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Host plants and natural enemies of rugose spiraling whitefly (Hemiptera: Aleyrodidae) in Florida

Antonio W. Francis^{1,*}, Ian C. Stocks², Trevor R. Smith², Anthony J. Boughton³, Catharine M. Mannion³, and Lance S. Osborne⁴

Rugose spiraling whitefly, Aleurodicus rugioperculatus Martin (Hemiptera: Aleyrodidae), was first described from Belize (Martin 2004). It was reported for the first time from Miami-Dade County, Florida, in Mar 2009, and in Florida is associated with numerous plant species (Stocks & Hodges 2012). Kumar et al. (2013) reported that this pest caused a great deal of concern in southern coastal counties in previous years. Rugose spiraling whitefly is a phloem feeder and excretes large quantities of honeydew, which covers anything under the infested plant. Thick layers of sooty mold rapidly develop, which is unsightly, disrupts normal leaf physiology, and exacerbates the nuisance condition. The type and level of damage vary by plant species and plant condition, and although this whitefly does not kill large or healthy trees, smaller or unhealthy plants might succumb to very high infestation levels (Mayer et al. 2010). Clean-up and chemical control costs can be substantial for affected homeowners and businesses (Kumar et al. 2013). The best long-term solution for rugose spiraling whitefly is biological control, which has already yielded success in affected areas. The objective of this study was to report the current distribution and host range of this whitefly and the composition of the natural enemy complex that attacks it.

Based on Florida Department of Agriculture and Consumer Services (FDACS), Division of Plant Industry (DPI) records from 2009 to 2015, rugose spiraling whitefly has been identified on at least 118 plant species from >500 whitefly samples. These hosts included edible plants, ornamentals, palms, and weeds of both native and non-native species (Stocks 2012). Susceptible hosts were found in 43 families, but 27 families were each represented by a single host species (Table 1). Many of the reported plant species are likely to be incidental hosts that cannot maintain long-term rugose spiraling whitefly populations and therefore require minimal or no management practices. DPI host record frequency data from 2009 to 2012 showed that 22% of rugose spiraling whitefly-affected hosts were palm species (Arecales: Arecaceae), 16% were gumbo limbo (Bursera simaruba (L.) Sarg.; Sapindales: Burseraceae), 10% were Calophyllum spp. (Malpighiales: Clusiaceae), 9% were avocado (Persea americana Mill.; Laurales: Lauraceae), 4% were black olive (Bucida buceras L.; Myrtales: Combretaceae), and 3% were mango varieties (Mangifera indica L.; Sapindales: Anacardiaceae). Within the family Arecaceae (palms), 44% of samples were coconut (Cocos nucifera L.) and the remainder comprised diverse species. Based on host frequencies, these species are primary or preferred hosts that may require additional management. White bird of paradise (Strelitzia nicolai Regel & Körn.; Zingiberales: Strelitziaceae) and Musa species (Zingiberales: Musaceae) were not included in the compiled data, but these popular south Florida landscape plants and other Musaceae are also considered preferred hosts.

Survey activities began in Dec 2012 and continued to May 2014, with over 300 locations visited. Examination of primary host plants for natural enemies was emphasized. Due to the diverse and variable nature of these locations, sampling times and locations were relatively unstructured. On large residential properties, for example, 4 to 8 plants of a preferred species were examined using a 5 to 10x folding pocket magnifier. At roadside areas with lower numbers of infested hosts, 1 to 3 plants were examined. If rugose spiraling whitefly was found with evidence of associated natural enemies (parasitoid exit holes and adult parasitoids, or adult and/or immature predators), 1 to 3 infested leaves or 3 to 6 terminal ends (20 cm long) per plant were clipped, stored in labeled plastic bags, and maintained in coolers until returned to the laboratory. In the laboratory, adult predators were collected from field material and placed in labeled vials with 70% alcohol. A predator was determined by having been observed feeding on the whiteflies. Adult parasitoids were reared from parasitized nymphs, along with immature to adult predators kept for some time on leaf material stored in vented containers. Natural enemies were collected, placed in vials of alcohol, and sent to DPI in Gainesville, Florida, for identification.

