

Invasion and escalation of *Aleurodicus rugioperculatus* (Hemiptera: Aleyrodidae): An alarming pest in east coast region of India

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Research Article

Keywords: Exotic, host plants, management, rugose spiraling whitefly

Posted Date: August 12th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-786195/v1>

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Abstract

Invasive species causes serious threat to the natural ecosystem. Severe and up surging phenomenon of exotic rugose spiraling whitefly (RSW), *Aleurodicus rugioperculatus* Martin became a major concern in global crop production. The present study aimed to document and assesses the host range, nature, and intensity of damage caused by this cryptic species. The roving survey was conducted to study the occurrence of RSW in the fruit orchards, vegetable gardens, ornamental crops, and avenues trees plantation in the east-coast region of India. Hierarchical clustering was performed based on its incidence on different host plants and correlated with the dissimilarity index. The RSW was identified based on morphological characteristics and the nature of the damage. RSW infested a total of twenty-seven crops was noticed. Four host plants viz., *Cocos nucifera* L., *Musa sp.*, *Psidium guajava* L., and *Syzygium cumini* L. Skeels showed severe levels of infestation. An important implication from the current study is the occurrence of its incidence on the two new host crops viz., *Amaranthus tricolor* L. and *Solanum torvum* that was envisaged firstly to the scientific world. This study provides baseline information about RSW among various stakeholders and helps to develop a sustainable management strategy for timely mitigation of RSW menace.

Full Text

Biological invasions by exotic species are of major concern to the native ecosystems, biodiversity, and livelihood security. These frequent invasions are causing nearly 25% of economic loss globally. Being an agrarian economy, India constantly realizes the havoc of invasive pests, particularly insect menace. So far, more than 110 exotic insect species have been reported from India (Mandal 2011). Among these insects, exotic whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae), commonly known as the rugose spiraling whitefly (RSW), is one of the worst species causing frequent losses in agriculture, horticulture, and forestry (Naveena et al. 2020). Although the species origin occurred from Belize, South America (Martin 2004), it was first reported on coconut plantations of the Pollachi area of Tamilnadu, India in 2016 (Sundararaj and Selvaraj 2017). Further, it spread to many parts of the country, wrecking direct and indirect damages (Sumalatha et al. 2020). The polyphagous species has a shorter life cycle of 37-48 days (Pradhan et al. 2020), exhibiting phenotypic plasticity and high competitiveness with other native species. Data on Climate Match Index (CMI, 0.62-0.73) predicted through CLIMEX based modeling by Chakravarthy et al. (2017) revealed that the eastern region of India, Odisha, Andhra Pradesh, West Bengal, in particular, is the potential area for the incursion of the RSW. In general, the degree of climate similarity is considered the factor governing the spread and establishment of the pest, i.e., a higher CMI value coupled with the higher chance of settlement of RSW in that particular locality. This pest wreaks severe havoc and worries over 5000 coconut farmers in Cuttack, Odisha, in 2020.

(<https://www.newindianexpress.com/states/odisha/2020/nov/09/whitefly-pesttakes-a-toll-on-coconut-trees-in-odisha-2221319.html>). Later, it affected the *Acacia auriculiformis* plantation in India drastically (Sundararaj et al. 2021). Although in global scenario, many continents were reported the invasion and diverse host menace of RSW, reports on the occurrence of RSW on various host ranges in east coastal

region of India are unavailable. Therefore, the present studies aimed to document and assess the expansion of host range, nature, and intensity of damage caused with the economic impacts of this cryptic invasive species in coastal tract of India particularly Odisha. This study could provide awareness to various stakeholders and help to develop a sustainable management strategy for the upcoming time.

A continuous and systematic roving survey was conducted during January-May 2021 in Bhubaneswar (20°24'05.13" N and 85°78'17.62" E at 62.37 meter above mean sea level) and its surrounding areas. Fruit orchards, coconut plantations, vegetable cultivated areas, ornamental and avenue areas, and wild germplasm resources were focused for the survey. The infested host plants were collected along with whitefly adults and preserved with 70% ethanol. The host plants were identified by observing visual images contained during the study with the help of the taxonomists. The nature and extent of damage were examined critically on each host plant species. The intensity of damage was assessed on randomly selected five leaves (leaflets) per plant. An assessment of their population level (intensity) was carried out following the scale described by Sundararaj (2021). (i.e., Low: less than ten live egg spirals or adults/leaflet; moderate: 11-20 live egg spirals or adults/leaflet; severe-more than 20 live egg spirals or adults/leaflet). In addition, the dissimilarity index was estimated using XLSTAT statistical software (XLSTAT Premium 2020.2.1, Adinsoft, NY)

