



Invasion of the Rugose spiralling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae) in Pollachi tract of Tamil Nadu, India

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Following the outbreak for the first time in 2016 of a new invasive rugose spiraling whitefly (RSW), *Aleurodicus rugioperculatus* Martin in Pollachi, Coimbatore district, Western agro climatic zone of Tamil Nadu, India, a 3-grade damage rating scale was developed to categorize the extent of RSW infestation on different host plants when five host plants were recorded as new viz., *Areca catechu* L., *Azadirachta indica* A. Juss., *Manihot esculenta* Crantz., *Myristica fragrans* (Houtt.) and *Parthenium hysterophorus* L. Of the diverse array of natural enemy fauna, the aphelinid parasitoid, *Encarsia guadeloupe* Viggiani was observed to play a major role in bringing down RSW population. Prolonged dry spell during June to September 2016, after deficit rainfall (69 %) coupled with decreased relative humidity seem to favour the spread of the pest in coconut plantations of Pollachi tract of Tamil Nadu, India.

Key words: Coconut, Rugose spiralling whitefly (RSW), Invasive pest, Pollachi tract, Tamil Nadu.

Rugose spiralling whitefly (RSW), *Aleurodicus rugioperculatus* Martin, an invasive whitefly species belonging to the family Aleyrodidae (Order: Hemiptera), originally called as gumbo limbo spiralling whitefly, was first reported in coconut (*Cocos nucifera* L.) during 2004 in Belize, Central America (Martin, 2004), South Florida, United States in 2009 (Stocks and Hodges, 2012) and in Pollachi tract (10.491°N; 76.980°E), Coimbatore district, Tamil Nadu during August 2016 (Selvaraj *et al.* 2016). The RSW has been known to attack about 118 hosts including cultivated crops and weed flora (Stocks, 2012).

The adult females lay creamy yellow eggs on the under surface of the leaves in a concentric spiral fashion. The eggs hatch out and the nymphs develop by sucking the plant sap from the under surface of the leaves, exuding honey dew which fall on the upper surface of the underlying fronds (Josephraj Kumar *et al.*, 2016). Upon this honeydew, the fungus *Capnodium* gets established, presenting a charcoal black appearance which could be seen even from a longer distance (Chandrikamohan *et al.*, 2016). Thus the lowermost 10 - 12 fronds exhibit heavy sooty mould encrustation on the upper surface which later on spreads to the under surface of the leaves and may even drip on the ground vegetation.

Materials and Methods

Extensive field surveys were conducted in the coconut plantations of Pollachi tract of Tamil Nadu. Samples of RSW were collected from farmer's fields

as well as Coconut Research Station, Aliyarnagar and preserved in 70 per cent ethyl alcohol. Simultaneously, various predators and parasitoids co-occurring with the whiteflies were collected manually and by beating technique and were preserved in 70 per cent alcohol. The samples of whiteflies were identified by the National Bureau of Agricultural Insect Resources, Bengaluru while the natural enemy fauna at National Research Centre for Banana, Trichy. The identity of RSW was confirmed by examining slide-mounted dry puparial cases with the help of keys developed by Martin (2008).

A damage rating scale was developed based on the number of egg spirals noticed on the third or fourth frond from bottom focusing only the 5th, 10th, 15th, 20th, 25th, 30th, 35th, 40th, 45th and 50th leaflets so as to give due weightage for RSW population spread within a frond (Table 1). A minimum of 20 palms were randomly selected in a garden in a diagonal fashion and categorised. An infestation index was arrived at using the formula given below to categorize the gardens as low/ medium/ high infested.

During the present survey, various host plants harbouring RSW life stages were documented. Infested leaflets collected from affected gardens were kept under laboratory conditions to observe for emergence of parasitoids. The number of puparial cases with and without emergence holes (made by parasitoids) was examined to determine the percentage natural parasitism. The weather data from April to December during 2015 and 2016 were

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obtained to relate the influence of weather factors on the population build up of whiteflies.

