



Research Article

First record of invasive rugose spiraling whitefly *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae) along with parasitoids in Karnataka

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ABSTRACT: Occurrence of the invasive rugose spiraling whitefly (RSW), *Aleurodicus rugioperculatus* Martin was found on coconut, banana, mango, guava, sapota, Indian almond, water apple, ball tree, rubber fig, butterfly palm, and ruffled fan palm for the first time in Karnataka. Severe damage was noticed in the coastal areas of Mangalore and Udupi and the infestation ranged from 20-35% in coconut and 24-38% in banana. Morphology and molecular based taxonomic tools were used to identify the pest and its natural enemies. Survey also revealed natural parasitism by the parasitoids *Encarsia guadeloupeae* Viggiani and *E. dispersa* Polaszek (Hymenoptera: Aphelinidae) with 5-15% in coconut, 7-18% in banana and 22-30% in sapota. Besides, other commonly found natural enemies viz., *Stethorus* sp. associated with mites and *Dichochrysta astur* were also recorded. Furthermore, augmentation and conservation strategies for these parasitoids for the management of this invasive pest were discussed.

KEY WORDS: *Aleurodicus rugioperculatus*, host-plants, invasive pest, natural enemies, rugose spiraling whitefly

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INTRODUCTION

Increased international agricultural trade lead to the movement of invasive exotic species from one region of the world to others. So far, more than 110 exotic insect species had been reported from India, of which, whiteflies and mealybugs constitute a major part of the invasion (Mandal, 2011). In India, there are 443 whiteflies under 64 genera reported to feed on many agricultural, horticultural and forestry crop plants. During August-September, 2016, yet another invasive rugose spiraling whitefly (RSW), *Aleurodicus rugioperculatus* Martin (Aleyrodidae: Hemiptera) was found heavily infesting coconut palm (*Cocos nucifera* L.) for the first time from India (Sundararaj and Selvaraj, 2017). Subsequently, the incidence and infestation of the pest was recorded on banana, custard apple, sapota and several other ornamental plants viz., areca palm/butterfly palm, oleander, bird of paradise in Tamil Nadu, Andhra Pradesh and Kerala. RSW prefers coconut and banana than other host plants and causes severe damage (Selvaraj *et al.*, 2016).

This pest has been found to feed on more than 120 plant species including several economically important horticultural crops. It was a serious threat to coconut palm in Florida (Stocks and Hodges, 2012; Kumar *et al.*, 2013). It is believed to have been originated from Central America

and its incidence is limited to Belize, Mexico, Guatemala and Florida in Central and North America (Evans, 2008). Keeping in view of RSW's economic importance, surveys were undertaken to monitor its occurrence on various host plants and to identify its potential natural enemies in Karnataka.

MATERIALS AND METHODS

Systematic and continuous surveys were conducted in Mysore, Mandya, Chamrajnagar, Udupi and Dakshina Kannada districts of Karnataka to investigate the incidence, distribution, host plant range and natural enemies of RSW. Intensity of damage was assessed randomly on five plants in three locations. Host plant leaves infested with immature stages, puparium in the paper envelopes and adults whiteflies in 70% alcohol were collected as described by Dubey and David (2012) along with relevant collection data. Part of the collection of host plant leaves/parts infested with immature stages and puparium were placed in rearing jar for the emergence of parasitoids.

The emerging parasitoids were collected using aspirator and preserved in vials containing 70% ethanol. Permanent mounts of the puparium were prepared as suggested by Martin (1987). Identification of RSW and its natural

enemies were confirmed by morphology and molecular based taxonomy (COI). Genomic DNA of this species was isolated using standard protocols (Selvaraj *et al.*, 2016). Assessment of parasitism (%) was determined based on the number puparium parasitized as against un-parasitized pupae in the host leaves.

RESULTS AND DISCUSSION

Identity of the pest species was confirmed as *A. rugioeperculatus* in all the host plants as per the descriptions by Martin (2004) and Stocks and Hodges, (2012). Colonies were generally poor in condition with groups of woolly wax puparia untidily grouped under the leaves of the host. RSW adults are lethargic, larger in size as compared to other commonly whiteflies and congregate mostly on abaxial surface of the leaves. The puparium of this species has a pair of small compound pores on each of seventh and eighth abdominal segments, characteristically rugose/corrugated operculum, reticulated dorsal cuticle and acute lingual apex which is easily distinguishable from *A. dispersus* (Sundararaj and Selvaraj, 2017). The identity of the species was further confirmed through amplification of mitochondrial COI gene (658 bp). The COI sequence was matched 99% with the available sequence of *A. rugioeperculatus* (KP032219) submitted from Florida, USA (Dickey *et al.*, 2015) and previously submitted sequence of the same species by NBAIR (Selvaraj *et al.*, 2016). It is closely related to giant whitefly, *A. dugesii* and spiraling whitefly, *A. dispersus* (Stocks and Hodges, 2012).

