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Management of Rugose Spiraling Whitefly (*Aleurodicus rugioperculatus*) in the South Florida Landscape

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Rugose spiraling whitefly (*Aleurodicus rugioperculatus*) is an invasive species discovered in Florida in 2009. This species feeds on many plant species but in the South Florida landscape it has been commonly found on gumbo limbo (*Bursera simaruba*), giant white bird of paradise (*Strelitzia nicolai*), *Calophyllum* spp., black olive (*Bucida buceras*), coconut (*Cocos nucifera*), and avocado (*Persea americana*). Currently, the management of this whitefly in urban settings is heavily reliant on systemic insecticides. Other control methods include natural enemies to keep the whitefly population at low levels. In this paper, the natural enemies of rugose spiraling whitefly will be reviewed and the possibility of combining systemic insecticides and biological control will be discussed.

Rugose spiraling whitefly (RSW), *Aleurodicus rugioperculatus* Martin, is a member of the whitefly family that was originally described from Belize in 2004 on coconut (*Cocos nucifera*). This species was found in South Florida in 2009, which is the first report of its occurrence in the United States. It is currently reported in Broward, Collier, Indian River, Lee, Martin, Miami–Dade, Monroe, Palm Beach, Polk, and St. Lucie counties.

Like some related species, such as spiraling whitefly (*A. dispersus*) and giant whitefly (*A. dugesii*), the female RSW lays her eggs in a waxy spiral and covers the eggs with wax. Whitefly feeding causes stress to the host plant by removing water and nutrients and also by producing honeydew, which covers the lower leaves and results in the growth of sooty mold. Although sooty mold is not a plant disease, its presence on the upper surface of the leaf can potentially reduce photosynthesis of the plant (Capinera, 2008). In areas of high infestation, honeydew will coat everything in the vicinity such as sidewalks, cars, and furniture. This makes them sticky and all eventually turn black from sooty mold. In addition, dead adult whiteflies, along with the wax they produce, can accumulate in pools and other areas, which becomes problematic (Mannion, 2010; Stocks and Hodges, 2012).

RSW has been reported on more than 60 plant species, such as copperleaf (*Acalypha wilkesiana*), black olive (*Bucida buceras*), gumbo limbo (*Bursera simaruba*), *Calophyllum* spp., cocoplum (*Chrysobalanus icaco*), *Conocarpus erectus*, coconut (*Cocos nucifera*), golden cane palm (*Dypsis lutescens*), mango (*Mangifera indica*), wax myrtle (*Myrica cerifera*), live oak (*Quercus virginiana*), broadleaf arrowhead (*Sagittaria latifolia*), Brazilian pepper (*Schinus terebinthifolius*), *Spondias* sp., *Terminalia catappa*, and *Veitchia* spp. The most commonly infested hosts in the South Florida landscape appear to be black olive, gumbo limbo, *Calophyllum* spp., coconut, avocado (*Persea americana*) (Stocks and Hodges, 2012) and giant white bird of paradise (*Strelitzia nicolai*).

To date, management of this pest has been heavily reliant on the use of systemic insecticides. Neonicotinoid insecticides can be applied with foliar, soil, or trunk applications; however, the systemic properties of these products are most evident in the soil and trunk applications. Soil applications include drenching with water, using granular formulations on the soil surface, or burying pellets. Trunk application includes basal bark sprays and trunk injection (Mannion, 2010).

Natural enemies on the other hand, have been collected and identified from the South Florida landscape. These include the predatory lady beetle *Nephaspis oculata* (Coleoptera: Coccinellidae), the parasitoid wasp *Encarsia guadeloupae* (Hymenoptera: Aphelinidae) and lacewings. *N. oculata* is a whitefly predator that is found in Florida, Louisiana, and Texas. It has been studied for use against the silverleaf whitefly (*Bemisia tabaci*) in Florida (Liu and Stansly, 1996, 1999, 2002, 2005; Liu et al., 1997) and spiraling whitefly in Hawaii (Kumashiro et al., 1983; Yoshida and Mau, 1985). This beetle has been collected from gumbo limbo trees infested by RSW. Adult beetles are small (<2 mm) and hairy. Males have a yellowish pronotum while females have a dark one. *E. guadeloupae*, which is a whitefly parasitoid, has been collected from trees infested with RSW and can be distinguished by its tiny size, yellow scutellum, and reddish eyes. This tiny wasp lays her eggs in the body of immature whiteflies and the larva feeds on the body as they mature. The wasp will complete its development within the whitefly and emerge as an adult by chewing the cuticle of the whitefly, leaving an exit-hole.

