International Journal of Ecology and Environmental Sciences 46 (2): 187-194, 2020
ISSN: 0377-015X (Print); 2320-5199 (Online)

Current Status of Coconut Rugose Spiralling Whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae) in Karnataka

Sanjay Kumar Pradhan[1*], Deepak Kumar Swain[2], and Shubhasree Dash[3]

[1]*Department of Agricultural Entomology, University of Agricultural Sciences, Gandhi Krishi Vigyan Kendra (GKVK), Bengaluru-560065, Karnataka, India*
[2]*Department of Agricultural Statistics, Institute of Agricultural Sciences, Siksha 'O' Anusandhan Deemed to be University (SOADU), Bhubaneswar-761029, Odisha, India*
[3]*Department of Entomology, College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar-751003, Odisha, India*
E-mails: [1]sanjaymkg314@gmail.com ; [2]dsagrico14@gmail.com; [3]shubh291193@gmail.com
[*]Corresponding author

ABSTRACT

An invasive rugose spiraling whitefly (RSW) *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae), which was first time reported on coconut palm in Pollachi, Tamil Nadu in 2016, was found infesting several plantation crops like coconut, banana, Indian almond and several ornamental plants in southern states of India. The pest was identified through their morphological characters and through molecular characterization. PCR amplification of mitochondrial cytochrome c oxidase-I gene (658 bp) of RSW from five different locations were sequenced (GenBank accession number MK883218, MK883219, MK883220, MK926750, MK926751) for identification. During the study, 20 host plants were recorded and several natural enemies were found associated with the pest. *Encarsia guadeloupae* Viggiani (Hymenoptera: Aphelinidae) was the major parasitoid associated with the pest. Natural parasitism by the parasitoid ranges from 7 to 80% across different agroclimatic zones of Karnataka. Other natural enemies like *Encarsia dispersa,* chrysopids and coccinellids were also recorded feeding on RSW.

Key Words: Invasive Pest; Field Survey; Host Plants; Natural Enemies

INTRODUCTION

Rugose spiraling whitefly (RSW), *Aleurodicus rugioperculatus* Martin, an invasive species was originally described from Belize in 2004 on coconut (*Cocos nucifera* L), was first time reported feeding on gumbo limbo plant, *Bursera simaruba* in South Florida in 2009. In India, it was reported first time on coconut palm in Pollachi, Tamil Nadu during August, 2016 (Selvaraj et al. 2016, Sundararaj and Selvaraj 2017). Subsequently, the pest was found to feed on banana, Indian almond, palms and several other ornamental plants in Karnataka, Andhra Pradesh and Kerala. Coconut, banana and Indian almond are among the most preferred host plants. Nymphs and adults of the whitefly remove water and nutrients from the host plants by feeding, which results in stress to the host plant. Release of honeydews on the upper surface of the lower leaves encourages growth of sooty mold which reduces photosynthesis of the plant (Capinera 2008).

The southern states of India have recently experienced heavy infestation of RSW. It has extended its host ranges at greater level which could be due to its polyphagous nature. Immature stages of RSW produce profuse quantity of wax filaments both tufts of fluffy and long crystal like glassy rods. The severity of infestation ranged between 40-60% in coconut and 25-40% in banana. Complete drying of banana leaves was also noted in several places in Tamil Nadu and Kerala (Selvaraj et al. 2016).

Several predators and parasitoids were found associated with RSW. Among the parasitoids, the aphelinid parasitoid, *Encarsia guadeloupae* Viggiani (Hymenoptera: Aphelinidae) was found in large numbers

parasitizing RSW. Besides *E. guadeloupae*, several other natural enemies like *Encarsia dispersa,* chrysopids and coccinellids were also recorded feeding on RSW. There is a considerable degree of shared parasitism between coconut and intercrop herbivores. Pest populations could thus be suppressed by indirect interactions.

Due to its invasiveness to India and rapid spread in short duration, we studied the intensity of damage of the pest in different agroclimatic zones of Karnataka, and the favoured host plants of the pest and its natural enemies.