Results and Discussion

The whitefly samples were identified as *Aleurodicus rugioperculatus* Martin at NBAIR, Bengaluru and confirmed with the taxonomic expertise available at TNAU, Coimbatore on the basis of the distinguishing features of the species (Martin, 2004) viz., rugose nature of the operculum, triangular shape of the lingula, reticulated margin and compound pores with dagger-shaped axial process (Plate 1).

Table 1. Damage rating scale developed for infestation by *A. rugioperculatus*

No. of egg spirals	Grade	Category	Infestation index
No egg spirals and sooty mold encrustation noticed	0	Nil	0.0
Fewer than 10 egg spirals per leaflet; presence of sooty mold encrustation in 5- 6 lowermost fronds	1	Low	0.01 to 1.0
Ten to 20 egg spirals per leaflet; presence of sooty mold encrustation in 10-12 fronds	2	Medium	1.01 to 2.0
More than 20 egg spirals per leaflet; presence of sooty mold encrustation in more than 12 fronds	3	High	2.01 to 3.0

$$\text{Infestation Index} = \frac{(\text{No. of palms under Scale 0 X 0}) + (\text{No. of palms under Scale 1 X 1}) + \dots + (\text{No. of palms under Scale 3 X 3})}{\text{Total no. of palms observed}}$$

Based on the rating scale it was observed that, the Dwarf coconut palms such as Chowghat Orange Dwarf, Malayan Yellow Dwarf and Malayan Green Dwarf and Dwarf x Tall hybrids (COD X WCT) suffered severe attack (Category: High) with an Infestation Index of 2.55, 2.35, 2.53 and 2.45, respectively (Table 2) as against low levels of infestation in West Coast Tall (0.55) and Arasampatti Tall (0.60) and medium level of infestation in Kenthali Dwarf (1.45). These observations indicated that Dwarf coconut varieties and hybrids are more prone to heavy infestation than the tall varieties.

As many as 15 hosts belonging to 13 botanical families (2 each under Euphorbiaceae, Malvaceae and Arecaceae and one each under Anacardiaceae, Annonaceae, Asteraceae, Meliaceae, Musaceae, Myristicaceae, Myrtaceae, Piperaceae, Rutaceae and Sapotaceae) harboured different life stages of the RSW (Table 3). Among them only eight supported all the life stages of the insects while the remaining hosts harboured only the egg stage indicating the unsuitability of the hosts which needs further investigation. Moreover, five new hosts viz., *Areca catechu* L., *Azadirachta indica* A. Juss., *Manihot*

esculenta Crantz., *Myristica fragrans* (Houtt.) and *Parthenium hysterophorus* L. were also recorded that were not reported by earlier workers (Stocks and Hodges, 2012; Francis *et al.*, 2016; Shanas *et al.*, 2016; Selvaraj *et al.*, 2016).

Plate 1. Distinguishing features for the identification of *A. rugioperculatus*



Plate a. *Aleurodicus rugioperculatus* Martin, puparium

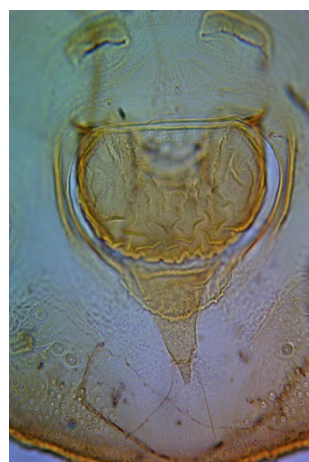


Plate b. Rugoseness/ wrinkled nature of operculum



Plate c. Triangular shape of lingula

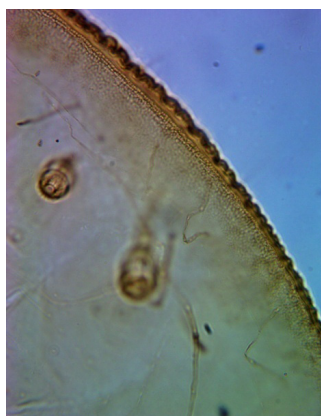


Plate d. Reticulated margin



Plate e. Compound pores with dagger-shaped axial process

Out of the nine natural enemy fauna collected from the RSW infested palms (Table 4), eight were predators of the family Coccinellidae (6) and Chrysopidae (2) and one was the aphelinid parasitoid,