In the summer of 2011, we received a report concerning RSW infestation from Pineland, FL. This site is located at the Randell Research Center (RRC), a part of the University of Florida Foundation, which is more than 53 acres (21.44 ha) in area. One of the main features of the RRC is its landscape, which is

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a combination of different trees, shrubs, and grasslands. Among the trees, gumbo limbos are of special importance due to their aesthetic value and old age. The center was visited and the trees were inspected. Some of the trees were heavily infested with RSW and there was a big concern regarding the health of the trees and the negative impacts of the infestation (honeydew and sooty mold) on the attractiveness of the center to visitors. The goal was to assist the center in controlling the whitefly population and collect some quantitative data on whitefly and natural enemy populations. The first step was to identify key trees with heavy whitefly infestations for insecticide application. The second step was to introduce known natural enemies in the area. The procedure for the insecticide application, release of natural enemies, and the possibility of combining these two methods are discussed in this paper.

Materials and Methods

Fifteen infested gumbo limbo trees were selected and divided into three treatment groups: 1) imidacloprid, trunk injection; 2) imidacloprid, drench; and 3) control. All the insecticide treatments were done by the staff of TruGreen® company in Aug. 2011. Injected trees were injected with IMA-jet at the recommended label rate based on tree diameter. The drenched trees were drenched with Merit 2F with 20–30 gal of diluted solution at a rate of 7.5 gal per minute.

Both species of *N. oculata* and *E. guadeloupae* were released on several infested trees that were not part of the insecticide experiment. Natural enemies were released on infested leaves by the following procedure: the whitefly infested leaf was flipped in a way that the lower (abaxial) surface of the leaf faced up and the vial(s) containing natural enemies was gently opened and inverted over the leaf surface. The vial and the leaf were kept in the same position until all individual parasitoids and beetles walked over the leaf surface. Then, the leaf was gently flipped back to its natural position. The predatory beetles were released in three different locations while all parasitoids were released on a single tree.

Sampling method. Whitefly sampling was done on a monthly basis. Eight terminals from each tree were randomly selected, cut, and placed in plastic bags. Bags were labeled with the tree number and were transported to the lab for counting. Five leaves were randomly selected from each terminal and live whitefly nymphs on the leaves were counted. Also, the number of adult and immature natural enemies and the number of exit holes made by parasitoids were recorded (eggs were not taken into account). The mean number of whiteflies per terminal, per tree, and per treatment was calculated and used for comparison between treatments. There was no sampling between January and Apr. 2012 due to the defoliation of gumbo limbo trees. The first sampling in the subsequent year started in May, as soon as trees started to grow a considerable number of leaves. Sampling continued until Aug. 2012.

Results and Discussion

The mean number of live nymphs is shown in Fig. 1. The mean number of whiteflies was the highest in the beginning of the experiment in all treatments but decreased over time. All of the trees underwent seasonal defoliation and therefore the whitefly population was assumed to be negligible between January and April. In May 2012, the injection treatment had considerably lower whitefly populations compared to the drench and control treatments. In subsequent samplings, however, the difference between the injection and other treatments was less dramatic (data not shown).

The number of natural enemies (*N. oculata* + *E. guadaloupae*) per treatment is shown in Fig. 2. There was a sharp increase in the number of natural enemies in July and Aug. 2012 on insecticide treatments but no such a trend was observed in the control treatment.

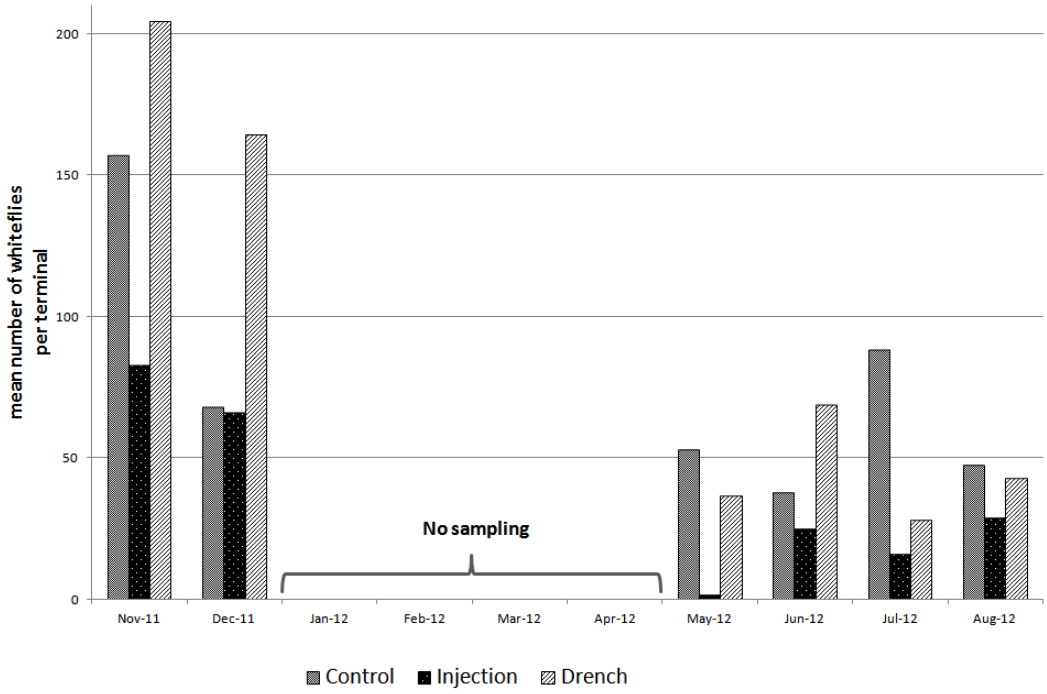

Fig. 1. Mean number of RSW nymphs per terminal.