STUDY AREA

The Indian State of Karnataka is located 11° 30' and 18°30' North latitudes and 74° East and 78°30' East longitude. The climatic condition varied in different agroclimatic zones. South Karnataka had little hot and North Karnataka had semi-arid, tropical steppe type of climate. Intensive survey was carried out in 24 districts of Karnataka like Mandya, Ramanagara, Mangaluru, Chikkamagaluru, Davanagere, Mysuru, Shivamogga, Hassan, Chamarajanagar, Bengaluru rural, Tumakuru, Kolar, Bengaluru urban, Kodagu, Dakshina Kannada, Uttara Kannada, Belgavi, Bagalkote, Bidar, Bellary, Chitradurga, Dharwad, Raichur and Udupi. The details of the locations are presented in Table 3. Minimum five locations from each agroclimatic zones were sampled and the average infestation was estimated.

METHODS

In situ sampling of 10 leaflets from infested plants in the field was done randomly in a random manner in plantations, ornamental gardens, kitchen gardens and in field crops in both rural and urban areas to study distribution patterns, intensity of damage and host range of *A. rugioperculatus* on different host plants. The details of the location, host plants, estimated area coverage by the host plants was noted. The adults were collected in 10 mL vials containing 70% ethanol and labeled. The intensity of damage and sooty mould growth status in the survey area was categorized into different grades by visual observation (Table 1). Percentage infestations and the intensity of damage of *A. rugioperculatus* in different agroclimatic zones of Karnataka were calculated from the grades (Table 2 and 4) and presented in the map (Figure 1).

The natural enemies present along with the pest were collected and preserved in 10 mL vials containing 70% ethanol and labelled. Identification of the species was carried out at ICAR- National Bureau of Agricultural Insect Resources (NBAIR), Bengaluru. The leaflet samples were taken back to lab and observed under 40× stereozoom microscopes. The mean number of egg patches, nymphs, pupae, adults, active stages and parasitized pupae per leaflet were calculated (Table 4).

Molecular Characterization

Adult RSW samples from five different locations of Karnataka *viz.* GKVK, Mandya, Kunigal, Kolar and

Table 1. Rating scale adapted to record *A. rugioperculatus* infestation during survey (from (Geetha 2000)

Intensity of Damage (%)	Damage Category	Grade
0	Nil	0
1-20	Very Low	1
21-40	Low	2
41-60	Moderate	3
61-80	High	4
81-100	Very High	5

Table 2. Agroclimatic zones of Karnataka state

Zone	Zone name	District
Z1	North Eastern Transition Zone	Bidar, Kalaburgi
Z2	North Eastern Dry Zone	Kalaburgi, Yadgir, Raichur
Z3	Northern Dry Zone	Koppal, Gadag, Dharwad, Belgavi, Vijayapura, Bagalkot, Bellary, Davanagere, Raichur
Z4	Central Dry Zone	Chitradurga, Davanagere, Tumakuru, Chikkmagaluru, Hassan
Z5	Eastern Dry Zone	Bengaluru rural, Bengaluru urban, Ramanagar, Kolar, Chikkaballapur, Tumakuru
Z6	Southern Dry Zone	Mysuru, Chamarajanagar, Mandya, Tumakuru, Hassan
Z7	Southern Transition Zone	Hassan, Chikkamagaluru, Shivamogga, Mysuru, Davanagere
Z8	Northern Transition Zone	Belgavi, Dharwad, Haveri, Gadag
Z9	Hilly Zone	Uttara Kannada, Belgavi, Dharwad, Haveri, Shivamogga , Chikkamagaluru, Kodagu, Hassan
Z10	Coastal Zone	Udupi, Dakshina Kannada, Uttara Kannada

Table 3: Categorization of the areas surveyed for *A. rugioperculatus* infestation in Karnataka under different agroclimatic zones

