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Incidence, intensity and host dynamics of rugose spiralling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae) in Andhra Pradesh

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ABSTRACT: The rugose spiralling whitefly (RSW), *Aleurodicus rugioperculatus* Martin has spread across Andhra Pradesh since its first report and has become a serious pest in the several pockets of India, especially in Godavari districts of Andhra Pradesh. Surveys were conducted in the Godavari districts of Andhra Pradesh during 2018-19 to know the incidence, infestation levels, damage intensity and natural enemy fauna of RSW. Study revealed that, a total of 101 plant species under 47 families were recorded as hosts of *A. rugioperculatus*, particularly 10 crop families with 100 per cent incidence. Natural enemies mainly predators *viz., Menochilus sexmaculata*, spider sp. and *Dichochrys*a sp. were recorded. Further, the incidence, infestation levels and damage intensity of RSW on coconut, oil palm, guava, banana and cocoa were elaborately discussed.

Keywords: *Aleurodicus,* Rugose spiralling whitefly, host range, invasive, coconut, banana

INTRODUCTION

In India about 442 species of whiteflies belonging to 63 genera are known to attack diverse crops (Karthick, 2018). Of them, the rugose spiralling whitefly (RSW), *Aleurodicus rugioperculatus* Martin is of recent addition. The mode of entry of RSW into India was assumed to be through trade via ornamental plants (Shanas *et al.* 2016). In India, this pest was initially observed in coconut growing areas of Tamil Nadu and Kerala during July-August 2016 and assumed significance (Sundararaj and Selvaraj, 2017). It has emerged as a potential pest of several horticultural crops in south Indian states *viz.*, Tamil Nadu, Karnataka, Kerala and Andhra Pradesh (Chakravarthy *et al.,* 2017). However, this notorious pest on coconut was first time reported in Andhra Pradesh during the December, 2016. Especially, severe infestation was observed in Kadiyam village of East Godavari district which is a major hub of nursery activities for the supply of planting material throughout the country. Further, the intensity of RSW also reached to peak levels signaling a serious threat to coconut, oil palm and various ornamental crops; because of extension of host range and geographical distribution of the pest in the state. Keeping in view of RSW's staggering spread, surveys were undertaken to examine its occurrence on various host plants, incidence, infestation levels, intensity and potential natural enemies in Godavari districts of Andhra Pradesh.

MATERIALS AND METHODS

Systematic and continuous surveys were conducted in RSW infested gardens at three villages *viz.,* Nallajerla, Venkataramannagudem and Niladripuram in West Godavari district and two villages *viz.*, Nagullanka and Kadiyapulanka in the East Godavari districts of Andhra Pradesh which come under the coastal zone of Agro ecosystems to document the incidence, infestation levels and damage intensity of RSW on five major crops *viz.,* coconut, oil palm, guava, banana and cocoa (which is intercropped in coconut gardens). The incidence of natural enemies was also recorded from each selected garden during 2018-19. Also the host plants and the percentage of RSW incidence on different host plants were worked out.

To observe the incidence and infestation of RSW, five per cent sample palms or plants/ garden were selected randomly in each selected village. Incidence and infestation were calculated using following formulae,

$$\text{RSW incidence} = \frac{\text{No.of palms/plants infested with RSW}}{\text{Total no.of palms/plants in the garden}} \times 100$$

$$\text{RSW infestation} = \frac{\text{No.of leaves infested with RSW per palm/plant}}{\text{Total no.of leaves per palm/plant in the garden}} \times 100$$

To find out the incidence and intensity of RSW, three sample leaflets per palm one each from the top, middle and lower whorls of the palms *i.e.,* coconut and oil palm whereas crops like guava, banana and cocoa, leaves were randomly selected from three levels of plant canopy from branches oriented in four directions *i.e.,* North, South, East and West. Observations were made on number of spirals, number of live spirals, population count/leaflet, spiral size and shape etc on all the crops studied.

Table 1. Incidence and intensity of Rugose spiralling whitefly, *A. rugioperculatus* in West Godavari district, Andhra Pradesh, India