Encarsia guadeloupae Viggiani. Though a rich and diverse predatory fauna was observed on the infested palms, the natural parasitism by *E. guadeloupae* ranged from 4.5 to 78.2 per cent (Table 5), indicating the essential role of the aphelinid parasitoids in infested gardens (Taravati *et al.*, 2013). Though the coccinellid, *Nephaspis oculata* was reported to be an effective predator of RSW in Florida (Francis *et al.*, 2016), this species could not be recovered in the present investigations.

Table 2. Infestation index on selected varieties studied at CRS, Aliyarnagar

Coconut variety	No. of palms under the Grade				Infestation index	Category
	0	1	2	3		
Chowghat Orange Dwarf (COD) (n=20)	0	2	5	13	2.55	High
West Coast Tall (WCT) (n=20)	10	9	1	0	0.55	Low
Malayan Yellow Dwarf (MYD) (n=15)	0	2	3	10	2.35	High
Malayan Green Dwarf (MGD) (n=8)	0	0	1	7	2.53	High
Kenthali Dwarf (KTD) (n=20)	2	11	9	0	1.45	Medium
Arasampatti Tall (ALR1) (n=20)	9	10	1	0	0.60	Low
**COD X WCT hybrid (n=20)	0	3	5	12	2.45	High

'n' refers to the no. of palms sampled

** farmer's field

Weather factors appeared to assist the spread of the pest. Compared to 2015, the mean maximum temperature rose by 0.9 °C while the morning and

Table 3. Host plants of *A. rugiperculatus* observed during December, 2016

Common Name	Scientific name	Family	Life stage		
			Egg	Nymph	Adult
Bhendi	<i>Abelmoschus esculentus</i> (L.)	Malvaceae	+	+	+
Sapota	<i>Achras zapota</i> (L.)	Sapotaceae	+	+	+
Custard apple	<i>Annona squamosa</i> L.	Annonaceae	+	+	+
Arecanut	** <i>Areca catechu</i> L.	Arecaceae	+	-	-
Neem	** <i>Azadirachta indica</i> A. Juss.	Meliaceae	+	-	-
Citrus	<i>Citrus limon</i> (L.)	Rutaceae	+	+	+
Coconut #	<i>Cocos nucifera</i> L.	Arecaceae	+++	+++	+++
Hibiscus	<i>Hibiscus rosa-sinensis</i> L.	Malvaceae	+	+	+
Physic nut	<i>Jatropha curcas</i> L.	Euphorbiaceae	+	-	-
Mango	<i>Mangifera indica</i> L.	Anacardiaceae	+	-	-
Cassava	** <i>Manihot esculenta</i> Crantz.	Euphorbiaceae	+	-	-
Banana	<i>Musa paradisiaca</i> L.	Musaceae	+	+	+
Nutmeg	** <i>Myristica fragrans</i> (Houtt.)	Myristicaceae	+	+	+
Congress grass	** <i>Parthenium hysterophorus</i> L.	Asteraceae	+	-	-
Pepper	<i>Piper nigrum</i> L.	Piperaceae	+	-	-
Guava	<i>Psidium guajava</i> L.	Myrtaceae	+	+	+

** New host record; '+' present; '-' absent

Recorded during August 2016

evening relative humidity and rainfall decreased by 5.0 per cent, 9.1 per cent and 35 mm, respectively (Table 6). As much as 337 mm rainfall was received in June-September, 2015 as against 102 mm in 2016, accounting for an approximate 69 per cent reduction in rainfall.