Rugose spiraling whitefly populations were found in 22 counties based on DPI detection records (Fig. 1), indicative of its rapid spread from 2009 to 2015. Following the last major outbreaks in 2013 (Fig. 1), there were no new reports until Aug 2015 in St. Johns County. Flagler, Hernando, Polk, Seminole, and Volusia Counties had single host records, and infestations in these areas caused no noticeable levels of aesthetic damage and did not elicit the public concern that was observed in southern Florida. Consequently, counties such as Miami-Dade (40%), Broward (14%), and Palm Beach (18%) accounted for 72% of plant samples submitted for identification during the first 2 yr of the rugose spiraling whitefly outbreak.

Although a diverse assemblage of rugose spiraling whitefly—associated natural enemies was collected during the survey, the most commonly found parasitoid species were *Encarsia guadeloupae* Viggiani and *Encarsia noyesi* (Hayat) (Hymenoptera: Aphelinidae). Both species were recorded from 15 counties (Fig. 1). A change in the parasitoid species composition was noted in St. Lucie and Martin Counties. At 12 sampling points within an area overlapping both counties in Jul 2013, of 464 dead parasitoids collected from whitefly samples, *E. guadeloupae* was the dominant species, comprising 76%, and the remaining

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Table 1. Host plants associated with rugose spiraling whitefly from 43 botanical families in Florida.

Table 1. (Continued) Host plants associated with rugose spiraling whitefly from 43 botanical families in Florida.