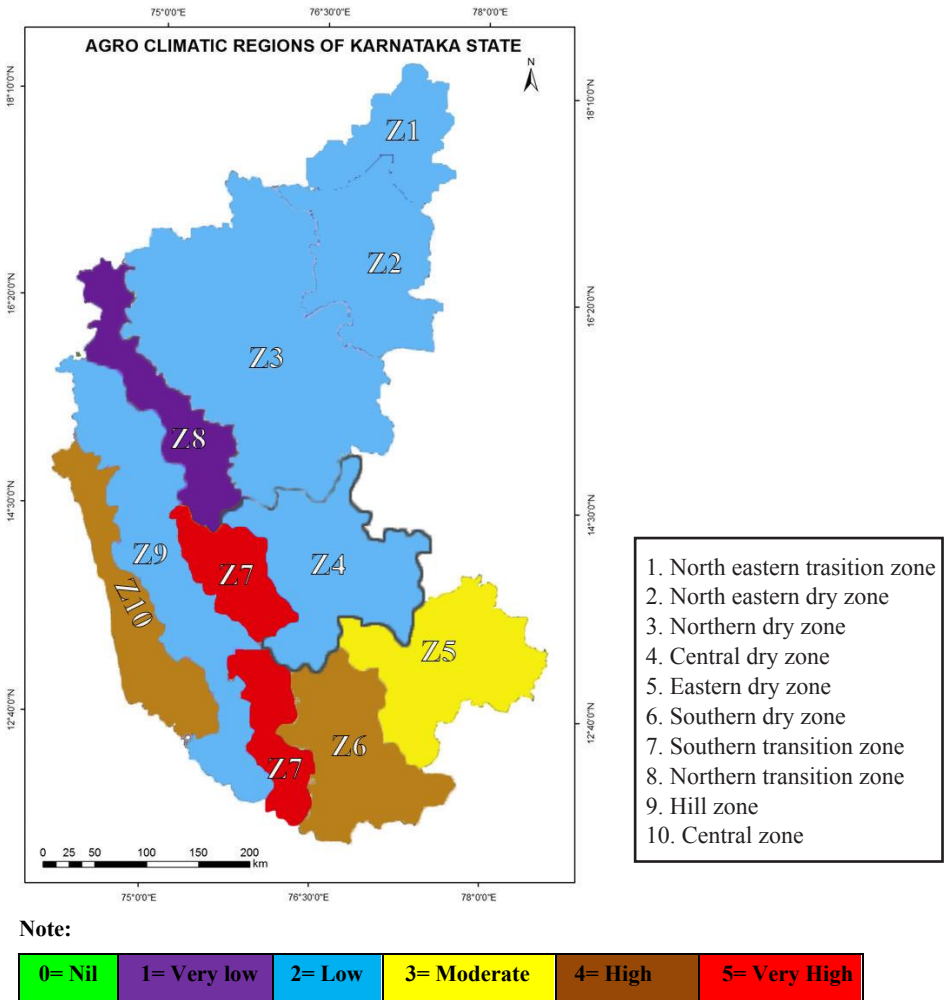
Location	Zone No.	Zone Name	Longitude	Latitude
Channapatna, Hanganur	Z5	Eastern Dry Zone	77° 21’70.861’’E	12° 60’05.846’’N
Channapatna- Halguru road	Z5	Eastern Dry Zone	77° 21’86.201’’E	12° 57’90.863’’N
Mangadahalli	Z5	Eastern Dry Zone	77° 22’02.451’’E	12° 55’74.414’’N
Mangaluru (South Canara)	Z10	Coastal Zone	74° 84’32.154’’E	12° 91’28.432’’N
Kadur (Chikkamagaluru)	Z4	Central Dry Zone	76° 02’11.241’’E	13° 45’21.354’’N
Davanagere	Z4	Central Dry Zone	75° 95’17.235’’E	14° 48’24.573’’N
Maddur (Ramnagar)	Z6	Southern Dry Zone	77° 05’43.567’’E	12° 61’59.831’’N
Krishnarajapete (Mysuru)	Z6	Southern Dry Zone	75° 74’89.675’’E	13° 25’75.124’’N
Shivamogga	Z7	Southern Transition Zone	75° 41’26.181’’E	13° 12’81.276’’N
Kanakapura	Z5	Eastern Dry Zone	77° 43’17.815’’E	12° 54’92.716’’N
Hassan	Z6	Southern Dry Zone	76° 14’82.882’’E	13° 08’44.130’’N
Chamarajanagar	Z6	Southern Dry Zone	77° 38’42.134’’E	12° 12’34.276’’N
Mandya	Z6	Southern Dry Zone	76° 83’36.946’’E	12° 57’17.121’’N
Yentaganahalli (Nelamangala)	Z5	Eastern Dry Zone	77° 34’27.505’’E	13° 06’16.163’’N
Tumakuru	Z5	Eastern Dry Zone	77° 23’28.312’’E	13° 44’92.388’’N
Kolar	Z5	Eastern Dry Zone	78° 23’81.521’’E	13° 18’27.624’’N
Kunigal	Z6	Southern Dry Zone	77° 12’37.966’’E	13° 04’08.009’’N
GKVK	Z5	Eastern Dry Zone	77° 58’12.991’’E	13° 07’92.651’’N
Kodagu	Z9	Hilly Zone	75° 68’38.289’’E	12° 37’62.428’’N
Dakshina Kannada	Z10	Coastal Zone	75° 28’65.336’’E	12° 78’52.146’’N
Bangarapet	Z5	Eastern Dry Zone	78° 07’18.244’’E	12° 98’79.681’’N
Kolar	Z5	Eastern Dry Zone	78° 24’85.426’’E	13° 26’60.288’’N
Belgavi	Z8	Northern Transition Zone	74° 38’41.228’’E	15° 66’14.290’’N
Bagalkot	Z3	Northern Dry Zone	75° 61’45.452’’E	16° 32’22.242’’N
Uttara Kannada	Z9	Hilly Zone	74° 56’62.214’’E	14° 71’30.296’’N
