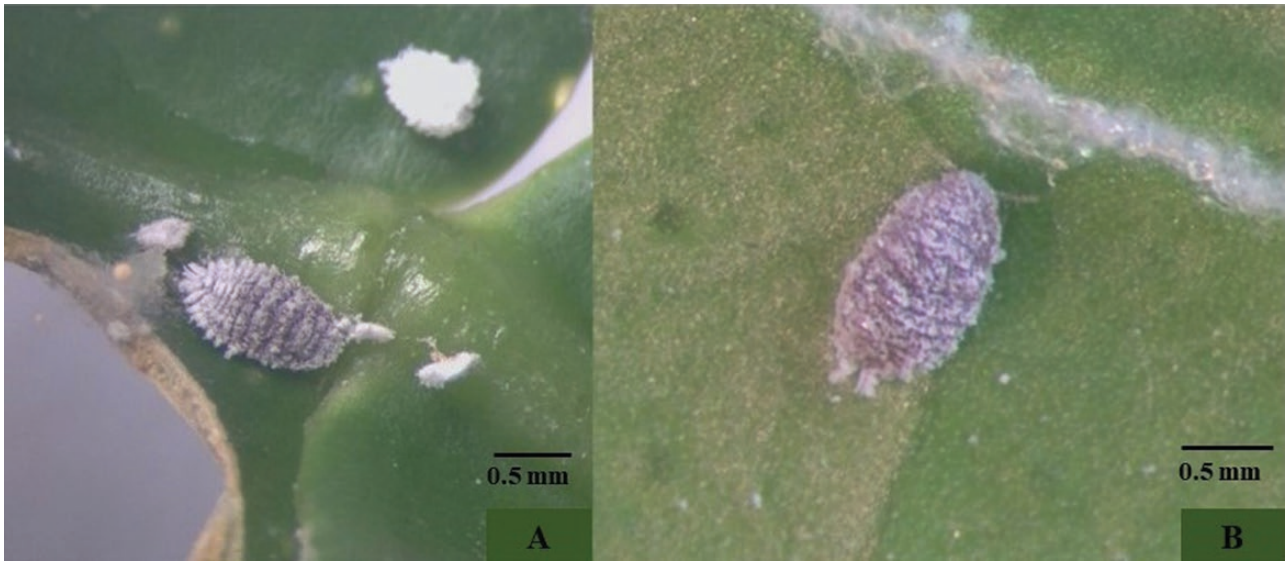

Fig. 5. (a) a third instar female and (b) pre-pupal male hibiscus mealybugs. Photograph by David Olabiyi.

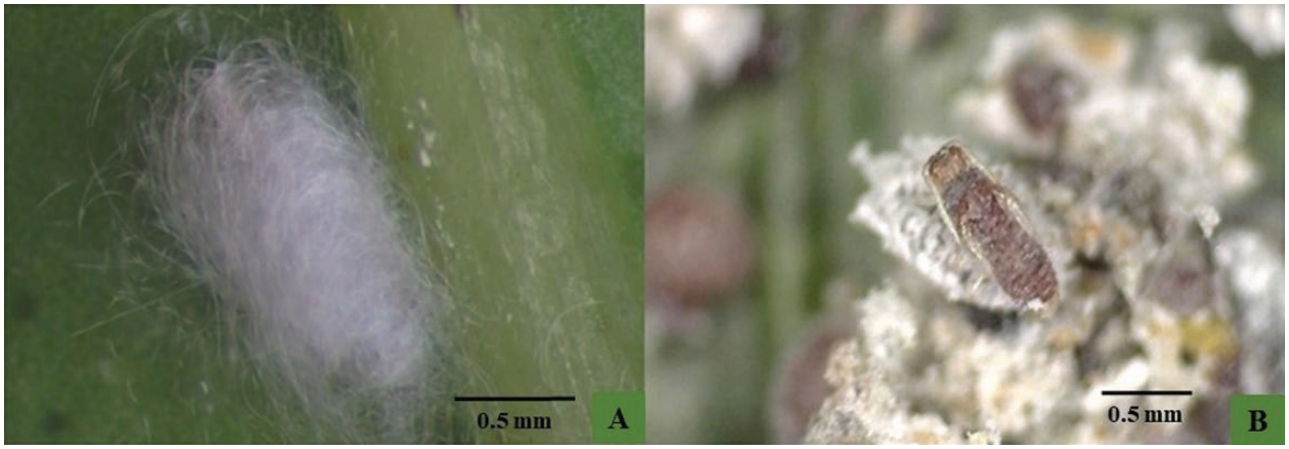

Fig. 6. (a) Cottony cocoon containing pupating male hibiscus mealybug (b) Pupal male hibiscus mealybug with developing wing-pads outside cocoon. Photograph by David Olabiyi.