Crop	Village	Incidence (%)	Infestation (%)	Population / leaflet	Spirals/ leaflet	Live spirals / leaflet	Spiral size (cm)	Spiral shape	Intensity/ Damage level	Natural enemies observed
Coconut	Nallajerla	81.40	75.85	127.25	18.15	15.50	1.0 - 1.5	Oval, Circular, Elliptical and irregular	Medium -High	Spiders
	V.R. Gudem	85.18	80.60	123.43	14.00	11.00	1.5-2.0	Oval, Chordate and irregular	Low - High	*Menochilus* grubs, *Dichochrysa sp.* and spiders
	Niladripuram	100.00	95.00	121.6	28.00	25.00	3.0-5.0	Oval, irregular	High	*Dichochrysa sp.*
	MEAN	**88.86**	**83.82**	**124.09**	**20.05**	**17.17**	**2.8**	-	-	-
Oil palm	Niladripuram	88.60	95.00	163.10	50.00	43.00	1.5-2.0	Oval,circular and irregular	High	-
	V.R. Gudem	90.50	88.00	150.90	12.50	11.00	1.0 - 1.5	Oval, irregular	Low - Medium	Spiders
	Nallajerla	90.00	72.00	126.75	39.00	35.50	2.0-3.0	Oval, Elliptical	High	*Menochilus* grubs, *Dichochrysa sp.*
	MEAN	**89.70**	**85.00**	**146.92**	**33.83**	**29.83**	**2.2**	-	-	-
Guava	Niladripuram	92.00	63.50	144.00	9.00	8.00	0.5-1.5	Oval, elongated	Low-Medium	*Menochilus* grubs and adults
	V.R. Gudem	53.30	79.00	172.20	10.00	7.00	0.5-1.5	Round	Low	-
	MEAN	**72.65**	**71.25**	**158.10**	**9.50**	**7.50**	**1.5**	-	-	-
Banana	V.R. gudem	**83.13**	**82.93**	**109.37**	**26.33**	**19.67**	**1.8**	Oval, Round and chordate	Low - High	-
Cocoa	Niladripuram	100.00	30.00	25.10	2.00	1.00	0.5-1.0	Oval, irregular	Low	-
	V.R. gudem	83.30	42.00	38.00	3.00	1.00	1.5	Irregular	Low	-
	MEAN	**91.65**	**36.00**	**31.55**	**2.5**	**1.00**	**1.3**	-	-	-

To record the damage intensity of RSW on the host plants, damaged leaf area with number of egg spirals was recorded from three sample leaflets/palm. The intensity of damage was calculated using the scale given by Central Plantation Crops Research Institute (CPCRI), ICAR, Kasaragod, Kerala:The grading was low (<10 egg spirals/leaflet), medium (10-20) and high (>20).

RESULTS AND DISCUSSION

The data obtained through the survey conducted in RSW infested coconut, oil palm, guava, banana, and cocoa gardens are discussed below.

Coconut

In the East Godavari district the per cent incidence of RSW was recorded from Nil to 100.00. While, in West Godavari district, the percentage of incidence was ranged from 81.40 to 100.00 per cent in seven coconut gardens located in three villages (Tables 1 & 2). The mean incidence in Godavari districts was recorded as 61.10 per cent. Infestation percentage of RSW in East Godavari district was from 0.00 to 100.00 per cent, where as coconut gardens of West Godavari district, the infestation of RSW ranged from 75.85 to 95.00 per cent. The mean infestation in Godavari districts was recorded as 58.58 per cent.

The data from study revealed that the average number of RSW spirals/leaflet and live spirals per leaflet in different locations of East and West Godavari districts were recorded as 21.05 and 9.42 number, respectively. The RSW damage intensity was "low to high" in the villages of West Godavari district and in case of East Godavari district, "low" level of damage intensity was recorded. Further, observations revealed that, the galleries were also present on the entire laminar portion of the leaflet, petiole of the leaf and nuts in bunches in all the locations. The average size of the gallery on coconut leaflets was recorded as 1.65 cm in diameter with a mean total population (eggs, crawlers, nymphs, pupae and adults) 20.00 and 124.09 number of RSW/ leaflet in infested coconut gardens located in East and West Godavari districts respectively (Tables 1 & 2).

Oil palm

The incidence levels of RSW were ranged from 88.60 to 90.50 per cent in five oil palm gardens located in three villages *viz.,* Niladripuram, Venkataramannagudem and Nallajerla (Table 1) with a mean of 89.70 per cent incidence. The data from oil palm gardens at Niladripuram, Venkataramannagudem and Nallajerla villages showed that, the infestation percentage of RSW was ranged from 72.00 to 95.00 per cent (Table 1) while mean infestation was 85.00 per cent.

In the West Godavari district, the average number of spirals and live spirals per leaflet in oil palm gardens was recorded as 33.83 and 29.83 no., respectively. The intensity of RSW observed was "low" to "high" in oil palm gardens (Table 1). In oil palm gardens, RSW galleries were concentrated more on top 50 per cent portion of the leaflet and individual galleries were found on the entire leaflet by coalescing and appearing as a continuous waxy coating over the leaflets. The average size of the gallery on an oil palm leaflets was about 2.2 cm in diameter and the mean total population of RSW was 146.92 per leaflet (Table 1).

