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Field Report and Survey of *Fiorinia phantasma* (Hemiptera: Diaspididae), Potential Pest of Palms, and Ornamental Plants in the United States

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Abstract

Fiorinia phantasma Cockerell & Robinson is an invasive, polyphagous pest recently found causing frond losses in ornamental palms in Miami-Dade County and in nurseries in Palm Beach County, Florida, USA. In this article, we document the discovery of this pest, its associated damage, closely related species, potential host plant species, a field guide, basic diagnostics, field dispersal, and available management options. *Fiorinia phantasma* is a pest of concern for ornamental plants demanding quick development of its management in Florida and preventative measures for other states in the United States. This article will help in detecting, identifying, and managing its early infestations.

Key words: invasive species, economical pest, landscape and ornamental pests, nurseries, Florida

Fiorinia phantasma Cockerell & Robinson is an economically important pest of nursery plants, particularly of ornamental palms and can be transported to new localities by movement of live nursery stock (Ahmed 2018, Ahmed and Miller 2018). It was first found in the Philippine Islands in 1915 (Cockerell and Robinson 1915) and had a major global expansion during the last decade. It is now known in 23 countries and territories (American Samoa, France, French Polynesia, Grenada, Guam, Hawaii, Hong Kong, Indonesia, Malaysia, Maldives, Nauru, Netherlands, New Caledonia, Papua New Guinea, Reunion, Saint Barthelemy, Saint Martin, Singapore, Solomon Islands, Taiwan, Thailand, the continental United States, and Vietnam; Watson et al. 2015). The first USA continental record was collected on *Phoenix canariensis* Hort, Canary Island date palm, in 2018 from Miami-Dade County, Florida, where it was abundant and causing damage to fronds in ornamental palms (Ahmed 2018, Ahmed and Miller 2018). Heavy infestations of *F. phantasma* have also been reported on palms in Hawaii and Grenada (Garcia 2011). It has apparently been introduced without its natural enemies and has the potential to cause serious damage (Garcia 2011, Garcia and Hara 2011, Watson et al. 2015). Its preference for palms may be of concern in Florida where palms are important components of natural and ornamental environments.

The presence of all life stages and dense populations of *F. phantasma* on palm trees in Miami-Dade County indicates that the infestation had been there for an extended period (M. Z. Ahmed, personal observation). It is not surprising that the Florida infestation remained undetected, as the scale is identical in field appearance to other species in the genus *Fiorinia* that occur in Florida on similar or identical hosts.

Closely Related Species

There are six species of the genus *Fiorinia* in the United States [*F. externa* Ferris, *F. fioriniae* (Targioni Tozzetti), *F. japonica* Kuwana, *F. pinicola* Maskell, *F. proboscidaria* Green, and *F. theae* Green] (Table 1). Three of them (*F. fioriniae*, *F. proboscidaria*, and *F. theae*) are found in Florida (Fig. 1). All of them require microscopic analysis to be correctly identified to genus and species. Currently, *F. phantasma* is present in two counties in Florida, Miami-Dade, and Palm Beach. *Fiorinia fioriniae* also occurs on various palms in these

Table 1. Species of the genus *Fiorinia* reported from the United States, their geographical distribution, and occurrence on palms

Fiorinia species in the United States	Distribution in the United States	Reported on palms	Established in Florida
Fiorinia proboscidaria	Florida only	No, common on citrus	Yes, recently
Fiorinia fioriniae	18 States	Yes, commonly	Yes, widespread
Fiorinia theae	22 States	Yes, rarely; commonly on camellias and hollies	Yes, widespread
Fiorinia japonica	California, District of Columbia, Georgia, Maryland, New York and Virginia	Yes, rarely; common on conifers	No
Fiorinia pinicola	California, Georgia	No, common on junipers	No
Fiorinia externa	Connecticut, District of Columbia, Georgia, Maryland, Massachusetts, New Jersey, New York, Ohio, Pennsylvania, Rhode Island and Virginia	No, only on conifers	No, intercepted in Florida

Current study and Garcia Morales et al. 2016

Fig. 1. Other *Fiorinia* species found in Florida (photo credit: M. Z. Ahmed, L. Deeter, and L. Buss).

counties (FDACS-DPI 2021). One other species rarely found on palms is *F. japonica*. It has been found in other states in the United States including Georgia, but it is not known to occur in Florida (Garcia Morales et al. 2016).

Potential Threat

The presence of *F. phantasma* in Florida poses a potential threat to homeowners as well as nursery and landscape industries, due to its broad host range represented by 25 families and 56 genera (Watson et al. 2015, Garcia Morales et al. 2016, Ahmed and Miller 2018, FDACS-DPI 2021), including many important ornamental plants and several fruit crops (Table 2). An example of the heavy damage this pest can cause comes from the Maldives, where over 6,000 palm trees were infested in a single resort (Watson et al. 2015). The infestation caused yellowing of the leaves, leaf drop, loss of plant vigor, stunting of the host, and death (Watson et al. 2015). This scale insect particularly threatens palms in Florida that accounts for annual sales of approximately $400 million (Khachatryan and Hodges 2012).

Initial scale infestations usually start with the arrival of crawlers (first instar, mobile stage) either blown by the wind, on contaminated plant material, or hitchhiking on pruning or gardening tools (M. Z. Ahmed, personal observation). Crawlers settle on plant parts and molt to the second instar within a few days (M. Z. Ahmed, personal observation). In palms, an initial infestation typically starts within the fold of a leaflet either near the base or scattered on the upper side of young palm fronds. The first generation commonly stays hidden in the upper leaf fold and can easily be missed if only inspecting the underside of palm leaves. It is necessary to cut leaves and open the upper fold to check for hidden infestations. The second generation may come out of the fold to find new colonizing sites on the lower sides of leaves.