The RSW was identified based on the descriptions given by Martin (2004) and Stocks and Hodges (2012). It could be easily identified under field conditions by its larger size (compared to commonly found species in the real world), the spiral pattern of occurrence, and sluggish nature. In general, RSW mostly noticed on the abaxial surface of the leaf with white flocculent matter dispersed in a spiraling pattern. Close observation under microscope 10X (Olympus CX21i, India) depicted brown patches on the forewings. A pair of sword-like pincer structures was noticed at the tip of the abdomen in male species. The investigation revealed the whole body of the adult was white and appeared like a tiny moth. The study also explored that nymphs were oval with waxy material all over the body, whereas the pseudopuparium is considered the final nymphal stage. The RSW was found to feed twenty-seven plant species, including economically important cultivated plants and palms in the covered study area. Its infestation was found on *Mangifera indica* L., *Anacardium occidentale* L., *Annona squamosa* L., *Psidium guajava* L., *Syzygium aqueum* Alston, *Syzygium jambos* L. Alston, *Syzygium cumini* L. Skeels, *Averrhoa carambola* L., *Cocos nucifera* L., *Areca catechu* L., *Roystonea regia*, *Acacia auriculiformis*, *Solanum torvum* Swartz, *Amaranthus tricolor*, *Polyalthia longifolia*, *Zea mays* L., *Trichosanthes dioica* Roxb., *Musa* sp., *Aegle marmelos* L. Correa, *Ficus religiosa*, *Hylocereus undatus*, *Ficus benghalensis*, *Carica papaya* L., *Zizyphus mauritiana* Lam., *Artocarpus heterophyllus* Lam., *Codiaeum variegatum* L., and *Manilkara hexandra* (Roxb) Dubard (Fig 1). The natural infestations on various host plants are in accordance with the earlier reports (Stocks and Hodges 2012; Selvaraj et al. 2016; 2017; Anonymous 2017). The present study explored the expansion of its host plant (Table 1). Our study found two new host crops i.e. *Amaranthus tricolor* L. and *Solanum torvum* Swartz invaded by RSW, that reported firstly to the scientific society. The present findings agree with the observations of Sundararaj et al. 2021. Hierarchical clustering was performed based on RSW incidence on different host plants. The 27 host plants were grouped into two clusters (20 host plants in cluster I and 7 host plants in cluster II). In cluster II, four host

plants i.e. coconut, banana, guava, and jamun showed severe levels, and three host plants i.e. areca nut, custard apple, and royal palm exhibited moderate to severe levels of infestation (Fig 2). The present study revealed the variation in infestation level on twenty-seven host plants. Further its incidence on multi-flora is surmised due to favorable weather factors and availability of host plants.

Both nymphs and adults were usually found crowded on the abaxial surface of leaflets causing direct damage by driving phloem sap. Indirectly, larger excrement of honeydew facilitates the growth of black fungus, *Capnodium sp.* (sooty mold), which affects normal photosynthesis and disrupts leaf configuration. Further, it caused leaf drooping and wilting. Moreover, in jamun and wax apple (Fig 1b), leaf litter was also covered with a heavy infestation of the sooty mold with white mealy matters along with RSW infestation. The infestation was also not exempted from reproductive parts i.e., mango, guava, wild brinjal, etc (Fig. g-i). The initial feeding and colonization of RSW were observed on amaranthus, wild brinjal, ashoka, custard apple, ber, and other ornamental plants. Still it found that the insect failed to feed continuously and establish successfully in those plants. As RSW is a highly polyphagous pest on more than a hundred hosts (Stocks and Hodges 2012), frequent monitoring is essentially required from further havoc.

RSW poses a serious challenge to the agricultural sector and economy as the biologist and public witnessing and recognizing the damage caused. Despite the severe ecological damage and economic loss caused by the RSW, the factors contributing to its success remain elusive. Further, the ongoing dispersal and establishment of RSW are some of the most remarkable biological outcomes of climatic variability (Gao and Reitz 2017). In addition to that, the prediction report revealed an increase in the number of invasive species like RSW increase number for India (Bellard et al. 2013) and particularly eastern Part of the country, including Odisha (Chakravarthy et al. 2017) and across the world indeed. Interestingly the current study reveals that although the climate of east coast of India is favorable for many major and minor fruit crops, the host preference of RSW towards coconut, banana, jamun, and guava is more (Fig 2). Our study claims that its establishment on these hosts plants and spreading in this region is highly conducive.