Guava

The incidence levels of RSW was recorded in three guava gardens, located at Venkataramannagudem and Niladripuram villages (Table 1) with a mean of 72.65 per cent incidence. The mean percentage infestation of RSW in guava gardens of Niladripuram and Venkataramannagudem villages of West Godavari district was recorded as 71.25 per cent (Table 1). The average number of spirals and live spirals/leaf was recorded as 9.50 and 7.50 in guava gardens located at Niladripuram and Venkataramannagudem villages. "Low" and "medium" damage intensity of RSW was observed from guava garden located at different locations of West Godavari district (Table 1).

In guava gardens, it was observed that the galleries were present on the entire leaf surface and individual gallery was found to be small when compared to that of other host plant leaves. The average size of the gallery was with 1.50 cm in diameter on guava leaves and the mean total population number of RSW/leaf in infested guava gardens in surveyed areas of West Godavari district was 158.10 no. per leaf (Table 1).

Banana

From the survey, it was found that, the mean incidence was 83.13 per cent observed in three banana gardens located at Venkataramannagudem village (Table 1). The mean percentage of RSW infestation in banana gardens located at V.R. gudem village of West Godavari district was 82.93 per cent infestation (Table 5). The intensity of RSW was also recorded from banana gardens in West Godavari district. The observations revealed that, the average number of spirals and live spirals/leaf in banana gardens in Venkataramannagudem village were found as 26.33 and 19.67 numbers respectively. The damage intensity recorded was "low" and "high" in all the three banana gardens at different locations of West Godavari district (Table 5).

Besides that, the galleries of RSW were found more concentrated along the leaf midrib and later spread over the entire leaf lamina. The average size of the gallery

Table 2. Incidence and intensity of Rugose spiralling whitefly, on coconut in East Godavari district, Andhra Pradesh, India

Village	Incidence (%)	Infestation (%)	Population /leaflet	Spirals/ leaflet	Live spirals / leaflet	Spiral size (cm)	Spiral shape	Intensity/ Damage level
Ambajipet	0.00	0.00	0.0	0.00	0.00	0.00	-	-
Nagullanka	0.00	0.00	0.0	0.00	0.00	0.00	-	-
Kadiyapulanka	100.00	100.00	60.0	6.00	5.00	1.0-1.5	Oval, circular	Low
MEAN	**33.33**	**33.33**	**20.00**	**2.00**	**1.67**	**0.5**	**-**	**-**

The overall mean incidence, infestation and population of RSW on coconut in Godavari districts was 61.10, 58.58 and 72.05 respectively.

was 1.8 cm in diameter on banana leaves and the mean total population of RSW/leaf in infested banana gardens was 109.37 no. per leaf (Table 1).

Cocoa

The incidence levels of RSW *i.e.,* 100.00 and 83.30 percent were recorded in Niladripuram and Venkataramannagudem villages respectively (Table 1) while mean incidence was 91.65 per cent. Infestation levels of RSW were 30.00 and 42.00 per cent in Niladripuram and Venkataramannagudem villages respectively (Table 1) with a mean of 36.00 per cent infestation. The average number of spirals and live spirals/ leaf was found to be 2.50 and 1.00 no./leaf, respectively in three cocoa gardens of Niladripuram and V.R. gudem villages respectively. "Low" level of damage intensity of RSW was observed in all the cocoa gardens located in surveyed villages of West Godavari district (Table 1).

In cocoa plants, very few galleries *i.e.,* one or two were observed on the entire surface of the leaf and galleries were found empty without any life stages of RSW. The average size of the galleries was also very small *i.e.,* about 1.3 cm in diameter on cocoa leaves and the mean total population of RSW/leaf in infested cocoa gardens was 31.55 per leaf.

From the above study it was established that, the RSW infestation, incidence and damage intensity was highest on oil palm crop but the population count/ leaf was highest on guava crop. The pest status was found high and occurring on more number of crops in West Godavari district when compared to that of East Godavari district of A.P. The RSW spirals varied from oval, circular, irregular, elliptical or chordate in shape in all the five crops studied. On cocoa crop, counts recorded on all aspects evidencing that cocoa was least preferred crop for RSW. The presence of high phenol content in cocoa leaves, shading of cocoa leaves (intercrop) by the coconut palms might have resulted in low pest attack. However, confirmatory studies are needed to be conducted.