Host Plant Surveys in Florida

There were 475 reports of *F. phantasma* in the last 3 yr (2018–2020) in Florida (FDACS-DPI 2021). These were from 30 plant species in 28 genera and nine host plant families. We ranked these host plants based on the number of reports in Table 3. The most reports were from *Phoenix* species (including *canariensis*, *dactylifera*, *reclinate*, and *roebelenii*), followed by *Wodyetia bifurcata* > *Dypsis lutescens* > *Cocos nucifera* > *Ligustrum japonicum* (Table 3).

Field Guide

Species in the genus *Fiorinia* are unusual in that adult females are encased within the second-instar shed skin and are known as pupillarial (Miller and Davidson 2005). Male and female scales usually intermingle on the topsides and undersides of leaves (Fig. 2) (Ahmed 2019). Infestation in palms can be detected by looking at the upper and lower sides of the leaves and searching for any sign of damage, particularly for the whitewash areas on leaves (Fig. 2a). Any small, white, snow-like spots on the leaves could be male *F. phantasma* (Fig. 2b and c). Second-instar female shed skins (Fig. 2c) sometimes have red stripes running the width of the scale exuviae, but many Florida specimens lack these stripes and are transparent to darkish red (Ahmed 2019). If the infestation is at an early stage, signs might not be obvious. Initial infestation is often hidden in a fold on the upper side of a palm leaf (Fig. 3) (Ahmed 2019). Adult females have an unusual body shape that is wide in the thorax and anterior abdomen but abruptly narrows to the body apex (Fig. 4a). Second-instar females have a notch on the side of the body near the anterior end of the pygidium and five macroducts along the posterior margin of the pygidium (Fig. 5). Slide-mounted specimens are unique by having a rounded process between the antennae bearing several small projections (Fig. 4d). *Fiorinia phantasma* is almost identical in appearance to *F. fioriniae* which also infests palms (Fig. 4). Suspect *F. phantasma* must be examined and confirmed by an expert.

Identification and Temporary Slide-Mounting Procedure

Several adult females that are usually the largest specimens should be removed from the host and placed in a watch glass containing 10% KOH (see Fig. 6 for tools and materials; Steps I and II, Fig. 7). The watch glass should be covered and heated at 70–90°C for 5–10 min on a hot plate (Steps II–IV, Fig. 7). The watch glass is removed from the heat source and allowed to cool and examined using a binocular

Table 2. Host plants of *Fiorinia phantasma* in Florida

Species	Common names
Palms	
Adonidia merrillii	Christmas palm
Archontophoenix cunninghamiana	Bangalow palm/king palm/Illawara palm
*Arenga undulatifolia**	n/a
Chamaerops humilis	European fan palm/Mediterranean dwarf palm
Cocos nucifera	Coconut palm
Cycas revoluta	Sago palm
Dictyosperma album	Princess/hurricane palm
Dypsis decaryi	Triangle palm
Dypsis lutescens	Areca palm/butterfly palm
Howea forsteriana	Kentia palm/ thatch palm
Hyophorbe lagenicaulis	Bottle palm
Livistona chinensis	Chinese fan palm/fountain palm
Nypa fruticans	Nipa palm, mangrove palm
Phoenix species including *canariensis, dactylifera, reclinata, robellinii, sylvestris*	Canary Island date palm, date palm, wild date palm/Senegal date palm, pygmy date palm, silver date palm/ Indian date
Pinanga coronata	Ivory cane palm
Raphia farinifera	Raffia palm
Ravenea rivularis	Majesty palm
Wallichia disticha	Wallich palm
Sabal mexicana	Rio Grande palmetto/Mexican palmetto/Texas palmetto/Texas sabal palm/ palmmetto cabbage
Syagrus romanzoffiana	Queen palm
Tahina spectabilis	Tahina palm
Thrinax radiata	Florida thatch palm
Trachycarpus fortunei	Windmill palm
*Veitchia*sp.	n/a
*Washingtonia*sp.	n/a
Wodyetia bifurcata	Foxtail palm
Flowering/ornamental Plants	
Bambusoideae	Bamboo
Calophyllum inophyllum	Beauty leaf
Carissa macrocarpa	Natal plum
Cycadales	Cycads
Ficus benjamina	Weeping fig
Ficus racemosa	Cluster fig tree
Ficus rubiginosa	Rusty fig/Port Jackson fig
Ficus microcarpa	Chinese banyan/curtain fig
Heliconia caribaea	Lobster-claws
Jasminum	Jasmine
Monstera deliciosa	Monstera/tarovine
Orchidaceae	Orchids
Pittosporum tobira	Japanese cheesewood
Plumeria	Frangipani
Senna alata	Candlestick
Strelitzia reginae	Crane flower/bird of paradise
Shrubs/trees (ornamentals and fruits)	
Artocarpus heterophyllus	Jackfruit
Azadirachta indica	Neem tree
*Calophyllum neoebudicum**	n/a
Jatropha integerrima	Peregrina
Ligustrum japonicum	Wax-leaf privet/Japanese privet
Litchi chinensis	Lychee
Mangifera indica	Mango
Murraya koenigii	Curry-leaf
Murraya paniculata	Orange-jasmine
Nerium oleander	Oleander
Noronhia emarginata	Madagascar olive
*Pandanus*sp.	Screw pine
Schinus terebinthifolius	Brazilian peppertree/Florida holly
Podocarpus	Japanese yew
Ravenala madagascariensis	Traveler's tree

*Uncommon in Florida (current study and FDACS-DPI 2021).