Hessaraghata	Z5	Eastern Dry Zone	77° 51’64.229’’E	13° 13’14.655’’N
GKVK	Z5	Eastern Dry Zone	77° 57’34.182’’E	13° 08’42.095’’N
Kanur	Z9	Hilly Zone	76° 01’66.912’’E	12° 07’99.274’’N
Mandalpatti	Z9	Hilly Zone	75° 72’34.731’’E	12° 50’21.192’’N
Kalooru	Z9	Hilly Zone	75° 72’29.263’’E	12° 50’05.419’’N
Cheyyandane	Z9	Hilly Zone	75° 68’95.482’’E	12° 22’86.926’’N
Kadanga Marur	Z9	Hilly Zone	75° 73’75.289’’E	12° 22’43.254’’N
Madikeri- Virajpet road	Z9	Hilly Zone	75° 75’55.064’’E	12° 27’89.079’’N
Tonse west (Hanging bridge road)	Z10	Coastal Zone	74° 71’27.178’’E	13° 40’51.491’’N
Kodi Bengare Island	Z10	Coastal Zone	74° 69’52.329’’E	13° 44’94.918’’N
St. Mary’s Island	Z10	Coastal Zone	74° 67’31.802’’E	13° 37’91.432’’N
Ambalpadi (Udupi)	Z10	Coastal Zone	74° 73’08.646’’E	13° 33’72.838’’N
Kannarpady Shree Jaya Durga Parameshwari	Z10	Coastal Zone	74° 73’69.091’’E	13° 32’46.839’’N
Nelamangala	Z5	Eastern Dry Zone	77° 35’12.279’’E	13° 03’05.529’’N
NBAIR farm, Attur layout	Z5	Eastern Dry Zone	77° 56’78.593’’E	13° 09’79.978’’N
Nagashettyhalli, Agram	Z5	Eastern Dry Zone	77° 62’45.575’’E	12° 95’76.804’’N
Botanical Garden, GKVK	Z5	Eastern Dry Zone	77° 57’72.391’’E	13° 07’87.389’’N
CK Pura, Chitradurga	Z4	Central Dry Zone	76° 41’05.643’’E	14° 21’99.158’’N
Aimangala, Chitradurga	Z4	Central Dry Zone	76° 53’76.051’’E	14° 09’06.972’’N
ICAR-NIVEDI, Ramagondanahalli	Z5	Eastern Dry Zone	77° 56’05.356’’E	13° 12’58.160’’N
Bellary	Z3	Northern Dry Zone	76° 90’19.112’’E	15° 14’82.741’’N
Raichur	Z2	North Eastern Dry Zone	77° 19’47.523’’E	16° 21’75.221’’N
Dharwad	Z8	Northern Transition Zone	74° 98’47.852’’E	15° 48’76.849’’N
Kalaburgi	Z2	North Eastern Dry Zone	76° 81’52.364’’E	17° 42’88.568’’N
Bidar	Z1	North Eastern Transition Zone	77° 56’34.842’’E	17° 84’62.186’’N