Fig. 7. Adult male hibiscus mealybug, *Nipaecoccus viridis*. Photograph by David Olabiyi.

Fig. 8. Adult female hibiscus mealybug, *Nipaecoccus viridis*. Photograph by David Olabiyi.

Fig. 9. Hibiscus mealybugs, *Nipaecoccus viridis* feeding around calyx of developing fruit. This fruit will be aborted by the tree. Photograph by Lauren Diepenbrock.

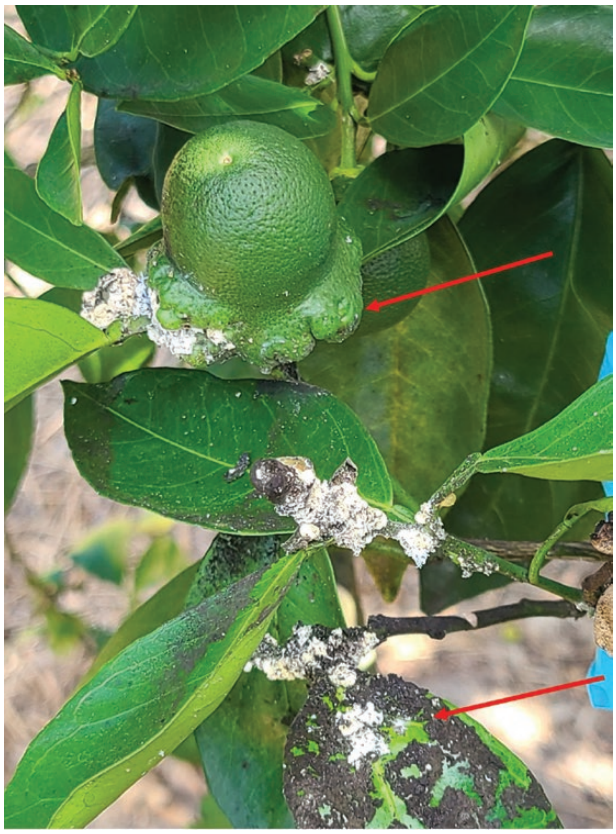

Fig. 10. Damage caused by hibiscus mealybug, *Nipaecoccus viridis* (Newstead) on citrus plant (top arrow) and sooty mold developing on honeydew excretions (bottom arrow). Photograph by David Olabiyi.

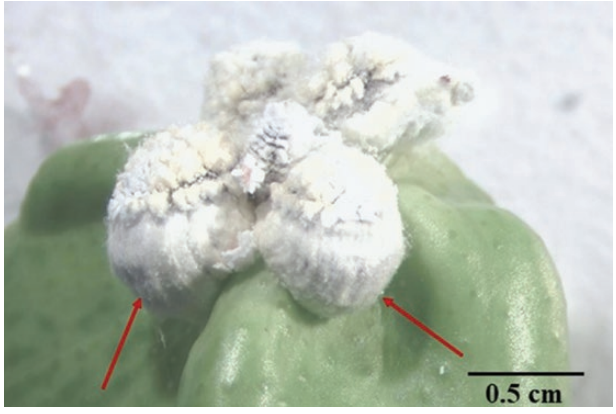

Fig. 11. Ovisac attached ventrally to a gravid female Hibiscus mealybug. Photograph by David Olabiyi.

are cryptic feeders, using their hidden feeding locations to avoid insecticides, and because frequent applications reduce the abundance of natural enemies (Franco et al. 2004). Additionally, the presence of protective wax on many of the life stages of hibiscus mealybug may help protect it from contact insecticides (Sharaf and Meyerdirk 1987). However, some insecticides have been effective; applications of dimethoate and mineral oil controlled nymphal hibiscus mealybugs in South African citrus (Cilliers and Bedford 1978). Insecticides such as spirotetramat, chlorpyrifos, imidacloprid, and buprofezin are effective against other mealybugs in citrus (Mansour et al. 2018), but their efficacy on hibiscus mealybug has yet to be determined. In laboratory trials, several contact insecticides including chlorpyrifos,

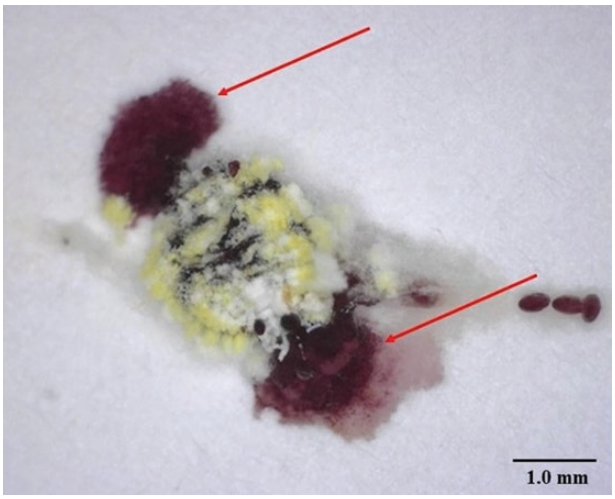

Fig. 12. Purple colored hemolymph from a crushed hibiscus mealybug. Photograph by David Olabiyi.

spirotetromat, and buprofezin were effective in killing 70% or more second and third instars (Diepenbrock 2021, Diepenbrock et al. 2021). However, efficacy on adult females and eggs protected within ovisacs is currently unknown.