microscope (Steps III–V, Fig. 7). A micro-spatula is used to push on the second-instar exuvium to force the adult female body out (Step V, Fig. 7). It may be necessary to make a small incision in the shed skin to help eject the body of the adult female. The body of the adult female is cleared by lightly tapping it with the micro-spatula. The body contents will flow out of the adult. However, it may be necessary to make a small incision on the side of the abdomen and continue manipulating it with the micro-spatula (Steps IV and V, Fig. 7). The cleared adult females are placed in distilled water and heated for 2 or 3 min at 80°C to remove any excess KOH (Steps IV and V, Fig. 7). A very tiny drop of Hoyer's mounting medium is placed on a slide and the cleared specimens immersed in the liquid; they should not be floating on the surface (Step VI, Fig. 7). A cover slip is placed on the Hoyer's drop and the slide is labelled (Step VI, Fig. 7). A compound microscope (Step VII, Fig. 7) is used to observe the diagnostic characters of *F. phantasma* (i.e., a 'crown' between the antennae and large macroducts on the pygidium, see Fig. 4). However, in the case of a new host plant or new county, state, or country record, we would recommend permanent slide-mounting of specimens and deposition of slides in an easily accessible collection for future references. Please see Ahmed et al. (2021) for the protocol of permanent slide mounting.

Fiorinia phantasma is almost identical to *F. fioriniae* in the field, but clearly differs under a microscope (characters in parentheses are those of *F. fioriniae*) in the shape of the body of the adult female being broad and abruptly narrowing to the body apex (body long and narrow) (Fig. 4a and b), the presence of a process with spicules between the antennae (process is absent) (Fig. 4b and c), and antennae not horn like (antennae horn like; Fig. 4b and c). In the second-instar female shed skin, there is a conspicuous notch in the body margin at the anterior end of the pygidium (without a notch) (Fig. 5f). Please see Ahmed et al. (2021) for the taxonomic key to adult females of seven *Fiorinia* species occurring in the United States.

Pest Dispersal

The first-instar nymphs, known as crawlers, which are short-lived in the absence of suitable feeding sites, are the primary dispersal agents through short-term crawling, wind dispersal, and attachment to birds or mammals. Movement of contaminated plant material or horticultural tools is potential mechanisms of dispersal of scale insects and is likely to play an important role with the *F. phantasma* dispersal.

Management

Chemical Control

Effective chemical control of armored scale insects involves selecting the right type of insecticide and timing of applications to control vulnerable stages while minimizing the impact on resident natural enemies (McClure 1977, McClure 1979, Sadof and Neal 1993, Juarez-Hernandez et al. 2014, Quesada and Sadof 2017,

Table 3. Host plant reports of *Fiorinia phantasma* in Florida during surveys between 2018 and 2020

Family	Genus	Species	No. of reports	Survey ranking
Anacardiaceae	*Schinus*	*Terebinthifolia*	3	
Apocynaceae	*Carissa*	*Macrocarpa*	3	
Arecaceae	*Adonidia*	*merrillii*	6	8
Arecaceae	*Adonidia*	sp.	2	
Arecaceae	*Archontophoenix*	*cunninghamiana*	2	
Arecaceae	*Arenga*	sp.	2	
Arecaceae	*Chamaerops*	*humilis*	6	8
Arecaceae	*Cocos*	*nucifera*	37	4
Arecaceae	*Dypsis*	*decaryi*	4	10
Arecaceae	*Dypsis*	*lutescens*	41	3
Arecaceae	*Dypsis*	sp.	2	
Arecaceae	*Howea*	*forsteriana*	6	8
Arecaceae	*Hyophorbe*	*lagenicaulis*	4	10
Arecaceae	*Livistona*	*chinensis*	3	
Arecaceae	*Livistona*	*chinensis*	6	8
Arecaceae	*Livistona*	sp.	2	
Arecaceae	NA	NA	5	9
Arecaceae	*Nypa*	*fruticans*	6	8
Arecaceae	*Phoenix*	*canariensis*	13	Including in 1
Arecaceae	*Phoenix*	*dactylifera*	2	
Arecaceae	*Phoenix*	*reclinata*	14	Including in 1
Arecaceae	*Phoenix*	*roebelenii*	39	Including in 1
Arecaceae	*Phoenix*	sp.	2	
Arecaceae	*Phoenix*	sp.	141	1
Arecaceae	*Ravenea*	*rivularis*	2	
Arecaceae	*Sabal*	*mexicana*	6	8
Arecaceae	*Syagrus*	*romanzoffiana*	*	
Arecaceae	*Tahina*	*spectabilis*	11	6
Arecaceae	*Thrinax*	*radiata*	2	
Arecaceae	*Trachycarpus*	*fortunei*	*	
Arecaceae	*Veitchia*	sp.	4	10
Arecaceae	*Washingtonia*	sp.	2	
Arecaceae	*Wodyetia*	*bifurcata*	50	2
Cycadaceae	*Cycas*	*revoluta*	4	10
Moraceae	*Ficus*	*microcarpa*	3	
Moraceae	*Ficus*	*racemosa*	3	
Moraceae	*Ficus*	*rubiginosa*	3	
Oleaceae	*Ligustrum*	*japonicum*	13	5
Pandanaceae	*Pandanus*	sp.	6	8
Pittosporaceae	*Pittosporum*	*tobira*	7	7
Strelitziaceae	*Strelitzia*	*reginae*	5	9
Strelitziaceae	*Strelitzia*	sp.	3	

*Host plants reported in host range trials. The host plant reports are ranked in the column of survey ranking based on their frequency (current study and FDACS-DPI 2021).