Table 4. List of natural enemies from RSW infested palms

Name of the predator/ parasitoid
Parasitoid
<i>Encarsia guadeloupae</i> Viggiani (Hymenoptera: Aphelinidae)
Predators
<i>Chilocorus nigrita</i> (F.) (Coleoptera: Coccinellidae)
<i>Chrysoperla zastrowi sillemi</i> Esben-Petersen (Neuroptera: Chrysopidae)
<i>Coccinella transversalis</i> F. (Coleoptera: Coccinellidae)
<i>Mallada desjardinsi</i> (Navas) (Neuroptera: Chrysopidae)
<i>Menochilus sexmaculatus</i> (F.) (Coleoptera: Coccinellidae)
<i>Propylea dissecta</i> (Mulsant) (Coleoptera: Coccinellidae)
<i>Scymnus nubilis</i> Mulsant (Coleoptera: Coccinellidae)
<i>Scymnus saciformis</i> (Motschulsky) (Coleoptera: Coccinellidae)

This prolonged dry spell from June 2016 onwards could be one of the predisposing factors for the proliferation and quick dispersal of this invasive pest. Similar observation pertaining to deficit rainfall,

An introduced pest in the sub-continent, RSW poses a threat to coconut plantations in India. However, the remarkable levels of natural parasitism

Table 6. Weather data during the period of 2015 - 2016

Months	Maximum temperature (°C)		Morning Relative humidity (%)		Evening Relative humidity (%)		Rainfall (mm)	
	2015	2016	2015	2016	2015	2016	2015	2016
April	35.1	37.7	92.0	90.0	53.2	44.4	128.7	17.2
May	34.1	35.2	88.0	83.5	61.9	50.5	115.2	210.4
June	33.3	32.8	83.2	81.1	55.5	62.4	132.0	64.8
July	33.3	32.8	83.9	83.1	56.7	57.0	70.6	31.4
August	33.4	33.5	88.6	84	65.6	63.7	85.1	6.2
September	33.5	34.1	91.2	80.7	79.6	51.5	49.5	0.4
October	33.3	34.0	90.6	84.4	73.8	55.2	95.6	74.0
November	30.0	32.0	91.2	81.1	72.5	58.1	245.4	17.0
December	29.7	31.8	90.3	87.5	69.9	63.6	126.0	40.6
Mean	32.9	33.8	88.8	83.9	65.4	56.3	245.4*	210.4*

* Total rainfall (mm) during the study period

continuous surveillance, non-chemical approaches and conservation of the natural enemies are the need of the hour to contain the pest by creating awareness among the coconut farmers through interactive

increased temperature and reduced humidity as a reason for the flare up of the pest was opined by Josephraj Kumar *et al.* (2016).

Table 5. Extent of natural parasitism by *Encarsia guadeloupae* in farmer's field samples (2015-16)

Village	Block	District	Natural parasitisation (%)
Subbegundenpudur	Anaimalai	Coimbatore	6.1
Pongaliyur	Anaimalai	Coimbatore	45.2
Kottur	Anaimalai	Coimbatore	52.0
Malayandipattinam	Anaimalai	Coimbatore	70.5
Angalakurichi	Anaimalai	Coimbatore	60.1
Aalangandi	Anaimalai	Coimbatore	62.1
Aliyarnagar	Anaimalai	Coimbatore	74.4
Sethumadai	Anaimalai	Coimbatore	10.3
Thensangampalayam	Anaimalai	Coimbatore	30.3
Devipattinam	Anaimalai	Coimbatore	38.9
Vettaikaranpudur	Anaimalai	Coimbatore	15.8
Anaimalai	Anaimalai	Coimbatore	42.4
Kaliyapuram	Anaimalai	Coimbatore	78.2
Orakkaliyur	Pollachi (North)	Coimbatore	63.1
Negamam	Pollachi (North)	Coimbatore	15.6
Ravanapuram	Pollachi (North)	Coimbatore	7.1
Singanallur	Pollachi (South)	Coimbatore	4.5
Aandiyur	Udumalpet	Tiruppur	26.5
Mean ± S.D			39.1 ± 25.4

(up to 78.2%) coupled with the presence of a score of coccinellid and chrysopid predators, is expected to keep the pest species under check. Therefore,

meetings and campaigns. More research is needed to assess yield loss and to understand its biology and ecology to keep the RSW populations under check.

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