Prevention, early detection, and eradication are the key to mitigating RSW as an invasive pest (Wittenberg and Cock 2001). Under severe infestation, it was recommended to apply neem oil at 1% concentration as foliar spray and starch solution at 2% was also suggested to manage sooty mold on the leaf surface. So, far no chemical pesticides have been recommended against RSW as none of the insecticides have been label claimed, specifically for this. Further, it is advised to install yellow sticky traps for effective trapping of the adult flies. As natural enemies are imperative for any invasive pest, effort is put forth upon various conservation and augmentation strategies and advocated to farmers through awareness programs.

The invasive RSW is indeed an alarming threat and is now well established on twenty-seven species of host plants in east coast region of India. Although intensity level varies from low to severe in the focused area, regular monitoring is necessary to check its further spread and timely management. A

holistic approach is the need to adopt rapid response strategies against its invasion, which could be possible by educating farmers and creating awareness among various stakeholders and field entomologists.

Declarations

Acknowledgments

The authors are thankful to the Director, ICAR-Indian Institute of Horticultural Research, Karnataka, India, for providing necessary facilities and provisions to conduct the study. The gratitude also expressed to the Head, Central Horticultural Experiment Station (ICAR-IIHR), Bhubaneswar for the guidance and streamline of the work.

Declarations

Funding: NA

Conflicts of interest: The authors declare that they have no competing interests.

Availability of data and material: The dataset generated during and/or analyzed during the current study is available in the manuscript itself.

Code availability: NA

Ethics approval and Consent to participate: All the authors agree with the manuscript and consent to participate in it.

Consent for publication: The authors give their consent for the publication of this manuscript.

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Table 1

Table 1. Host plant distribution for the invasive RSW and its infestation level

Sl. No.	Plant species (Botanical name)	Common name	Family	Infestation level	Remarks
1	<i>Mangifera indica</i> L.	Mango	Anacardiaceae	Low to moderate	Colonize on Fruits and under surface of leaves
2	<i>Anacardium occidentale</i> L.	Cashew	Anacardiaceae	Low	
3	<i>Annona squamosa</i> L.	Custard apple	Annonaceae	Moderate to severe	Infestation on lower surface of leaves
4	<i>Psidium guajava</i> L.	Guava	Myrtaceae	Severe	Infestation on lower surface of leaves and black sooty mould on upper surface
5	<i>Syzygium aqueum</i> Alston	Watery rose-apple	Myrtaceae	Moderate	
6	<i>Syzygium jambos</i> L. Alston	Rose apple	Myrtaceae	Moderate	
7	<i>Syzygium cumini</i> L. Skeels	Jamun	Myrtaceae	Severe	Colonize on lower surface of leaves and black sooty mold on upper surface also traced on leaves litter on soil
8	<i>Averrhoa carambola</i> L.	Carambola	Oxalidaceae	Low	
9	<i>Cocos nucifera</i> L.	Coconut	Arecaceae	Severe	Coverage on Backside of leaf with sooty mold on upper surface
10	<i>Areca catechu</i> L.	Arecanut	Arecaceae	Moderate to severe	
11	<i>Roystonea regia</i>	Royal palm	Arecaceae	Moderate to severe	
12	<i>Acacia auriculiformis</i>	Acacia	Fabaceae	Low to moderate	
13	<i>Solanum torvum</i> Swartz	Wild brinjal	Solanaceae	Low	On fruits and leads to rotten
14	<i>Amaranthus tricolor</i> L.	Amaranthus	Amaranthaceae	Low to moderate	
15	<i>Polyalthia longifolia</i>	Ashoka tree	Annonaceae	Low	
16	<i>Zea mays</i> L.	Maize	Poaceae	Moderate	