amilies in Florida.			43 botanical families in Florida.		
	Scientific name	Family		Scientific name	Family
L.	Ruellia simplex	Acanthaceae	62.	Carya floridana	Juglandaceae
	Sagittaria latifolia	Alismataceae	63.	Laurus nobilis	Lauraceae
	Mangifera indica	Anacardiaceae	64.	Ocotea coriacea	Lauraceae
	Schinus terebinthifolia	Anacardiaceae	65.	Persea americana	Lauraceae
	Spondias mombin	Anacardiaceae	66.	Cordyline fruticosa	Liliaceae
	Spondias purpurea	Anacardiaceae	67.	Smilax auriculata	Liliaceae
	Spondias sp.	Anacardiaceae	68.	Lagerstroemia speciosa	Lythraceae
	Annona sp.	Annonaceae	69.	Hibiscus rosa-sinensis	Malvaceae
	Annona squamosa	Annonaceae	70.	Sterculia foetida	Malvaceae
).	Cananga odorata	Annonaceae	71.	Thespesia populnea	Malvaceae
L.	Catharanthus roseus	Apocynaceae	72.	Artocarpus heterophyllus	Moraceae
	Philodendron selloum	Araceae	73.	Ficus aurea	Moraceae
	Araucaria heterophylla	Araucariaceae	74.	Ficus benjamina	Moraceae
١.	Adonidia merrillii	Arecaceae	75.	Ficus carica	Moraceae
	Allagoptera arenaria	Arecaceae	76.	Ficus microcarpa	Moraceae
	Archontophoenix alexandrae	Arecaceae	77.	Ficus sp.	Moraceae
	Archontophoenix cunninghamiana	Arecaceae	78.	Musa sp.	Musaceae
	Chamaedorea sp.	Arecaceae	79.	Myrica cerifera	Myricaceae
	Coccothrinax sp.	Arecaceae	80.	Rapanea punctata	Myrsinaceae
	Cocos nucifera	Arecaceae	81.	Eugenia axillaris	Myrtaceae
	Dictyosperma album	Arecaceae	82.	Eugenia foetida	Myrtaceae
	Dypsis decaryi	Arecaceae	83.	Eugenia sp.	Myrtaceae
 I.	Dypsis lutescens	Arecaceae	84.	Eugenia uniflora	Myrtaceae
i.	Hyophorbe lagenicaulis	Arecaceae	85.	Myrcianthes fragrans	Myrtaceae
5.	Hyophorbe verschaffeltii	Arecaceae	86.	Psidium cattleianum	Myrtaceae
j.	Phoenix roebelenii	Arecaceae	87.	Psidium guajava	Myrtaceae
,. '.	Pinanga coronata	Arecaceae	88.	Syzygium cumini	Myrtaceae
3.	Ptychosperma elegans	Arecaceae	89.	Syzygium cummi Syzygium jambos	Myrtaceae
).).	Roystonea regia	Arecaceae	90.	Bougainvillea sp.	Nyctaginaceae
,.).	Sabal palmetto	Arecaceae	91.	Zeuxine strateumatica	Orchidaceae
 		Arecaceae	91.	Piper sarmentosum	Piperaceae
	Syagrus romanzoffiana		93.	•	•
 3.	Veitchia arecina	Arecaceae	93. 94.	Saccharum officinarum	Poaceae
	Veitchia sp.	Arecaceae		Coccoloba diversifolia	Polygonaceae
l.	Washingtonia robusta	Arecaceae	95. 06	Coccoloba uvifera	Polygonaceae
j.	Wodyetia bifurcata	Arecaceae	96.	Rosa sp.	Rosaceae
ō.	Basella alba	Basellaceae	97.	Citrus hystrix	Rutaceae
' .	Ceiba sp.	Bombacaceae	98.	Citrus sp.	Rutaceae
3.	Brassica rapa	Brassicaceae	99.	Zanthoxylum coriaceum	Rutaceae
	Bursera simaruba	Burseraceae	100.	Dimocarpus longan	Sapindaceae
).	Canna flaccida	Cannaceae	101.	Melicoccus bijugatus	Sapindaceae
L.	Chrysobalanus icaco	Chrysobalanaceae	102.	Chrysophyllum oliviforme	Sapotaceae
!.	Calophyllum antillanum	Clusiaceae	103.	Manilkara roxburghiana	Sapotaceae
	Calophyllum brasiliense	Clusiaceae	104.	Manilkara zapota	Sapotaceae
	Callophyllum inophyllum	Clusiaceae	105.	Sideroxylon foetidissimum	Sapotaceae
	Calophyllum sp.	Clusiaceae	106.	Sideroxylon salicifolium	Sapotaceae
i.	Bucida buceras	Combretaceae	107.	Simarouba glauca	Simaroubacea
' .	Conocarpus erectus	Combretaceae	108.	Ravenala madagascariensis	Strelitziaceae
i.	Terminalia catappa	Combretaceae	109.	Strelitzia nicolai	Strelitziaceae
).	Terminalia sp.	Combretaceae	110.	Strelitzia reginae	Strelitziaceae
	Diospyros kaki	Ebenaceae	111.	Strelitzia sp.	Strelitziaceae
	Acalypha wilkesiana	Euphorbiaceae	112.	Cissus verticillata	Vitaceae
	Jatropha curcas	Euphorbiaceae	113.	Leea guineensis	Vitaceae
	Acacia auriculiformis	Fabaceae	114.	Parthenocissus quinquefolia	Vitaceae
	Inga sp.	Fabaceae	115.	Vitis rotundifolia	Vitaceae
	Leucaena leucocephala	Fabaceae	116.	Vitis sp.	Vitaceae
5.	Lysiloma latisiliquum	Fabaceae	117.	Alpinia sp.	Zingiberaceae
7.	Lysiloma sabicu	Fabaceae	118.	Alpinia serumbet	Zingiberaceae
3.	Pithecellobium keyense	Fabaceae			
	Pongamia pinnata	Fabaceae			
	Quercus laurifolia	Fagaceae			
•	Quercus virainiana	Fagaceae			

Fagaceae

Quercus virginiana

61.

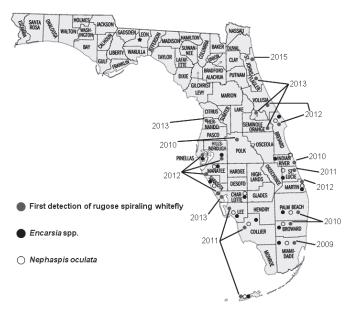


Fig. 1. County distribution of rugose spiraling whitefly and its key natural enemies (*Encarsia* spp. and *Nephaspis oculata*) in Florida.