Biological Control

Hibiscus mealybug has a diverse range of natural enemies that often keep populations in check in their native ranges in the absence of disturbances. Predators such as the coccinellids *Cryptolaemus montrouzieri* Mulsant (Coleoptera: Coccinellidae) and *Nephus arcuatus* Kapur (Coleoptera: Coccinellidae), the dipterans *Leucopis alticeps* Czerny (Diptera: Chamaemyiidae), *Gitonides perspicax* Knab (Diptera: Drosophilidae), and the neuropteran *Sympherobius* sp. (Neuroptera: Hemerobiidae) have been found to consume hibiscus mealybug in regions where the mealybug has is present (Cilliers and Bedford 1978; Nechols and Seibert 1985, Stocks 2013, Zarghami et al. 2016). Other predators are found more infrequently, such as the coccinellid *Scymnus roepki* Fluiter (Coleoptera: Coccinellidae),

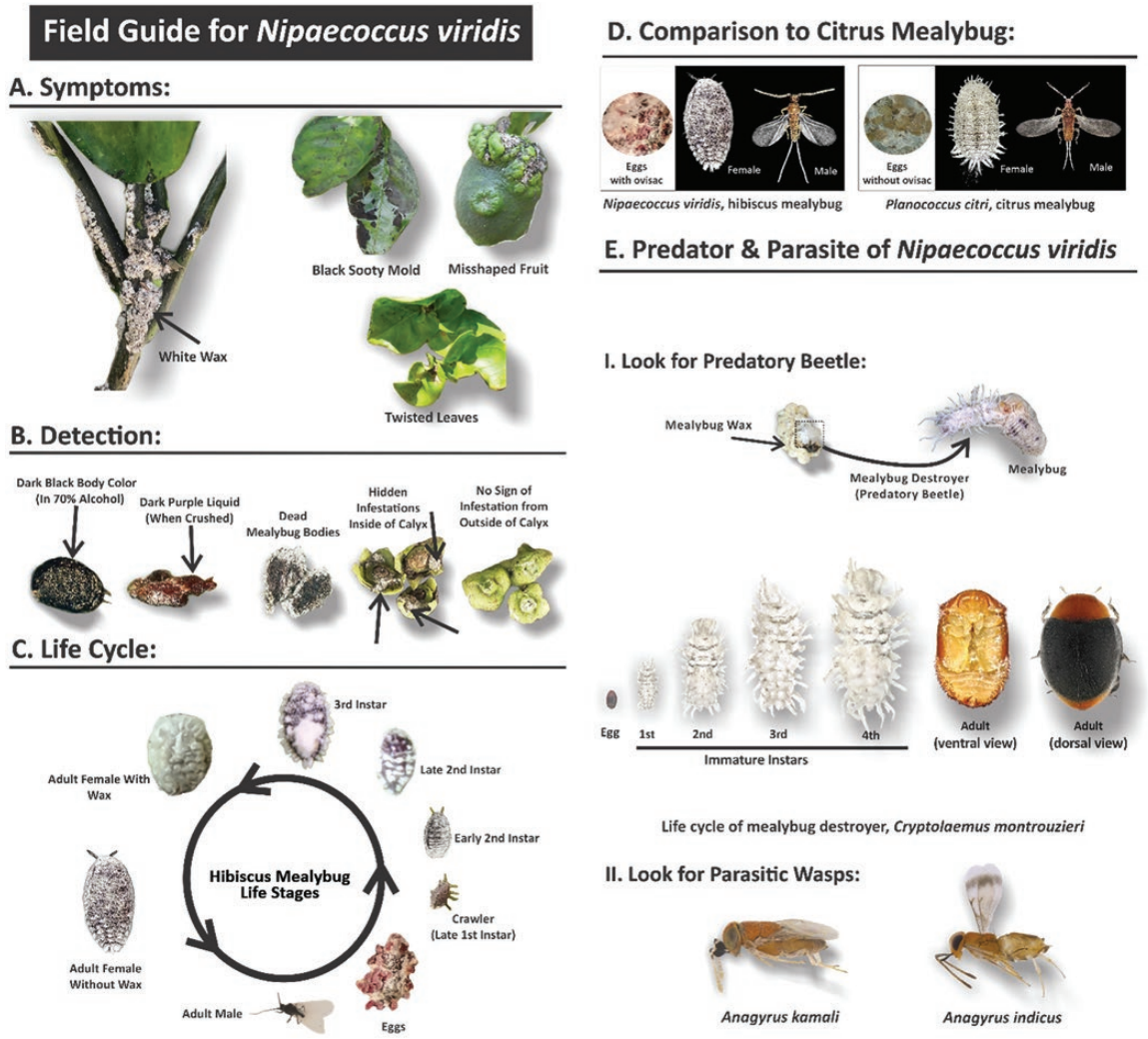

Fig. 13. Field guide of *Nipaecoccus viridis*. (A) Symptoms for heavy infestation, (B) field detection and tentative field diagnostics, (C)quick diagnostics of life stages, (D) quick field diagnostics commonly found mealybugs on citrus in Florida; mealybugs on the right side in the Section I of part E is *Phenacoccus solenopsis* Tinsley, (E) quick diagnostics of commonly found predators and parasitic wasps of mealybugs. Reprinted with permission from FDACS-DPI (Ahmed et al. 2019).

and dipterans *Cacoxenus* sp. (Diptera: Drosophilidae), and *Kalodiplosis* sp. (Diptera: Cecidomyiidae) in Guam (Nechols 2003). *C. montrouzieri* shows promise for controlling hibiscus mealybug as it can develop and reproduce on a diet consisting exclusively of hibiscus mealybug (Kairo et al. 2013), a property which has not yet been determined in other predators of *N. viridis*. Additionally, *C. montrouzieri* was shown to decrease hibiscus mealybug populations by over 80% in pomelo (Mani and Krishnamoorthy 2008). While the predator community in Florida is still being assessed, the coccinellid *C. montrouzieri*, lepidopteran *Anatrachyntis badia* (Hodges) (Lepidoptera: Cosmopterigidae), and dipterans *Leucopina bella* (Loew) (Diptera: Chaemyiidae) and *Fragosa* sp. (Diptera: Syrphidae) have been found preying on hibiscus mealybugs in citrus groves and previously unknown predators like *Ceraeochrysa* sp. (Neuroptera: Chrysopidae) have also been observed consuming hibiscus mealybugs (Middleton and Diepenbrock, in review).