17	<i>Trichosanthes dioica</i> Roxb.	Pointed gourd	Cucurbitaceae	Low	
18	<i>Musa sp.</i>	Banana	Musaceae	Severe	Severe colonization on below surface of leaves and black sooty mold on upper surface
19	<i>Aegle marmelos</i> L.Correa	Bael	Rutaceae	Low	
20	<i>Ficus religiosa</i>	Peepal/ aswatath	Moraceae	Low	
21	<i>Hylocereus undatus</i>	Dragon fruit	Cactaceae	Low to moderate	
22	<i>Ficus benghalensis</i>	Banyan	Moraceae	Low	
23	<i>Carica papaya</i> L.	Papaya	Caricaceae	Low	
24	<i>Zizyphus mauritiana</i> Lam.	Indian jujube/ ber	Rhamnaceae	Low to moderate	
25	<i>Artocarpus heterophyllus</i> Lam.	Jackfruit	Moraceae	Low	
26	<i>Codiaeum variegatum</i> L.	Variegated Croton	Euphorbiaceae	Low	
27	<i>Manilkara hexandra</i> (Roxb) Dubard	Khirni	Sapotaceae	Low	

Low: less than ten live egg spirals or adults/leaflet; moderate: 11-20 live egg spirals or adults/leaflet; severe-more than 20 live egg spirals or adults/leaflet

Figures

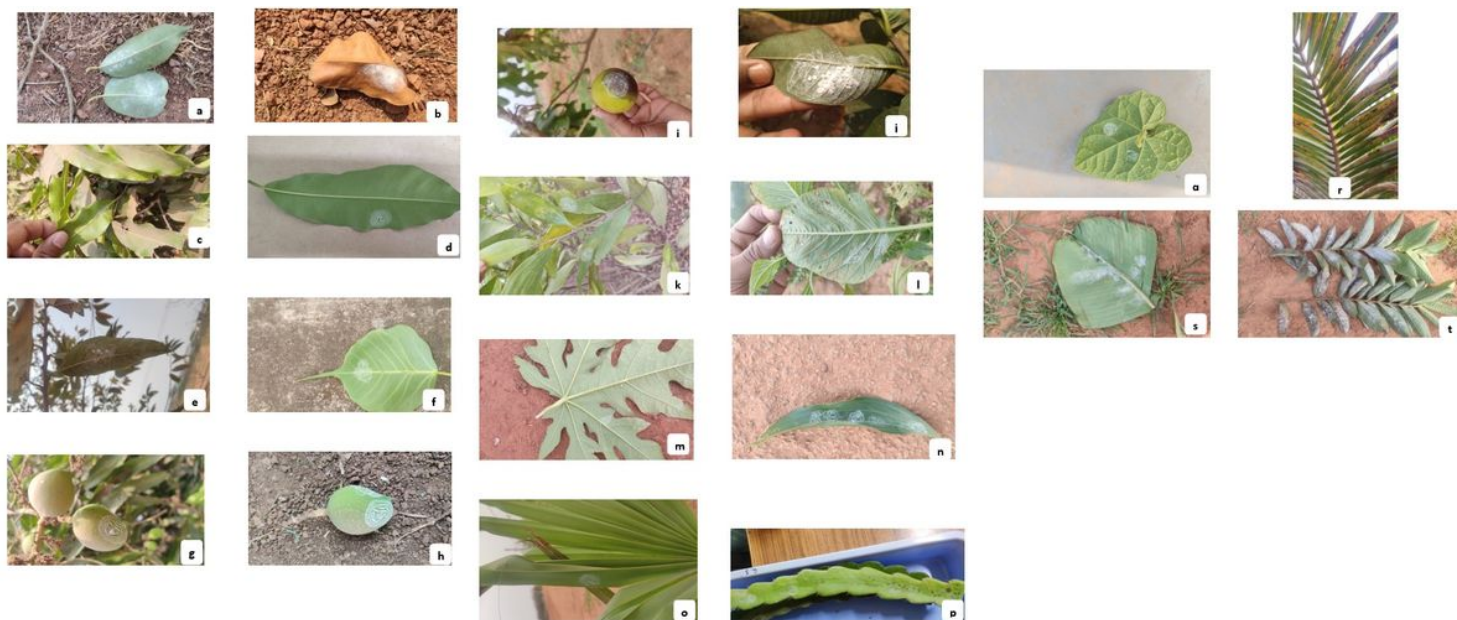


Figure 1

Infestation of RSW on different host crops (both vegetative and reproductive part) a,b, infestation on jamun (back side of leaf and fallen leaf); c, ashoka leaf; d, Khirni leaf; e, custard apple leaf; f, peepal leaf; g,h, fruits of mango affected; i, infestation on fruits of wild brinjal; j, guava leaf; k, acacia leaves; l, amaranthus leaf; m, papaya leaf; n, acacia leaf covered with RSW; o, royal palm; p, dragon fruit; q, pointed gourd leaf; r, coconut leaf covered with RSW; s, banana leaf; t, guava leaf covered with RSW.