Occurrence of RSW on other host plants

Further, the occurrence of RSW was also recorded on 101 host plants belonging to 47 families which were categorized into Plantation (4 species), Spice and Medicinal Plants (11 species), fruit crops (25 species), vegetable crops (15 species), ornamental plants (30 species), avenue trees (9 species) and weeds (7 species) (Fig. 1). Details of each plant species *i.e.,* common and scientific name, family, order, incidence percentage of RSW is presented in Table 3.

Among the different crop families observed, the highest incidence *i.e.,* 100 per cent of RSW was recorded in 10 crop families; Amaryllidaceae, Euphorbiaceae, Heliconiaceae, Cannaceae, Rutaceae, Musaceae, Moraceae, Myrtaceae, Caricaceae and Fabaceae. Among the fruit crops, highest incidence *i.e.,* 100 per cent was observed in acid lime, fig, jamun and papaya, whereas the lowest incidence *i.e.,* 8.60 per cent was recorded in phalsa. In vegetable crops, 100 per cent incidence was observed in curry leaf followed by moringa (95.80) and lowest *i.e.,* 5.20 per cent incidence was recorded in ivy gourd. In ornamental plants, highest incidence *i.e.,* 100 per cent was recorded in beach spider lilly, fire cracker flower, heliconia and india shot while lowest incidence *i.e.,* 6.00 per cent was observed in shell ginger. In case of avenue trees, highest *i.e.,* 100 per cent incidence was observed in peepal and lowest *i.e.,* 7.20 per cent was recorded in karanj. Among the weeds, the per cent incidence was highest on *Corchorus capsularis* L. (45.20 per cent) followed by *Cassia occidentalis* (25.90 per cent). The incidence of RSW was nil in teak (*Tectona*

Table 3. Host plants of Rugose spiralling whitefly recorded in Godavari districts, Andhra Pradesh, India

Common Name	Scientific Name	Order	Family	Incidence (%)
PLANTATION, SPICE AND MEDICINAL PLANTS				
All spice	*Pimenta dioica*	Myrtales	Myrtaceae	59.30
Aloe	*Aloe vera*	Asphodelaceae	Asphodelaceae	45.50
Ashwagandha	*Withania somnifera*	Solanales	Solanaceae	12.00
Cashew	*Anacardium occidentale*	Sapindales	Anacardiaceae	75.50
Clove	*Syzizium cumini*	Magnoliales	Myrtaceae	65.00
Cocoa	*Theobroma cacoa*	Malvales	Malvaceae	61.10
Coconut	*Cocos nucifera*	Arecales	Arecaceae	70.40
Costus	*Costus pictus*	Zingiberales	Costaceae	21.20
Indian spurge	*Euphobia neriifolia*	Malpighiales	Euphorbiaceae	23.50
Neem	*Azadirachta indica*	Sapindales	Meliaceae	53.00
Oil palm	*Elaeis guineensis*	Arecales	Arecaceae	89.90
Perwinkle	*Catharanthus roseus*	Gentinales	Apocynaceae	9.60
Sweet flag	*Acorus calamus*	Acorales	Acoraceae	30.10
Tamarind	*Tamarindus indica*	Fabales	Fabaceae	40.90
Turmeric	*Curcuma longa*	Zingiberales	Zingiberaceae	65.20
FRUITS				
Acid lime	*Citrus aurantifolia*	Sapindales	Rutaceae	100.00
Bael	*Aegal marmelos*	Sapindales	Rutaceae	42.50
Banana	*Musa paradisica*	Zingiberales	Musaceae	66.20
Ber	*Ziziphus mauritiana*	Rosales	Rhamnaceae	24.80
Custard apple	*Annona squamosa*	Magnoliales	Annonaceae	16.50
Fig	*Ficus carica*	Rosales	Moraceae	100.00
Grape	*Vitis vinefer*	Vitales	Vitaceae	35.00
Jackfruit	*Autocarpus heterophyllus*	Rosales	Moraceace	56.20
Jamun	*Syzygium cumini*	Myrtales	Myrtaceae	100.00
kumquat	*Citrus japonica*	Sapindales	Rutaceae	25.20
Mango	*Mangifera indica*	Sapindales	Anacardiaceae	96.40
Mulberry	*Morus nigra*	Rosales	Moraceae	55.20
Papaya	*Carica papaya*	Brassicales	Caricaceae	100.00
Passion fruit	*Passiflora edulis*	Malpighiales	Passifloraceae	26.90
Phalsa	*Grewellia robusta*	Malvales	Malvaceae	8.60
Pomogranate	*Punica granatum*	Zingiberales	Musaceae	75.00
Pummelo	*Citrus grandi*	Sapindales	Rutaceae	35.60
Ramphal	*Annona reticulata*	Magnoliales	Annonaceae	91.10
Rose apple	*Syzygium malaccense*	Myrtales	Myrtaceae	42.30
Sapota	*Manilkara zapota*	Ericales	Sapotaceae	89.70
Star fruit	*Averrhoa carambola*	Oxalidales	Oxalidaceae	25.40
Star gooseberry	*Phyllanthus acidus*	Malpighiales	Phyllanthaceae	38.10