Table 4: Infestation of *A. rugioperculatus* in different agroclimatic zones of Karnataka

Zone No.	Mean no of egg patches/ leaflet	Mean no of nymphs /leaflet	Mean no of pupae /leaflet	Mean no of adults /leaflet	Mean no of active stages/ leaflet	Mean no of parasitized pupae/ leaflet	Mean no of parasitoid adult emerged	Percent parasitization	Percent parasitoid adult emergence	Mean sooty mould status	Mean percentage infestation
Z1	4	29.2-37.8	10.7-12.5	11.8-12.7	2.7-3.0	1.8-2.1	0.6-0.7	16.7-18.3	38.3-43.3	2	40 (Low)
Z2	1.6-3.7	16.1-22.9	10.7 - 12.7	9.6-11.8	1.5 - 2.7	1.7 - 1.8	0.5 - 0.6	13.8-16.7	28.3-38.3	2	30 (Low)
Z3	1.9-4.1	27.7 - 31.7	14 - 20.2	17.2-18.4	3 - 4	2.3 - 4.5	0.8 - 1.8	17.7-22.6	36.7-43.4	2	30 (Low)
Z4	1.6 - 8	17.4 - 125.8	9.7 - 107.4	8.5 - 77.9	1.7 - 9.7	0.9 - 75.3	0.4 - 29.5	6.7 - 10.4	30 - 52.5	2	35 (Low)
Z5	1.6-13.9	16.2 - 251.4	9.2 - 203	9.4 - 107.2	1.6 -12.5	1.3-159.9	0.3 - 75.3	7.2 - 72	11.7-79.6	3	50.59 (Moderate)
Z6	2.7-12.6	60.4-271.7	33 -202.4	27 - 95.6	4.7 -13.6	8.3-158.5	3.4 - 72.5	23.4-79.9	23.4-71.6	4	73.33 (High)
Z7	11.7-17.8	281.7-325.0	238.2-324.2	98-302.8	14.7-28.2	150.7-289.7	80-223.8	63.6-77.8	54.6-69.4	5	100 (Very high)
Z8	1.6 - 2.1	13.4 - 15.6	6.5 - 6.6	10.6 - 10.8	1.4 - 2.7	1.6 - 2.1	0.5 – 1.0	16.1-20.2	28.3-32.8	1	20 (Very low)
Z9	0 - 8.9	0 - 124.9	0 - 94.1	0 - 59.4	0 - 9.3	0 - 130.3	0 - 87.8	0 - 75.2	0 - 67.3	2	35 (Low)
Z10	6 -13.5	74.7 -300.5	62.1 - 235.4	49.8 -122.8	6 - 15.3	13.2-179	8.2-124.6	21.5-76.4	36.8-69.4	4	71.43(High)

Note:

0= Nil	1= Very low	2= Low	3= Moderate	4= High	5= Very High



Note:

0= Nil	1= Very low	2= Low	3= Moderate	4= High	5= Very High

Figure 1. Percentage infestation of A. rugioperculatus in different agroclimatic zones of Karnataka

Tumkur were subjected to molecular characterization. PCR amplification of mitochondrial cytochrome c oxidase I (COI) (658bp) was carried out at Molecular Entomology Division of ICAR-NBAIR followed by sequencing for identification of the species. The sequences were submitted to the NCBI GenBank.