Quesada et al. 2018). Controlling armored scales is particularly challenging due to their feeding behavior and that most of their life stages are protected under coverings. Intracellular feeding behavior of armored scale insects makes them less susceptible to systemic insecticides compared to other scale insect species that feed continuously on phloem, as systemic chemicals do not reach parenchymal cells or vascular bundle tissues where armored scale insects usually feed (Sadof and Neal 1993, Juarez-Hernandez et al. 2014). Additionally, their nature of spending most of their life cycle in a relatively impervious wax cover makes them less susceptible to contact insecticides. Their susceptibility further decreases in pupillarial species, where adult females are encased within the second-instar shed skin like in *F. phantasma*. Crawlers are the most susceptible to contact insecticides as they do not have the protective coverings. Accurate timing of the application of contact insecticides is crucial because crawlers' susceptibility to contact insecticides can further decrease due to three reasons: 1) an increase in their age, 2) an increase in the period of their activity, and 3) a delay in their settlement on foliage (Quesada and Sadof 2017, Quesada et al. 2018). In addition, the peak abundance of crawlers may coincide with the seasonal occurrence of natural enemies, and post-spray populations of armored scale insects can rebound quickly due to reduced natural enemies and increased plant growth (McClure 1977, McClure 1979). The combination of horticultural oils and insecticidal soap in place of conventional contact insecticides (i.e., pyrethroids) can help conserve resident natural enemies (Buss and Dale 2016, Quesada and Sadof 2017). A resurgence of armored scale populations can also occur due to reinfestation of sprayed foliage by crawlers from nearby trees treated with contact insecticides applied with incomplete coverage (McClure 1977). As *F. phantasma* is a new invasive species, effective management strategies are still being developed.

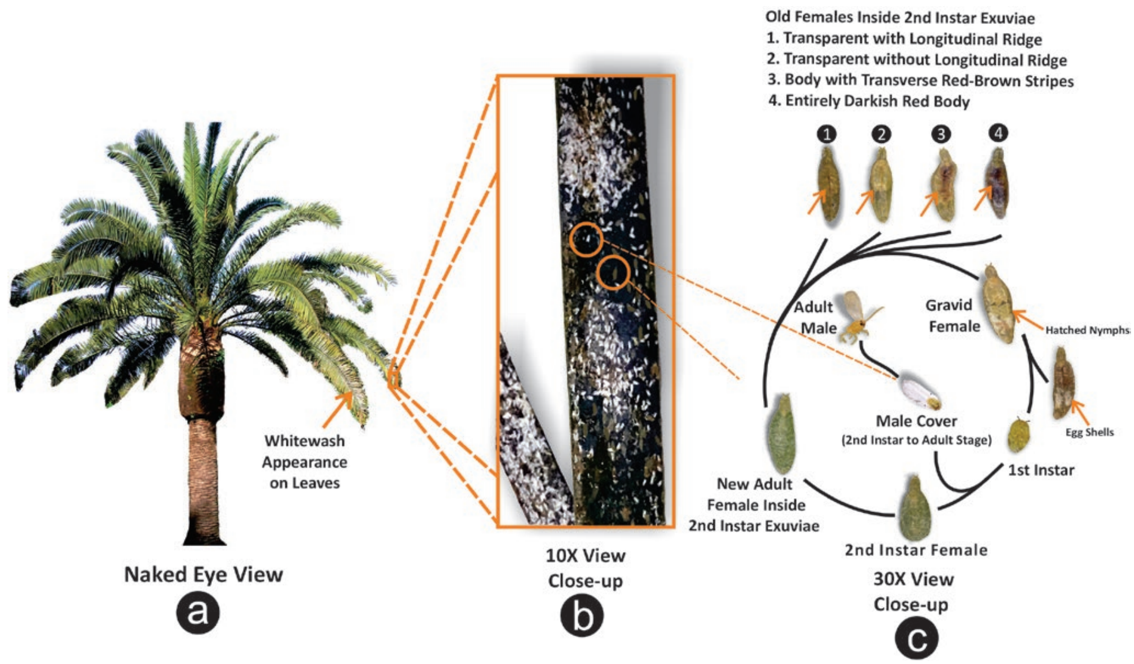

Fig. 2. A mature infestation of *F. phantasma* on *Phoenix canariensis*, Canary Island date palm in Miami showing (a) infested leaves, (b) infested leaflet, and (c) life cycle of *F. phantasma* showing different stages (photo credit: M. Z. Ahmed, G. Ouwinga, and L. Deeter).

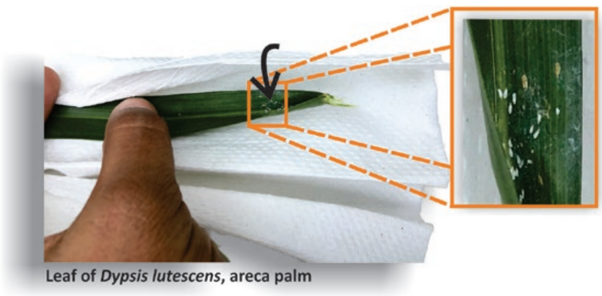

Fig. 3. Initial infestation hidden in a fold on the upper side of a leaf of *Dypsis lutescens*, areca palm (photo credit: M. Z. Ahmed).

However, four factors still should be considered when attempting chemical control of *F. phantasma*: 1) systemic insecticides could provide little or no control, 2) wrong timing of contact insecticide applications could also lead to little or no control, 3) contact insecticide applications could disrupt the conservation of resident natural enemies, and 4) an incomplete coverage of contact insecticide applications could lead to *F. phantasma* proliferation.