Sweet orange	*Citrus sinensis*	Sapindales	Rutaceae	100.00
Guava	*Psidium guajava*	Myrtales	Myrtaceae	83.10
West Indian cherry	*Malphiga glabra*	Malpighiales	*Malpighiaceae*	10.10
VEGETABLES				
Beetroot	*Beta vulgaris*	Caryophyllales	Chenopodiaceae	18.20
Bhendi	*Abelmoschus esculentus*	Malvales	Malvaceae	45.40
Bitter gourd	*Momordica charantia*	Cucurbitales	Cucurbitaceae	48.00
Brinjal	*Solanum melongena*	Solanales	Solanaceae	48.30
Cabbage	*Brassica oleracea* var. *capitata*	Brassicales	Brassicaceae	25.60
Cauliflower	*Brassica oleracea* var. *botrytis*	Brassicales	Brassicaceae	62.00
Chilli	*Capsicum annuum*	Solanales	Solanaceae	89.10
Curry leaf	*Murraya koenigii*	Caryophyllales	Rutaceae	100.00
Dolichos bean	*Lablab purpureus*	Rosales	Fabaceae	76.20
Ivy gourd	*Coccinia indica*	Cucurbitales	Cucurbitaceae	5.20
Moringa	*Moringa oleifera*	Brassicales	Moringaceae	95.80
Palak	*Beta vulgaris* var *bengalensis*	Caryophyllales	Chenopodiaceae	38.50
Radish	*Raphanus sativus*	Capparales	Brassicaceae	85.50
Red cabbage	*Brassica oleracea* var. *capitatafsp. Rubra*	Brassicales	Brassicaceae	68.10
Sorrel	*Rumex vesicarius*	Caryophyllales	Polygoniaceae	65.60
ORNAMENTAL PLANTS				
Acalypha	*Acalypha macrophylla*	Malpighiales	Euphorbiaceae	69.1
Acalypha	*Acalypha wilkesiana*	Malpighiales	Euphorbiaceae	65
Aglonema	*Aglonema commutatum*	Alismatales	Araceae	15.6
Alpinia	*Alpinia* speciosa	Zingiberaceaea	Zingiberales	6.2
Beach spider lilly	*Hymenocallis littoralis*	Asparagales	Amaryllidaceae	100
Bird of paradise	*Sterlitzia reginae*	Zingiberales	Sterlitzaceae	92
Bougainavillea	*Bouganvillea spectabilis*	Caryophyllales	Nyctaginaceae	42.5
Butterfly pea creeper	*Clitoria ternata*	Fabales	Fabaceae	9.5
Chinese fringe	*Loropetalum chinense*	Saxifragales	Hamamelidaceae	26
Chrysanthemum	*Dendranthema grandiflora*	Asterales	Asteraceae	59.2
Crepe jasmine	*Tabernamontana divariata*	Gentianales	Apocynaceae	30.4
Rose	*Rosa indica*	Rosales	Rosaceae	36.5
Fire cracker flower	*Crossandra infundibuliformis*	Lamiales	Acanthaceae	100
Four O' clock	*Mirabilis jalapa*	Caryophyllaceae	Nyctaginaceae	12.7
Gerbera	*Gerbera jamesonii*	Asterales	Asteraceae	56.6
Gladiolus	*Gladiolus communis*	Asperagales	Iridaceae	15.5
Gold shower	*Galphimia speciosa*	Malpighiales	Malpighiaceae	35.3
Golden trumpet	*Allamanda cathartica*	Gentianales	Apocynaceae	42.1
Graphtophyllum	*Graphtophyllum pictum*	Lamiales	Acanthaceae	6.5
Heliconia	*Heliconia acuminata*	Zingiberales	Heliconiaceae	100