RESULTS AND DISCUSSION

Identification of *Aleurodicus rugioperculatus* and Host Plants

Mitochondrial cytochrome c oxidase I (COI) gene of 658bp size was amplified and sequenced. The sequences were submitted to GenBank under accession number MK883218, MK883219, MK883220, MK926750, MK926751. Our sequences matched >90% with the available sequence of *A. rugioperculatus* (accession number KP032219) submitted from Florida, USA (Dickey et al. 2015), thereby confirming the identity of the pest.

Distribution and Intensity of Damage of *A. rugioperculatus*

Significant differences were observed in population density of *A. rugioperculatus* in different regions of Karnataka. The incidence was high on host plants like coconut, banana, palm etc.

The level of infestation was very low in Northern transition zone (Z8) and low in North eastern transition zone (Z1), North eastern dry zone (Z2), Northern dry zone (Z3), Central dry zone (Z4) and Hilly zone of Karnataka (Z9). The level of infestation was moderate in Eastern dry zone of Karnataka (Z5). The level of infestation was high and very high in Southern dry zone (Z6) and Southern transition zone of Karnataka (Z7) respectively.

In very low level of infestation zones, the mean number of egg patches, nymphs, pupae and adults per leaflet ranged 1.6-2.1, 13.4-15.6, 6.5-6.6 and 10.6-10.8 respectively. Mean numbers of active stages and parasitized pupae per leaflet were 1.4-2.7 and 1.6-2.1 respectively. The mean sooty mould status was 1 and the infestation level was 20%.

In low level of infestation zones, the mean number of egg patches, nymphs, pupae and adults per leaflet ranged 0-8.9, 0-125.8, 0-107.4 and 0-77.9 respectively. Mean numbers of active stages and parasitized pupae per leaflet were 0-9.7 and 0-130.3 respectively. The mean sooty mould status was 0-4 and the infestation level was 30-40%.

In moderate level of infestation zones, the mean number of egg patches, nymphs, pupae and adults per leaflet ranged 1.6-13.9, 16.2-251.4, 9.2-203.0 and 9.4-107.2 respectively. Mean numbers of active stages and parasitized pupae per leaflet were 1.6-12.5 and 1.3-159.9 respectively. The mean sooty mould status was 1-5 and the infestation level was 50.59%.

In high level of infestation zones, the mean number of egg patches, nymphs, pupae and adults per leaflet ranged 2.7-13.5, 60.4-300.5, 33-235.4 and 27-122.8 respectively. Mean numbers of active stages and parasitized pupae per leaflet were 4.7-15.3 and 8.3-179.0 respectively. The mean sooty mould status was 1-5 and the infestation level was 71.43-73.33%.

In very high level of infestation zones, the mean number of egg patches, nymphs, pupae and adults per leaflet ranged 11.7-17.8, 281.7-325.0, 238.2-324.2 and 98-302.8, respectively. Mean numbers of active stages and parasitized pupae per leaflet were 14.7-28.2 and 150.7-289.7, respectively. The mean sooty mould status was 5 and the infestation level was 100%.

Intensive surveys conducted across the state of Karnataka revealed that the level of infestation was quite high in southern and coastal regions (71.43 to 100%) as compared to northern regions (20 to 40%). Hot and humid climate along with suitable host plants favoured proliferation of the pest in coastal regions of Karnataka.

The pest was reported on several ornamental and commercial plants in Kerala, Karnataka and Andhra Pradesh causing death of the plants in severe cases. The spread to different states might be due to neighboring state boundaries (Geetha 2000). If it is unchecked, the pest may spread to other regions of the country.

Host Range of *A. rugioperculatus*

The knowledge about host range of any pest is quintessential for formulating IPM strategy. As RSW is a new invasive pest in India and to Karnataka (Selvaraj et al. 2016), the present study hastens to identify its host range in Karnataka keeping in view to see its potential impact especially on horticultural crops.

A wide range of host plants including palms, woody ornamentals and fruits were found infested with *A. rugioperculatus* (Mannion 2010). There were around 118 plant species recorded (Stocks and Hodges 2012). As per the record from 2009 to 2012 at Florida, 22% of RSW infected hosts were palm species, 16% were on gumbo limbo plant *Bursera simaruba,* 10% were on

Calophyllum spp. plant, 9% were onavocado plant, 4% were on dark olive plant and 3% were on mango varieties plants (Francis et al. 2016). Inside the family Arecaceae (palms), 44% of host records were from coconut. A total of 17 plant species under 11 families were recorded as preferred hosts of *A. rugioperculatus* at Kerala (Shanas et al. 2016). Selvaraj et al.(2016) witnessed 25-40% leaf infestation on banana and total drying of infested leaves in several places in Tamil Nadu and Kerala.