Biological Control

Scale insects are particularly susceptible to biological control. Since this scale may be native to the Philippines, a search for natural enemies for exotic biological control agents should be concentrated there. Established natural enemies may play a role in controlling *F. phantasma* in new areas of invasion. In Hawaii, *Aphytis* sp. (Aphelinidae: Hymenoptera) was found attacking about 10% of the scales (Garcia 2011). In addition, scales were found preyed upon by *Telsimia nitida* Chapin (Coccinellidae: Coleoptera), *Cybocephalus nipponicus* Endrödy-Younga (Cybocephalidae: Coleoptera), *Chrysoperla comanche* (Banks) (Chrysopidae: Neuroptera), and *Aleurodothrips fasciapennis* (Franklin) (Phlaeothripidae: Thysanoptera) in Hawaii (Garcia 2011). In recent surveys, we found several predators and parasitoids feeding on *F. phantasma* including predatory mites, *Amblyseius largoensis* (Muma) (Phytoseiidae: Mesostigmata), predatory beetles, *Cybocephalus nipponicus* Endrödy-Younga (Cybocephalidae), *Egius platycephalus* Mulsant, *Chilocorus cacti* (Linnaeus), *Chilocorus nigritus* (Fabricius) (Coccinellidae: Coleoptera), parasitoid wasps, *Encarsia* sp. (Aphelinidae: Hymenoptera), green lacewings, *Ceraeochrysa* sp. (Chrysopidae: Neuroptera), and predatory thrips, *Aleurodothrips fasciapennis* (Franklin) (Phlaeothripidae: Thysanoptera) (A. L. Roda, personal observation; FDACS-DPI 2021).

Mechanical Control

Under certain circumstances, mechanical control using high-pressure water sprays or hand-picking visible infestations may be possible (A. L. Roda, C. L. McKenzie, M. Z. Ahmed, personal observation).

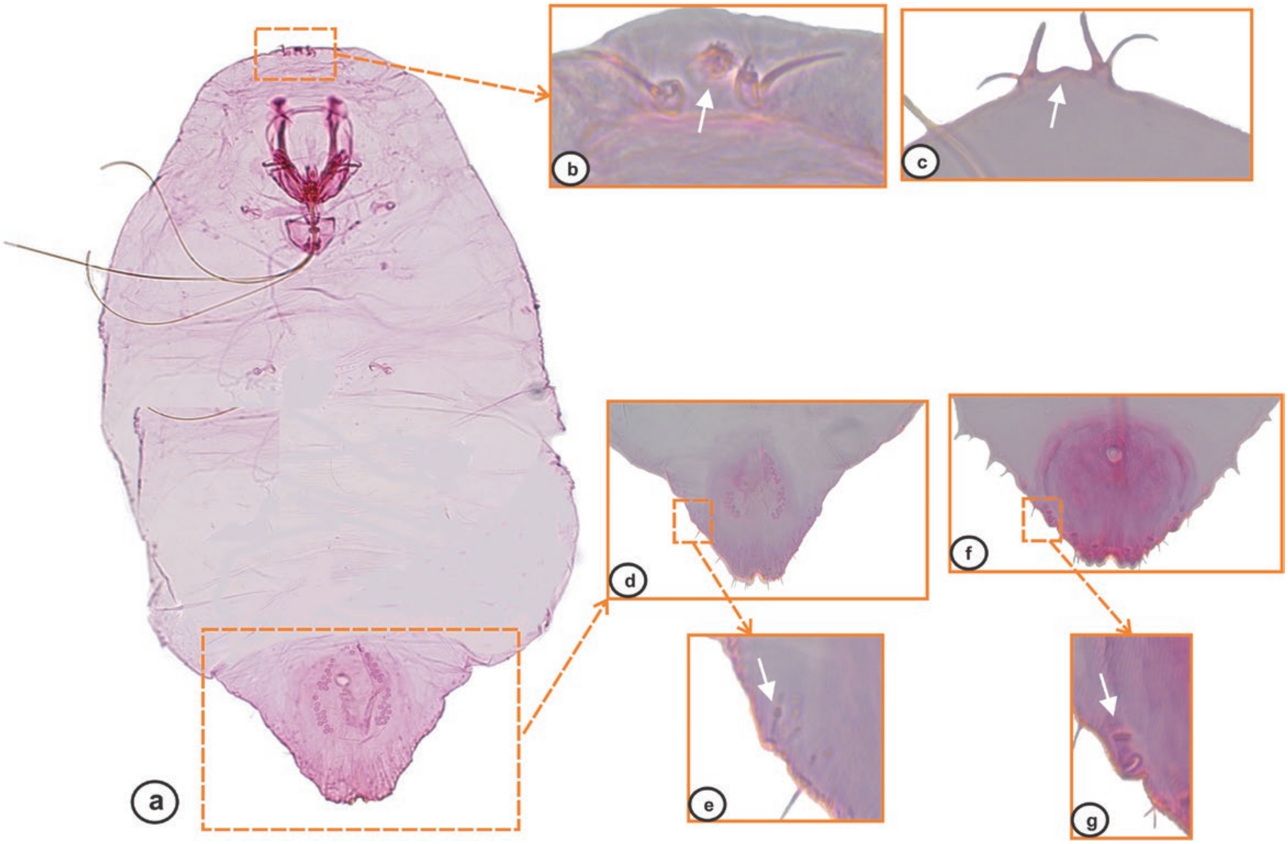

Fig. 4. Slide-mounted view of the body of an adult female, about 0.65 mm long and widest at about second abdominal segment, then narrowing abruptly to a triangular pygidium with a notch at apex formed by parallel median lobes separated by about the width of one lobe of *F. phantasma* (a), rounded process between the antennae bearing several small projections shown by arrow of *F. phantasma* (b), the absence of a such structure between the antennae in *F. fioriniae* (c), pygidium with 4 thin marginal macroducts, each duct about 4× longer than wide of *F. phantasma* (d), close-up of the shape of the third macroduct in *F. phantasma* (e), pygidium with 3–4 broad marginal macroducts, each duct about 2× longer than wide of *F. fioriniae* (f), close-up of the shape of the third macroduct in *F. fioriniae*. The purplish coloration is due to a dye used during staining as the part of permanent slide-mounting process (slide and photo credits: M. Z. Ahmed, G. Ouwinga, and L. Deeter).