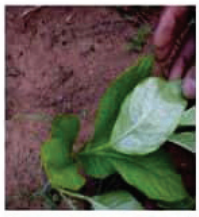
Hibiscus	*Hibiscus rosa-sinensis*	Malvales	Malvaceae	96
Indian shot	*Canna indica*	Lamiales	Cannaceae	100
Jasmine	*Jasminum officinale*	Lamiales	Oleaceae	30
Nerium	*Nerium oleander*	Gentianales	Apocynaceae	49
Jatropa	*Jatropa curcas*	Malpighiales	Euphorbiaceae	37
Peace lilly	*Spathiphyllum wallisii*	Alismatales	Araceae	25
Peacock flower	*Caesalpinia pulcherrima*	Fabales	Fabaceae	65
Song of India	*Dracena reflexa*	Asperagales	Asperagaceae	10.5
Syngonium	*Syngonium podophyllum*	Alismatales	Araceae	13
Yellow bells	*Tecoma stans*	Lamiales	Bignoniaceae	57
AVENUE TREES				
Akasha malli	*Millingtonia hotensis*	Bignoniaceae	Lamiales	5.90
Areca palm	*Areca triandra*	Arecales	Arecaceae	56.90
Butterfly tree	*Bahunia purpurea*	Fabales	Fabaceae	100.00
False rubber	*Ficus elastica*	Rosales	Moraceae	62.20
Karanj	*Pongamia pinnata*	Fabales	Fabaceae	7.20
Peepal	*Ficus religiosa*	Rosales	Moraceae	100.00
Pride of India	*Lagestromia indica*	Myrtales	Lythraceae	29.30
Umbrella tree	*Schefflera actinophylla*	Apiales	Araliaceae	11.30
Weeping fig	*Ficus benjamina*	Rosales	Moraceae	35.40
WEEDS				
Cassia	*Cassia occidentalis*	Fabales	Fabaceae	25.90
Cassia	*Cassia abbreviata*	Fabales	Fabaceae	14.20
Corchorus	*Corchorus fascicularis*	Malvales	Malvaceae	45.20
Jungle rice	*Echinochola colana*	poaceae	Poaceae	14.40
Solanum	*Solanum nigrum*	Solanales	Solanaceace	10.50
Stinking passion flower	*Passiflora foetida*	Malpighiales	Passifloraceae	13.00
Synedrella	*Synedrella nodiflora*	Asterales	Asteraceae	14.10

grandis), strawberry (*Fragaria×ananassa*) and milk weed (*Calotropis gigantea*).

Through the present studies, the pest has been grown to an alarming stage by attacking several host plants and spreading to all parts of A.P within a short period of its entry into the state. Moreover, the intensity of RSW also reached to peak levels signaling a serious threat to coconut, oil palm and various cultivated and ornamental crops due to its polyphagous nature, extension of host range and geographical distribution of the pest in the state.

Among the crops studied the pest incidence was very high on oil palm (*Elaeis guineensis*), coconut (*Cocos nucifera*), banana (*Musa paradisica*), acid lime (*Citrus aurantifolia*), fig (*Ficus carica*), jamun (*Syzygium cumini*), papaya (*Carica papaya*), curry leaf (*Murraya koenigii*), fire cracker flower (*Crossandra infundibuliformis*), heliconia (*Heliconia acuminata*), butterfly tree (*Bahunia purpurea*) and peepal (*Ficus religiosa*) where the infestation was exceptionally intense with overlapping generation of the pest on the abaxial surface of the leaves of plants.

Studies conducted by Mannion (2010) also reported that, RSW is a polyphagous pest feeding on a wide range of host plants *i.e.,* palms, woody ornamentals, and fruits. According to Selvaraj *et al.* (2017) pest incidence was noticed on 12 plant species (Coconut palm, Banana, Mango, Sapota, India Almond, Water apple, Laurel ball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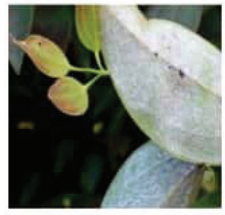
Aloe vera


Withania somnifera


Anacardia occidentalis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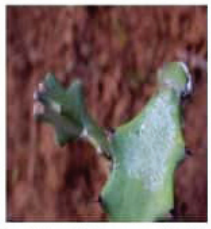
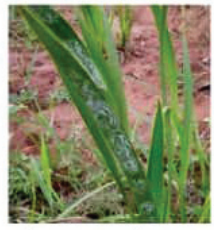