Parasitoids also play an important role in regulating hibiscus mealybug. *Anagyrus indicus* (Hymenoptera: Encyrtidae) was very effective at controlling hibiscus mealybug populations in Guam, resulting in 42%–100% mortality in first instars (Nechols and Seibert 1985). *A. indicus* oviposits in all nymphal stages and in adult female hibiscus mealybug (Nechols and Kikuchi 1985), and was also one of the most common natural enemies in Guam, Tinian, and Saipan, making up over 90% of the natural enemy community (Nechols 2003). *A. indicus* was taken from Guam and released in Jordan in 1984 where it successfully established and spread quickly. The related *Anagyrus kamali* (Hymenoptera: Encyrtidae) was also found to have naturally arrived in Jordan, although did not appear to have the same impact on hibiscus mealybug populations as *A. indicus* (Meyerdirk et al. 1988). Over 70 other parasitoid species have been found to parasitize hibiscus mealybug worldwide, including *Leptomastix phenacocci* (Hymenoptera: Encyrtidae), *Anagyrus dactylopii* (Hymenoptera: Encyrtidae), *Anagyrus aegyptiacus* (Hymenoptera: Encyrtidae), and *Anagyrus pseudococci* (Hymenoptera: Encyrtidae) (Sharaf and Meyerdirk 1987). However, few species appear to be as efficacious as *A. indica*.

Biological control by predators and parasitoids can be disrupted by the presence of ants tending mealybugs for honeydew and controlling ant populations can be key to effective biological control. Ants reduced parasitism of hibiscus mealybug by *A. indicus* from ~100% to 2% in Guam (Nechols and Seibert 1985), and ants had to be excluded for *C. montrouzieri* to successfully reduce hibiscus mealybug populations in India (Mani and Krishnamoorthy 2008). Different methods of controlling ants include using insecticide treated ant baits and insecticide treated sticky bands around citrus tree trunks (Smith et al. 1997, Franco et al. 2004).

Conclusions

Hibiscus mealybug is an important economic pest of citrus throughout much of the citrus-producing regions of the world, and now in Florida as well. Management for this pest is complicated in that citrus growers apply insecticides regularly for Asian citrus psyllid (*Diaphorina citri* Kuwayama), the vector for the pathogen which causes citrus greening. These management actions likely exacerbate hibiscus mealybug populations by reducing survival of predators for this pest. Successful field management of this pest will require greater knowledge of its seasonal population biology, development of scouting tools, incorporation of selective pesticides, and management practices that support predatory arthropods, with sanitation and exclusion to reduce spread.

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