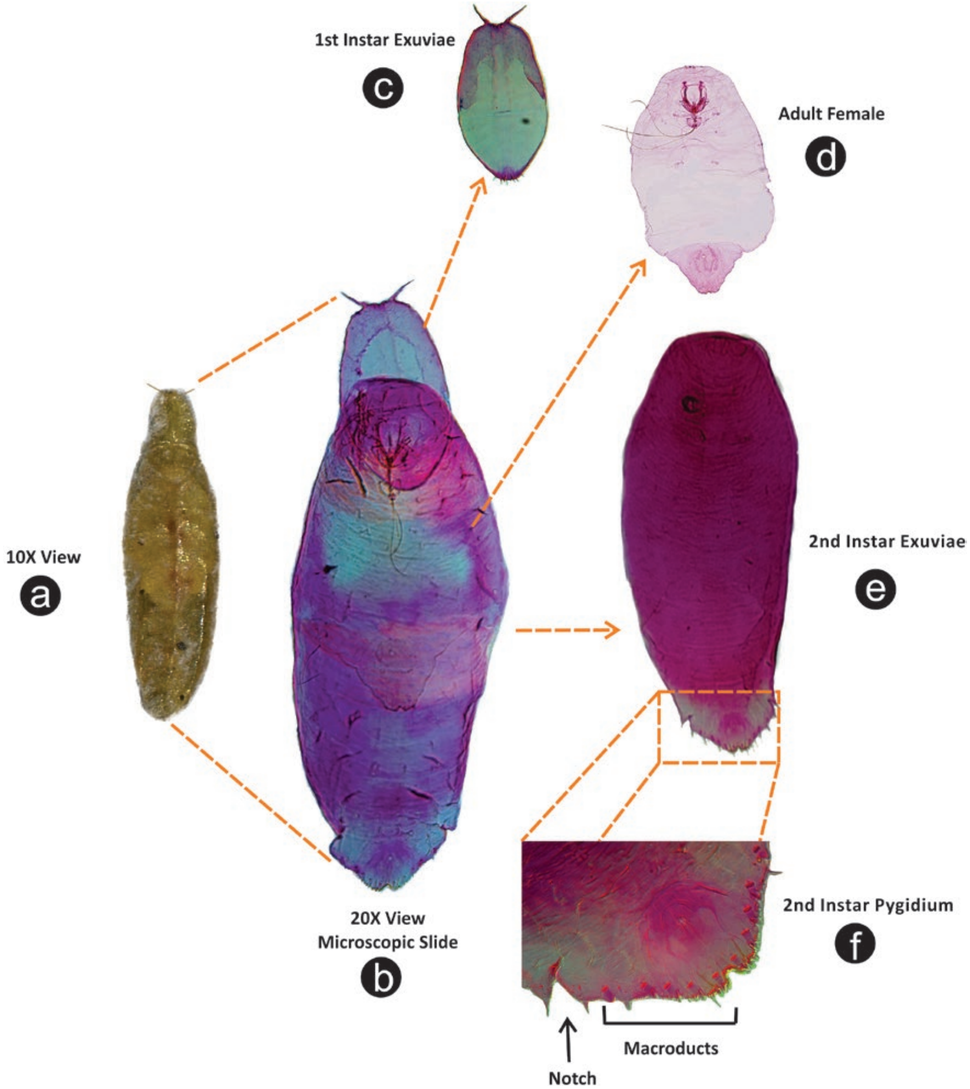

Fig. 5. Females inside second-instar exuvium with first-instar exuvium on the top. Naked eye view of adult female inside second instar exuvium (a), microscopic slide view (b), first-instar exuvium. (c), adult female inside second-instar exuvium (d), second-instar exuvium (e), pygidium of second-instar female with a notch on each side of the body at the anterior end of the pygidium and five macroducts along the posterior margin of the pygidium. The purplish coloration is due to a dye used during staining as the part of permanent slide-mounting process (slide and photo credits: M. Z. Ahmed, G. Ouwinga, and L. Deeter).