Euphorbia nertifolia


Azadirachta indica

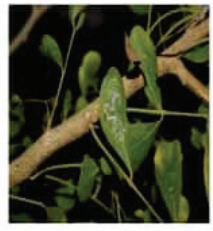

Catharanthus roseus


Acorus calamus


Tamarindus indica


Curcuma longa


Citrus aurantifolia


Aegal marmelos


Ziziphus mauritiana


Annona squamosa


Ficus carica


Vitis vinifera


Autocarpus heterophyllus


Syzygium cimini


Citrus japonica


Magnifera indica


Morus nigra


Carica papaya


Passiflora edulis


Grewellia robusta


Punica granatum


Citrus grandis


Annona reticulate

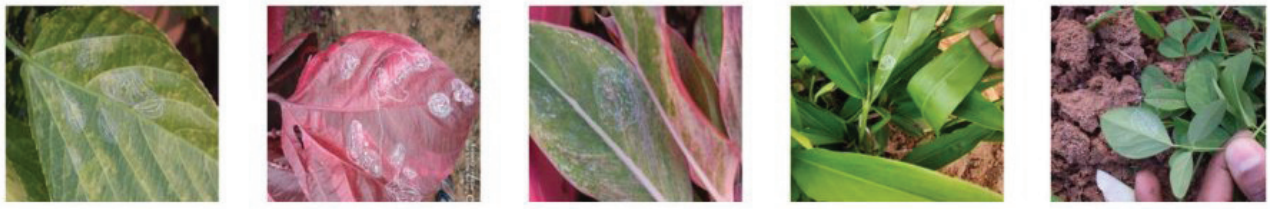

Syzygium malaccense

Manilkara zapota *Averrhoa carambola* *Phyllanthus acidus* *Citrus sinensis* *Malphiga glabra*

Beta vulgaris *Abelmoschus esculentus* *Momordica charantia* *Solanum melongena* *Lablab purpureus*

Brassica oleraceae var botrytis *Capsicum annum* *Murraya koenigii* *Brassica oleraceae var capitata* *Coccinia indica*

Moringa oleifera *Betavulgaris var bengalensis* *Raphanus sativus* *Brassica oleraceae var rubra* *Rumex vescarius*



Acalypha macrophylla *Acalypha wilkesiana* *Aglonema commutatum* *Alpinia speciosa* *Clitoria ternata*

Sterlitzia reginae *Hymenocallis littoralis* *Bougainvillea spectabilis* *Loropetalum chinensis* *Rosa indica*

