Madras Agric. J., 103 (10-12): 349-353, December 2016
https://doi.org/10.29321/MAJ.10.001047

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

Srinivasan, T., P.A. Saravanan[2], A. Josephrajkumar[3], K. Rajamanickam[1], S. Sridharan[2], P.M.M. David[4], N. Natarajan[2] and N. Shoba[1]

[1]Coconut Research Station, Aliyarnagar, Tamil Nadu, India
[2]Department of Agricultural Entomology, TNAU, Coimbatore, Tamil Nadu, India
[3] ICAR-CPCRI Regional Station, Kayankulam, Kerala
[4]Agricultural College and Research Institute, Killikulam, Tamil Nadu

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 guadeloupae* 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 (10.491ºN; 76.980ºE), 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 (Josephrajkumar *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

*Corresponding author email: sumalinikatragadda@gmail.com

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

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

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

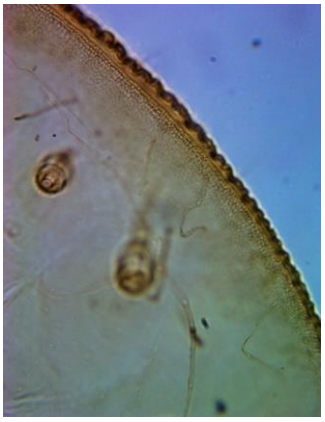

Plate d. Reticulated margin

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 ºC while the morning and

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

Common Name	Scientific name	Family	Life stage		
			Egg	Nymph	Adult
Bhendi	*Abelmoschus esculentus* (L.)	Malvaceae	+	+	+
Sapota	*Achras zapota* (L.)	Sapotaceae	+	+	+
Custard apple	*Annona squamosa* L.	Annonaceae	+	+	+
Arecanut	***Areca catechu* L.**	Arecaceae	+	-	-
Neem	***Azadirachta indica* A. Juss.**	Meliaceae	+	-	-
Citrus	*Citrus limon* (L.)	Rutaceae	+	+	+
Coconut #	*Cocos nucifera* L.	Arecaceae	+++	+++	+++
Hibiscus	*Hibiscus rosa-sinensis* L.	Malvaceae	+	+	+
Physic nut	*Jatropha curcas* L.	Euphorbiaceae	+	-	-
Mango	*Mangifera indica* L.	Anacardiaceae	+	-	-
Cassava	***Manihot esculenta* Crantz.**	Euphorbiaceae	+	-	-
Banana	*Musa paradisiaca* L.	Musaceae	+	+	+
Nutmeg	***Myristica fragrans* (Houtt.)**	Myristicaceae	+	+	+
Congress grass	***Parthenium hysterophorus* L.**	Asteraceae	+	-	-
Pepper	*Piper nigrum* L.	Piperaceae	+	-	-
Guava	*Psidium guajava* 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
Encarsia guadeloupae Viggiani (Hymenoptera: Aphelinidae)
Predators
Chilocorus nigrita (F.) (Coleoptera: Coccinellidae)
Chrysoperla zastrowi sillemi Esben-Petersen (Neuroptera: Chrysopidae)
Coccinella transversalis F. (Coleoptera: Coccinellidae)
Mallada desjardinsi (Navas) (Neuroptera: Chrysopidae)
Menochilus sexmaculatus (F.) (Coleoptera: Coccinellidae)
Propylea dissecta (Mulsant) (Coleoptera: Coccinellidae)
Scymnus nubilis Mulsant (Coleoptera: Coccinellidae)
Scymnus saciformis (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, increased temperature and reduced humidity as a reason for the flare up of the pest was opined by Josephrajkumar *et al.* (2016).

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

Village	Block	District	Natural parasitisation (%)
Subbegoundenpudur	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**

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

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

Months	Maximum temperature (ºC)		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

Acknowledgment

The authors wish to acknowledge the services of National Bureau of Agricultural Insect Resources, Bengaluru in fixing the identity of the species of the Rugose Spiralling Whitefly and Dr. J. Poorani, Principal Scientist (Entomology), National Research Centre for Banana, Trichy for identification of the natural enemy fauna. The authors also acknowledge the Director (Centre for Plant Protection Studies), TNAU, Coimbatore and the Project Coordinator (AICRP-Palms) for facilitating and providing the necessary funds to carry out the studies.

References

Chandrikamohan, A. Josephrajkumar, Vinayaka Hegde, V. Krishnakumar, P.B. Renjith, A.S. Anjali and P. Chowdappa. 2016. Gradient outbreak and bio-suppression of spiralling whitefly in coconut gardens in South India. *Indian Coconut Journal*, **59(8)**: 9-12.

Francis, A.W., I.C. Sticks, T.R. Smith, A.J. Boughton, C.M. Mannion and L.S. Osborne. 2016. Host plants and natural enemies of rugose spiraling whitefly (Hemiptera: Aleyrodidae) in Florida. *Florida Entomologist*, **99(1):** 150-153.

Josephrajkumar, A., Chandrikamohan and V. Krishnakumar. 2016. Parasitism induced bio-suppression of coconut whitefly in Kerala. *Kerala Karshakan e-journal*, December 2016, 26-27.

Martin, J.H. 2004. Whiteflies of Belize (Hemiptera: Aleyrodidae), Part 1 – Introduction and account of the subfamily Aleurodicinae Aquaintance and Baker. *Zootaxa* **681**: 1-119.

Selvaraj, K., R. Sundararaj, T. Venkatesan, C.R. Ballal, S.K. Jalali, A. Gupta and H.K. Mrudula. 2016. The invasive rugose spiraling whitefly Aleurodicusrugioperculatus Martin in India. *J. Biological Control* **30(3)**: (in press)

Shanas, S., J. Job, T. Joseph and G.A. Krishnan. 2016. First report of the invasive rugose spiraling whitefly, Aleurodicus rugioperculatus Martin (Hemiptera: Aleyrodidae) from the Old World. *Entomon*, **41(4)**: 365-368.

Stocks, I.C. and G. Hodges. 2012. The Rugose spiraling whitefly, Aleurodicusrugioperculatus Martin, a New Exotic Whitefly in South Florida (Hemiptera: Aleyrodidae). Pest Alert by Florida Department of Agriculture and Consumer Services, Division of Plant Industry, DACS-P-01745.

Taravati, S., C. Mannion and L.S. Osborne. 2013. Management of Rugose spiraling whitefly (Aleurodicus rugioperculatus) in South Florida Landscape. Proc. Florida State Horticultural Society, **126**: 276-278.

Received after revision : December 30, 2016; Accepted : December 30, 2016