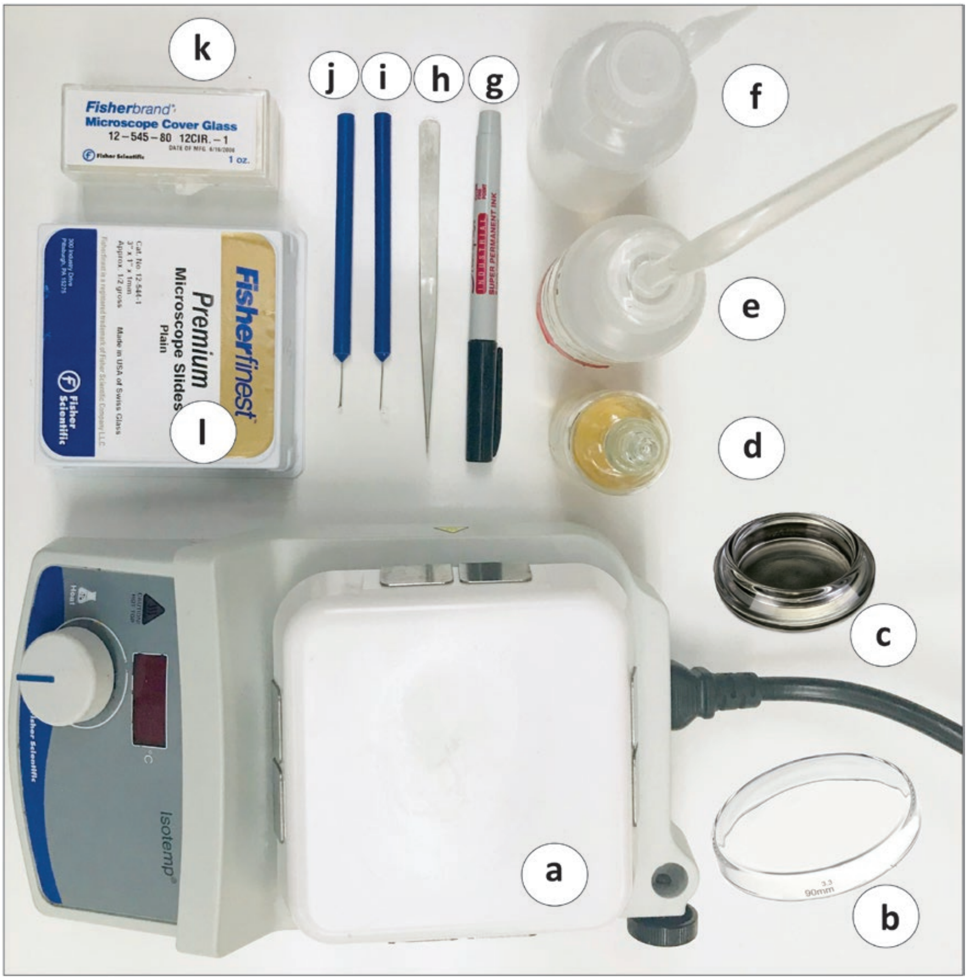

Fig. 6. List of tools needed in rapid slide mounting procedure. (a) Hot Plate, (b) Petri Dish Cover, (c) Watch Glass, (d) Hoyer's Mounting Medium, (e) 10 % Potassium Hydroxide, (f) Distilled Water, (g) Marker, (h) Forceps, (i) Micro-spatula, (j) Micro-scalpel, (k) Microscope Cover Glass 12CIR, and (l) Microscope Slides 3″ × 1″ × 1 mm (photo credit: M. Z. Ahmed).

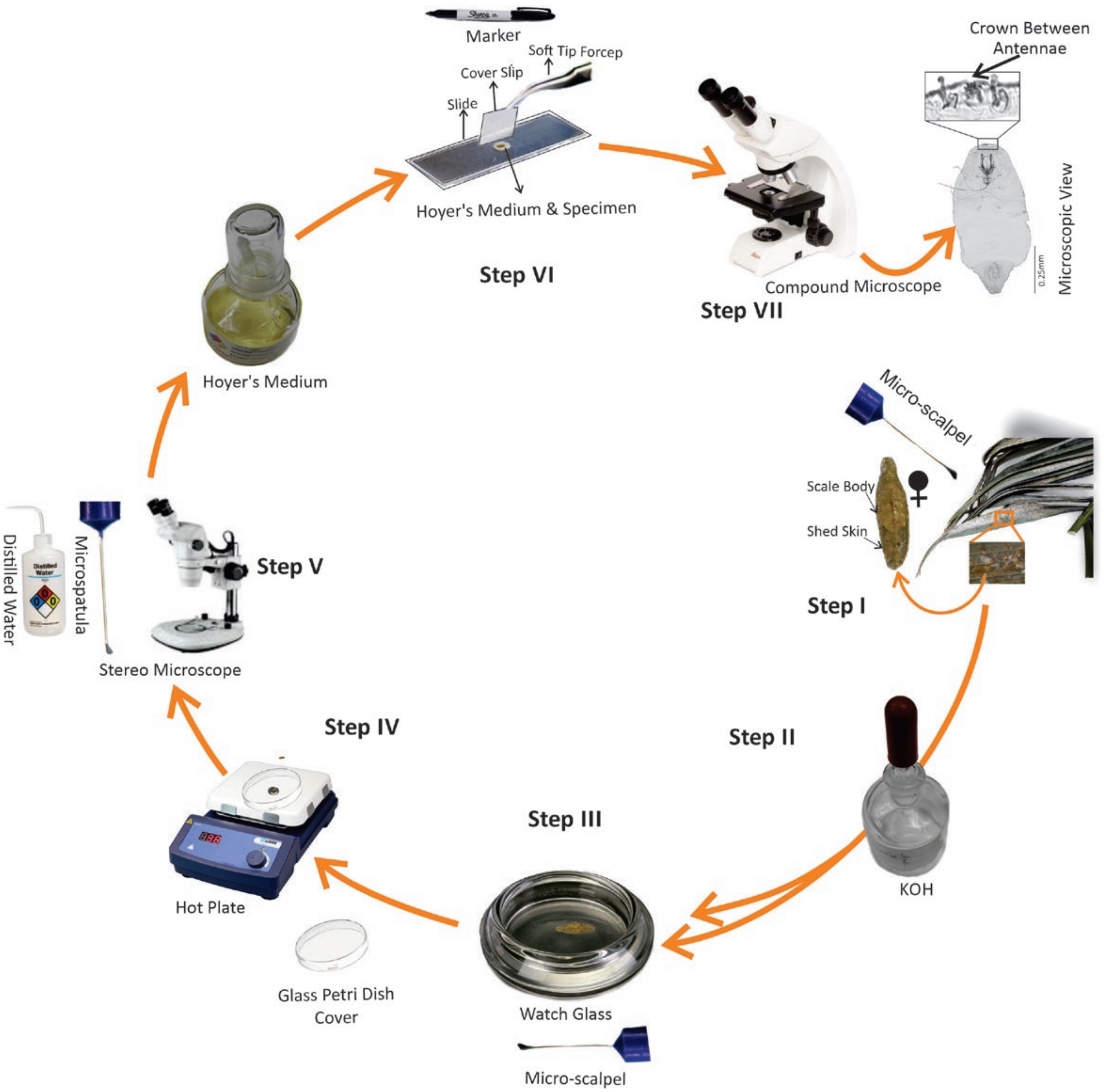

Fig. 7. Visual demonstration of rapid slide mounting procedure. Please see the identification section in the text for further details. Also see figure 6 for the list of tools needed in this procedure (photo credit: M. Z. Ahmed).