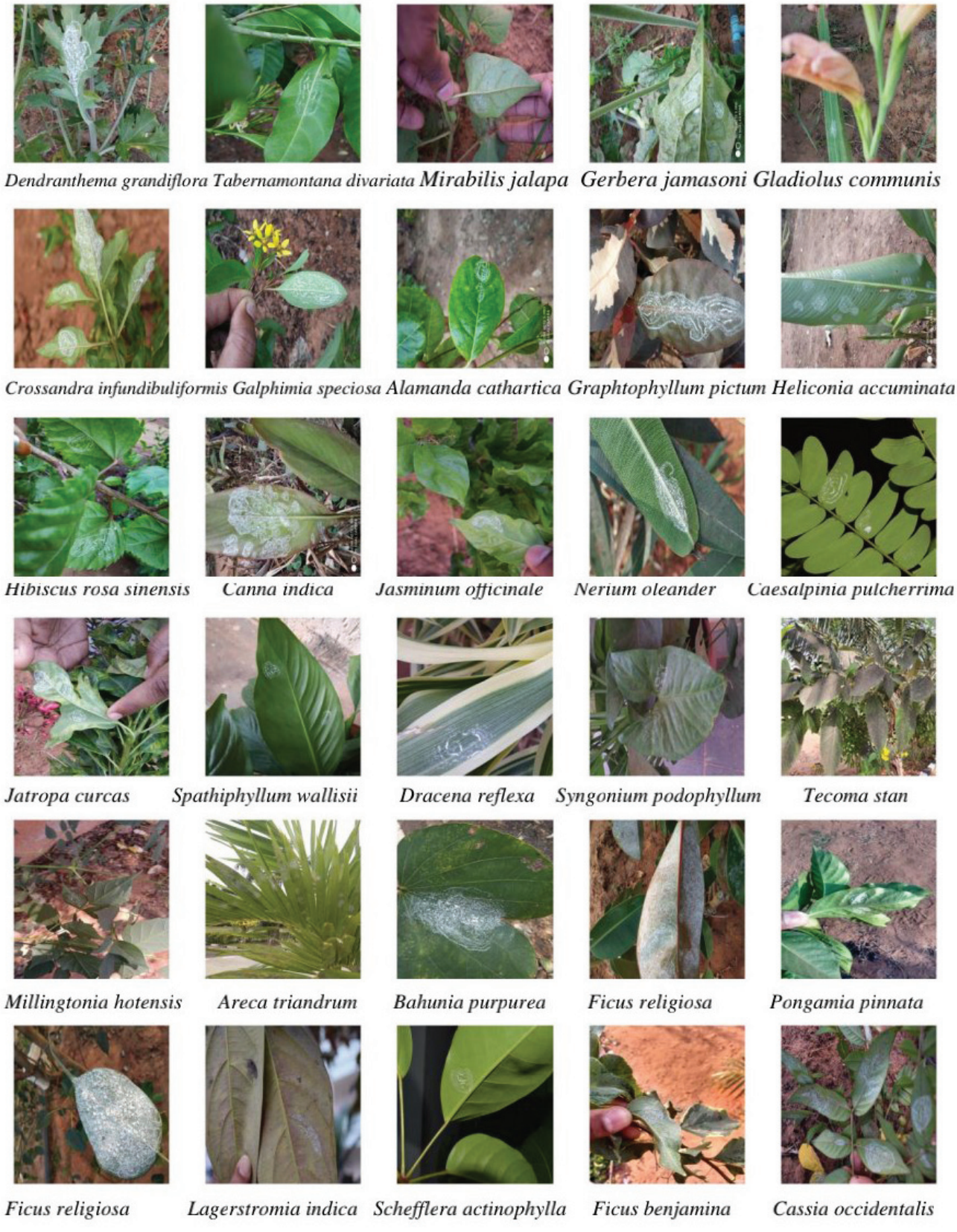


Figure 1: Host plants of rugose spiralling whitefly recorded in Godavari districts, Andhra Pradesh

tree, Betel vine, Guava, Rubber fig, Butterfly palm and Ruffled and Fan Palm of 9 families in Karnataka. In Tamil Nadu, Kerala and Andhra Pradesh, the pest was observed on coconut palm, banana, bird of paradise, custard apple, butterfly palm and Oleander (Srinivasan *et al.* 2016, Selvaraj *et.al.,* 2016). recorded 16 hosts (Bhendi, Sapota, Custard apple, Arecanut, Neem, Citrus, Coconut, Hibiscus, Physic nut, Mango, Cassava, Banana, Nutmeg, Congress grass, Pepper and Guava) of RSW belonging to 14 botanical families in Tamilnadu.

While surveying different host gardens of RSW, data was also recorded on natural enemies present in the respective garden. From the data it was found that, natural enemies mainly predators like spiders, grubs and adults of coccinellid beetle, (*Menochilus sexmaculatus*) were observed in infested coconut, oil palm and guava gardens while *Dichochrysa* sp. were found in few number. Selvaraj *et al.* (2016) enlisted predators like green lacewing (*Mallada* spp.), predatory mite and coccinellids as common natural enemies of RSW in Tamil Nadu, Andhra Pradesh and Kerala. Many indigenous predators like *Pseudomallada* sp., *Cybocephalus sp., Diadiplosis sp.* and *Jauravia pallidula* were observed on *A. rugioperculatus* by Poorani and Thanigairaj, 2017. Predators like *Chrysoperla zastrowii* and *Dichochrysa sp. nr. astur* were pre-dominantly recorded in the infested tracts of RSW in A.P. (Krishnarao and Rao NBVC, 2019). However, the present studies in A.P., especially in West Godavari district, high count of the predatory population was recorded on guava crop when compared to other hosts of RSW *viz.,* coconut, oil palm, banana *etc*.

Selvaraj *et al.* (2016) observed that the pest got reduced in its population by the action of natural enemies in due course of time. However, huge population of natural enemies are in need in order to diminish the pest population. In the present study also the coccinellid beetle was predominantly found as a potential feeder on RSW in guava crop when cultivated organically which gives us an indication that conservation of predatory coccinellid beetles in the ecosystem of orchard crops will definitely be helpful in reducing the RSW population with adoption of good agricultural practices.

As the Kadiyam village of East Godavari district of A.P. is the main center for the supply of the plant material throughout the country with various species like plantation crops, fruit crops, vegetable crops, ornamental plants *etc.* The present study highlights the information about the plants on which RSW can survive and spread though the plant material via nurseries to other parts of the country. With this information the enforcement of legislative measures can be proposed through National Horticulture Mission or State Horticulture Mission or state departments which are the certifying agencies for the nurseries and planting material to check the pest movement to other places.

From the survey it was established that, the RSW infestation, incidence and damage intensity was highest on oil palm crop but the population count/leaf was highest on guava crop. The pest status was high and occurring on more number of crops in West Godavari district when compared to that of East Godavari district of A.P. However, cocoa was found least preferred crop while, oil palm being highly preferred crop for RSW, which was laden with RSW population. Conclusively, it was conferred that RSW was polyphagous pest attacking a wide range of host plants (101 host plants belonging to 47 families). Besides these, natural enemies mainly predators like *Menochilus sexmaculata,* spider *sp.* and *Dichochrysa sp.* were recorded. Continuous monitoring, opting non chemical approaches, conservation of natural enemies, adaptation of bio-intensive IPM would be strong element for effective management of this type of invasive pests.

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