During survey, 20 plant species were found infested with *A. rugioperculatus*. Coconut, *Cocos nucifera*, banana, *Musa* sp. and Indian almond, *Terminalia catappa* were found heavily infested with *A. rugioperculatus*. Two crop plants *viz.,* sugarcane and maize were recorded as host plants for the first time in Karnataka. Plants belonging to family arecaceae mostly favored *A. rugioperculatus* infestation.

Very severe infestation was found in *Cocos nucifera, Musa* spp*., Terminalia catappa.* Severe infestation was found on *Dypsis lutescens, Manilkara zapota, Annona squamosa, Annona reticulata.* Moderate infestation was found in *Psidium guajava, Strelitzia reginae, Magnolia champaca, Roystonea regia, Mangifera indica, Canna indica, Syzigium cumini, Citrus aurantiifolia, Areca catechu, Artocarpus heterophyllus*. Negligible infestation was found on *Zea mays, Anacardium occidentale* and *Saccharum officinarum* (Table 5).

The infestations on different hosts were observed in orchards, kitchen garden, avenue trees and plantations along the highways etc. The spread of pest clearly indicated that it might be due to transport of planting materials which harbour the pest and human interferences. Prevailing wind and climatic factors also play a vital role in spreading of the pest.

During the study it was observed that intercropping was the main reason for wide spread prevalence of the pest to different host plants. Epigenetic changes might help the insect to feed on different host plants having different surface characteristics. When the plants had thick leaf lamina as compared to thin lamina in previous host plants, it tried to change its feeding behaviour in order to sustain in that new host plant.

Natural Enemies of *A. rugioperculatus*

During the surveys, several predators and parasitoids were found associated with *A. rugioperculatus*. Among the natural enemies, parasitoids were found most abundant as compared to predators in different locations and on different host plants in Karnataka.

During the study, natural parasitism by the parasitoid *Encarsia guadeloupae* Viggiani and *Encarsia dispersa* Polaszek was observed. Natural parasitism by the parasitoid *E. guadeloupae* was found higher as compared to *E. dispersa.* The population of *E. dispersa* was found at lower numbers where populations of *E. guadeloupae* were found. Natural parasitism ranged from 7 to 80% in different agroclimatic zones of

Table 5. Host plants of *A. rugioperculatus*

Sl. No.	Common name	Botanical name	Family	Remarks
1	Coconut palm	*Cocos nucifera*	Arecaceae	Very severe
2	Banana	*Musa* spp.	Musaseae	Very severe
3	Indian almond	*Terminalia catappa*	Combretaceae	Very severe
4	Sapota	*Manilkara zapota*	Sapotaceae	Severe
5	Butterfly palm	*Dypsis lutescens*	Arecaceae	Severe
6	Custard apple	*Annona squamosa*	Annonaceae	Severe
7	Ram phal	*Annona reticulata*	Annonaceae	Severe
8	Guava	*Psidium guajava*	Myrtaceae	Moderate
9	False bird of paradise	*Strelitzia reginae*	Strelitziaceae	Moderate
10	Mango	*Mangifera indica*	Anacardiaceae	Moderate
11	Champak	*Magnolia champaca*	Magnoliaceae	Moderate
12	Royal Bottle palm	*Roystonea regia*	Arecaceae	Moderate
13	*Canna*	*Canna indica*	Cannaceae	Moderate
14	Arecanut	*Areca catechu*	Arecaceae	Moderate
15	Jackfruit	*Artocarpus heterophyllus*	Moraceae	Moderate
16	Jamun	*Syzigium cumini*	Myrtaceae	Moderate
17	Citrus	*Citrus aurantiifolia*	Rutaceae	Moderate
18	Cashew	*Anacardium occidentale*	Anacardiaceae	Minor
19	Maize	*Zea mays*	Poaceae	Minor
20	Sugarcane	*Saccharum officinarum*	Poaceae	Minor

Karnataka. Adults of *E. guadeloupae* and *E. dispersa* lay their eggs by piercing ovipositor into early instar nymphs of *A. rugioperculatus*. The emerged larvae of the parasitoids feed on internal contents of the nymph and complete their growth and development. The adults emerged from the puparium by making small round hole on dorsal surface.