Semiochemical Control

Synthetic sex pheromones to attract male *F. phantasma* provide a selective and sensitive tool and might be useful in early detection and mating disruption in efforts to halt its establishment in Florida (McClure 1979, Dunkelblum 1999).

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References Cited

Ahmed, M. Z. 2018. Field detection and potential host plants of *Fiorinia phantasma* Cockerell & Robinson (Diaspididae: Hemiptera), phantasma Scale, potential pest of palms and ornamental plants in Florida. FDACS-P-01917, Circular, Issue No. 439. Available from https://www.fdacs.gov/content/download/82790/file/CIRCULAR%20-%20Phantasma%20Scale.pdf [accessed on July 14, 2021].

Ahmed, M. Z. 2019. Field guide for phantasma scale. Division of Plant Industry, Florida Department of Agriculture and Consumer Services, Florida. (Available by request at https://www.fdacs.gov/Divisions-Offices/Plant-Industry)

Ahmed, M. Z., and D. R. Miller. 2018. First U.S. continental record of *Fiorinia phantasma* Cockerell & Robinson (Hemiptera: Diaspididae), phantasma scale, potential pest of palms and ornamentals plants. Pest Alert. FDACS-P-01880. https://www.fdacs.gov/content/download/79840/file/pest_alert_-_fiorinia_phantasma.pdf [accessed on July 14, 2021].

Ahmed, M. Z., M. R. Moore, D. Liu, J. Feng, B. Normark, and D. Miller. 2021. Taxonomic and identification review of adventive *Fiorinia* Targioni Tozzetti (Hemiptera, Coccomorpha, Diaspididae) of the United States. Zookeys (In press).

Buss, E. A., and A. Dale. 2016. Managing scale insects on ornamental plants. University of Florida, Institue of Food and Agricultural Sciences, Electronic Data Information Source, ENY-350, Gainesville, FL.

Cockerell, T. D., and E. Robinson. 1915. Descriptions and records of Coccidae. Bull. Am. Mus. Nat. Hist. 34: 105–113.

Dunkelblum, E. 1999. Scale Insects. *Pheromones of Non-Lepidopteran Insects Associated with Agricultural Plants*. CABI Publishing Oxon, UK and New York.

FDACS-DPI. 2021. Florida department of agriculture and consumer services, division of plant industry. Division of Plant Industry, Florida Department of Agriculture and Consumer Service, Gainesville, FL. https://www.fdacs.gov/Divisions-Offices/Plant-Industry [accessed on January 20, 2021].

Garcia, J. N. 2011. *Fiorinia phantasma* Cockerell and Robinson (Hemiptera: Diaspididae), an armored scale pest new to Hawaii. Proc. Hawaii. Entomol. Soc. 43: 59–61.

Garcia, J., and A. Hara. 2011. *Fiorinia phantasma* Cockerell & Robinson (Hemiptera: Diaspididae). New Pest Advisory, Plant Pest Control Branch, Division of Plant Industry, Department of Agriculture, State of Hawaii 1: 1–2.

Garcia Morales, M., B. Denno, D. Miller, G. Miller, Y. Ben-Dov, and N. Hardy. 2016. ScaleNet: a literature-based model of scale insect biology and systematics. *Database*. doi: 10.1093/database/bav118. http://scalenet.info. [accessed on October 4, 2018].

Juarez-Hernandez, P., J. Valdez-Carrasco, G. Valdovinos-Ponce, J. A. Mora-Aguilera, G. OteroColina, D. Teliz-Ortiz, E. Hernandez-Castro, I. Ramí rez-Ramırez, and V. A. Gonza´lez-Hernandez. 2014. Leaf penetration pattern of *Aulacaspis tubercularis* (Hemiptera: Diaspididae) stylet in mango. Fla. Entomol. 97: 100–107.

Khachatryan, H., and A. W. Hodges. 2012. Florida nursery crops and landscaping industry economic outlook. UF-IFAS Nursery Report, 10 pp.

McClure, M. S. 1977. Resurgence of the scale, *Fiorinia externa* (Homoptera: Diaspididae), on hemlock following insecticide application. Environm. Entomol. 6: 480–484.

McClure, M. S. 1979. Spatial and seasonal distribution of disseminating stages of *Fiorinia externa* (Homoptera: Diaspididae) and natural enemies in a hemlock forest. Environ. Entomol. 8: 869–873.

Miller, D. R., and J. A. Davidson. 2005. Armored scale insect pests of trees and shrubs (Hemiptera: Diaspididae). Cornell University Press, Ithaca, NY. 456 pp.

Quesada, C. R., and C. S. Sadof. 2017. Efficacy of horticultural oil and insecticidal soap against selected armored and soft scales. HortTechnology 27: 619–624.

Quesada, C. R., Witte, A., and C. S. Sadof. 2018. Factors influencing insecticide efficacy against armored and soft scales. HortTechnology 28: 267–275.

Sadof, C. S., and J. J. Neal. 1993. Use of host plant resources by the euonymus scale, *Unaspis euonymi* (Homoptera: Diaspididae). Ann. Entomol. Soc. Am. 86: 614–620.

Watson, G. W., D. J. Williams, and D. R. Miller. 2015. The identity and distribution of *Fiorinia phantasma* (Cockerell & Robinson) (Hemiptera: Coccomorpha: Diaspididae), with a new synonym. Zootaxa. 4048: 291–300.