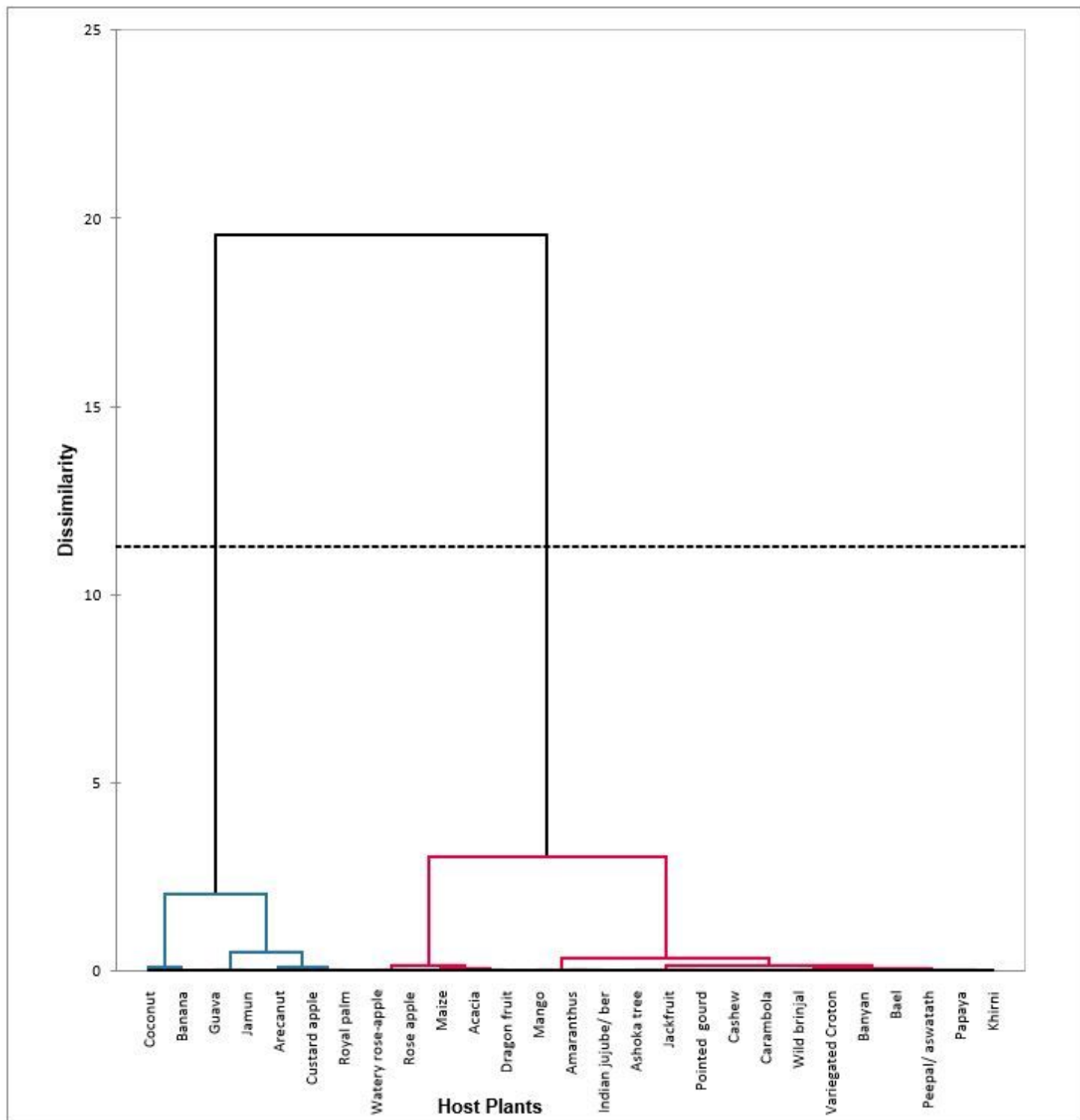


Figure 2

Hierarchical clustering of 27 host plants based on infestation of RSW