Gerling (1990) reported the parasitoid may face the host's venter during pupation but before emerging as an adult, it turns its face to dorsum through a hole that is chewed in the dorsum of the host. The other activities of the *Encarsia* species of parasitoids after emergence from the host *viz.,* walking, drumming, turning, mounting on nymphs and preening during host selection, host feeding and oviposition were observed (Lenteren et al. 1980). Host discovery and its suitability were ascertained by antennation and ovipositor probing.

Mass production of *E. guadeloupae* under laboratory conditions was quite a difficult task because of higher sensitivity of nymphs. The nymphs showed mortality when taken out from its natural conditions. Collection of parasitoid adults from heavily parasitized area and releasing in the highly infested area will facilitate decline in the pest population after establishment of the parasitoid in that location. Mass production and release of *Cheilomenes sexmaculata, Dichochrysa astur* will help in reduction of the pest as they are voracious feeder of eggs and nymphs.

Natural enemy complex of *A. dispersus* was earlier documented by several workers in several countries (Nechols 1982, Kumashiro et al. 1983, Waterhouse and Norris 1989 and Metzler and Laprade 1998) of which many are known to feed on *A. rugioperculatus.*

Commonly observed natural enemies were predatory green lacewing *Dichochrysa astur* Banks (Neuroptera: Chrysopidae)*, Cybocephalus* sp.*,* coccinellid beetle, *Cheilomenes sexmaculata* Fab., *Cryptolaemus montruzieri* Mulsant*, Jauravia* sp. etc. In case of *C. sexmaculata* and *C. montruzieri* both the adult and larval stages fed on the eggs and immature stages of the *A. rugioperculatus*. Continuous feeding by the predators in large numbers showed subsequent decline in whitefly population. *C. montrouzieri* was also recorded on *A. dispersus* in India (Mani and Krishnamoorthy 1997a and b; Mariam 1999) and in Hawaii (Paulson and Kumashiro 1985).

Predatory efficiency of the *C. sexmaculatus* and *Scymnus* sp. was observed on *A. dispersus* on casava (Palaniswamy 1995), on *Dombeya spectabilis* (Geetha et al. 1999) and mulberry (Mariam 1999) in Tamil Nadu. The adult and grubs of the predator *C. montrouzieri* were also known to feed on other whiteflies like *B. tabaci* (Venugopal Rao et al. 1990). Other predators like *Dichochrysa astur* Banks, *Cybocephalus* sp. and *Jauravia* sp. were also found feeding on eggs and nymphs of *A. rugioperculatus*.

Infestation started from Tamil Nadu, Kerala and its spreading. Receding of pest damage was observed in coastal Karnataka. Parasitization percentage in receding pestdamaging regions was very high. The major factors which may be attributed are monsoon, parasitoids and natural infection by *Isariafumosorosea.* Collection of parasitoid adults from heavily parasitized areas and releasing in the highly infested areas will show decline in the pest population after natural enemy establishment. Mass production and release of *C. sexmaculata* and *D. astur* will help in the reduction of the pest as they are voracious feeders of eggs and nymphs.

ACKNOWLEDGEMENTS

We are grateful to the Director, ICAR-NBAIR, Bengaluru for providing facilities and to the Indian Council of Agricultural Research, New Delhi for the Junior Research Fellowship for M.Sc. to the first author.

Authors' contributions: S.K. Pradhan and S. Dash conducted the experiment and D.K. Swain conducted the statistical analysis. All contributed to the preparation of the manuscript.

Conflict of interest: We declare that there is no conflict of interest among authors

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Received: 14 March 2020
Accepted: 26 July 2020