24% were *E. noyesi*. Twelve months later, the total number of dead parasitoids collected was 212, with *E. noyesi* comprising 89%, whereas the remaining 11% were *E. guadeloupae*. Although the displacement of *E. guadeloupae* by *E. noyesi* was not extensively studied, this occurrence supports the findings by Boughton et al. (2015) that *E. noyesi* was a very promising candidate for biological control of rugose spiraling whitefly populations. Two members of another parasitoid genus, *Aleuroctonus vittatus* (Dozier) and *Aleuroctonus* sp. near *marki* Hansson & LaSalle (Hymenoptera: Eulophidae), were found by University of Florida scientists from a few rugose spiraling whitefly locations in Miami-Dade County. These eulophids have been reported from *Aleurodicus* species elsewhere (Hansson & La Salle 2003; Evans 2008).

The most frequently encountered predator was *Nephaspis oculata* (Blatchley) (Coleoptera: Coccinellidae). It is recorded from 13 counties (Fig. 1), but is probably more widely distributed than the survey suggests. Due to their generalist nature, other beneficial coccinellids, such as *Azya orbigera orbigera* Mulsant, *Chilocorus cacti* (L.), *Cryptolaemus montrouzieri* Mulsant, *Delphastus pallidus* (LeConte), *Harmonia axyridis* (Pallas), *Hyperaspis bigeminata* (Randall), and *Psyllobora parvinotata* Casey, as well as *Cybocephalus* sp. (Coleoptera: Cybocephalidae), *Chrysoperla* spp., and *Ceraeochrysa* spp. (Neuroptera: Chrysopidae) play a lesser, albeit important, role in rugose spiraling whitefly suppression.

The 3 key species identified during the surveys have a well-documented history as control agents of *Aleurodicus* species (Evans 2008). *Encarsia noyesi* was introduced from Mexico into California and subsequently into Florida to control *Aleurodicus dugesii* Cockerell (Barton 1997; Nguyen & Hamon 2002). *Encarsia guadeloupae* has a more cosmopolitan distribution (Hernández-Suárez et al. 2003). The coccinellid predator *N. oculata* is found along the U.S. Gulf Coast from Florida to Texas (Taravati et al. 2013) and specializes on whiteflies (Gordon 1985; Turnbow & Thomas 2008). It was also imported into Hawaii in 1979 for the control of *Aleurodicus dispersus* Russell (Kumashiro et al. 1983).

Presently, the leading edge of rugose spiraling whitefly infestation appears to be St. Johns County on the Atlantic coast and Hernando County on the Gulf Coast. Undoubtedly, climate and host availability play significant roles in determining the northern limits of rugose spiraling whitefly, but accidental dispersal will be a contributing factor in

new outbreaks. Problems with this whitefly continue to decline as a result of passive dispersal and inoculative releases of natural enemies identified in the early stages of whitefly establishment. Resident beneficial species found during the survey have been established in Florida for some time, and it is not surprising that they exploited rugose spiraling whitefly as a host and progressively achieved substantial control of this pest. Continued monitoring of rugose spiraling whitefly will continue to quantify population decline and evaluate the long-term persistence of natural enemies.

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Summary

The rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae), is a polyphagous pest that has caused significant damage in the Florida landscape. Various plants have been identified as primary hosts in affected areas. Rugose spiraling whitefly was confirmed in 22 counties, and surveys for biological control agents have found several important natural enemies and other species that collectively provide appreciable control of this whitefly pest.

Key Words: Aleurodicus rugioperculatus; survey; biological control; predator; parasitoid; susceptible host

Sumario

La mosca blanca espiral rugosa, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae), es una plaga polífaga que ha causado un daño significativo en los campos de la Florida. Varias plantas han sido identificadas como hospederas primarias en las zonas afectadas. Se confirmó la mosca blanca espiral rugosa en 22 condados, y los sondeos de agentes de control biológico han encontrado varios enemigos naturales importantes y otras especies que proveen colectivamente un control considerable de esta plaga de mosca blanca.

Palabras Clave: Aleurodicus rugioperculatus; sondeo; control biológico; depredador; parasitoide; hospedero susceptible

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