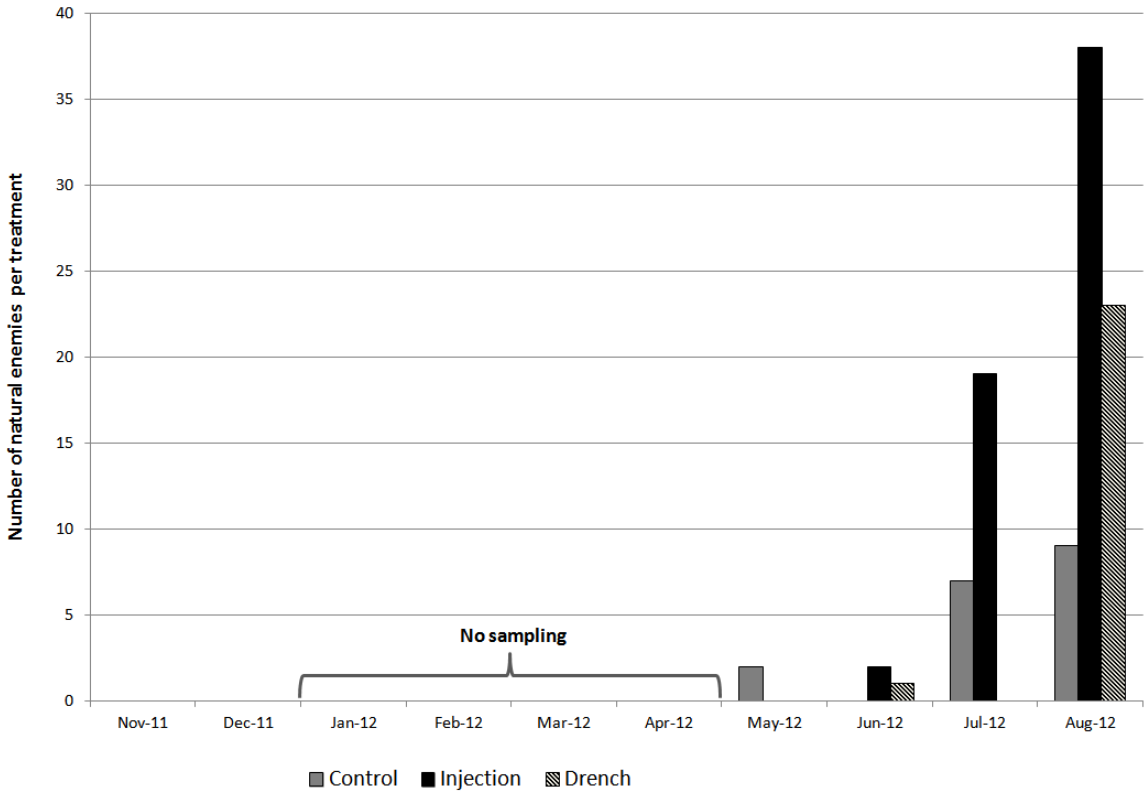

Fig. 2. Number of natural enemies (*N. oculata* + *E. guadaloupae*) per treatment.

Overall, the injection treatment may be more effective than drench in reducing the whitefly population. Nevertheless, there was no statistically significant difference among the treatments on any sample date ($P > 0.05$). When dealing with large trees, there are obstacles that need to be taken into account before making conclusions. First, it is sometimes difficult to get sufficient insecticide active ingredient or volume to large trees. Second, it is difficult to design a sampling program to get a true representation of the entire infestation of the tree. Third, seasonal leaf shedding of gumbo limbos reduces the availability of leaves to the whitefly population and therefore it is not possible to easily link the whitefly density with the insecticide treatment. Consequently, the efficacy of these chemical methods in this case needs further investigation.

The results showed that the introduced natural enemies were successfully established in RRC and their numbers dramatically increased in July and Aug. 2012. They were found on both treated and untreated trees 6 months after application. This indicates that there is potential to combine chemical (imidacloprid) and biological control of RSW in an area at least when the biological control agents are released on the untreated trees.

Gumbo limbo trees lose their leaves and the whiteflies living on them in early spring. Therefore, if the RSW infestation occurs just before the tree loses its leaves, it is recommended not to treat the tree until the tree is done with the leaf shedding and refoliation process.

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