In the present study, incidence and infestation of RSW on 12 plant species *viz.*, coconut (*Cocos nucifera*), banana (*Musa spp.*), sapota (*Manilkara zapota*), guava (*Psidium guajava*), mango (*Mangifera indica*), Indian almond (*Terminalia catappa*), water apple (*Syzygium samarangense*), ball tree (*Calophyllum inophyllum*), betel vine (*Piper betle*), rubber fig (*Ficus elastica*), butterfly palm (*Dyopsis lute-*

scens) and ruffled fan palm (*Licuala grandis*) was recorded in coastal districts of Karnataka (Table 1; Fig. 1). Among host plants, RSW was found more severe on coconut, banana, almond, *Calophyllum* and sapota plants than other host plants. The infestation ranged from 20-35 % in coconut and 14-26 % in banana. However, the pest was not found in Mysore and Chamrajanagar districts in Karnataka. During our earlier study, RSW was recorded on coconut palm, banana, bird of paradise, custard apple, butterfly palm and oleander in Tamil Nadu, Kerala and Andhra Pradesh (Selvaraj *et al.*, 2016; Sundararaj and Selvaraj, 2017). Francis *et al.* (2016) reported its host ranges of about 118 plant species in 43 families. Similarly, Stocks (2012) and Stocks and Hodges (2012) recorded about 95 host plants in Florida.

Since, the first report of occurrence in August, 2016, the distribution of RSW is expanding over the period time in entire southern states of India. The quick spread might be through transport of seedling, plant materials, tender coconut and vehicle movement. Moreover, the pest was found extending its host ranges at greater level on many cultivated and ornamental plant species due to its polyphagous nature. Severe infestation of the pest was noticed especially in the coastal areas of Mangalore and Udupi.

The pest infestation was very high on Indian almond, coconut, banana and sapota and *Calophyllum inophyllum*. Infestations were extremely dense with almost complete coverage on under surface of leaf with overlapping generation of the pest species. Often, the distinctive egg spirals were seen on leaves but with no developing larvae or pupae on the plant. It has been observed that the females were found to lay eggs on any nearby surface which are not even suitable for subsequent development. The highest honey dew excretion was found in *Calophyllum* and least in Indian almond plant. Similar observation was made by Stocks and Hodges (2012) on black olive and *Calophyllum* in Florida.

Table 1. Host plants of rugose spiraling whitefly recorded in Karnataka

S.NO	Common name	Botanical Name	Family	Remarks
1	Coconut palm	<i>Cocos nucifera</i> (L.)	Arecaceae	Very severe
2	Banana	<i>Musa acuminata</i> Colla, <i>M. balbisiana</i> Colla	Musaceae	Very severe
3	Mango	<i>Mangifera indica</i> L.	Anacardiaceae	Moderate
4	Sapota	<i>Manilkara zapota</i> (L.)	Sapotaceae	Severe
5	India Almond	<i>Terminalia catappa</i> L.	Combretaceae	Very severe
6	Water apple	<i>Syzygium samarangense</i> (Blume) Merr. & L.M.Perry	Myrtaceae	Moderate
7	Laurel ball tree or Punnai	<i>Calophyllum inophyllum</i> L.	Clusiaceae	Very severe
8	Betel vine	<i>Piper betle</i> L.	Piperaceae	Minor
9	Guava	<i>Psidium guajava</i> (L.)	Myrtaceae	Moderate
10	Rubber fig	<i>Ficus elastic</i> Roxb.	Moraceae	Minor
11	Butterfly palm	<i>Dyopsis lutescens</i> (H.Wendl.) Beentje & J.Dransf.	Arecaceae	Severe
12	Ruffled Fan Palm	<i>Licuala grandis</i> (hort. ex W. Bull) H. Wendl.	Arecaceae	Severe

Note: Minor- less than 5%, Moderate-6-10%, Severe -11-20% and very severe- more than 20%



Fig. 1. Host plants a-c). Coconut, d). Sapota, e). Banana, f). Mango, g). Guava, h). Water apple, i-j). Ball tree, k-l). Indian Almond, m). Butterfly palm, n). Ruffled fan palm heavily infested with *Aleurodicus rugioeperculatus* in Karnataka.

Taravati *et al.* (2013) and Francis *et al.* (2016) documented the RSW host plants which include agricultural, horticultural and ornamental plants species in Florida. Selvaraj *et al.* (2016) and Sundararaj and Selvaraj (2017) reported that the severity of infestation ranged 40-60% in coconut and 25-40% in banana.

Nymphs and adults were prolific phloem feeder which suck the sap from the leaves by direct feeding especially on underside of the leaves. Indirectly, adult whitefly excretes excessive honey dew which in turn completely darkened by sooty mold development on the upper surface of leaves which interferes photosynthesis process of the host plants

(Stocks and Hedges, 2012; Taravati *et al.*, 2013; Kumar *et al.*, 2013; Selvaraj *et al.*, 2016). Survey also revealed occurrence of natural parasitism by the parasitoids *Encarsia guadeloupae* Viggiani and *E. dispersa* Polaszek (Hymenoptera: Aphelinidae) (Fig.2). These parasitoids were believed to be fortuitously introduced along with *A. dispersus* into India (Ramani *et al.*, 2002). Adult wasps of *E. guadeloupae* are already reported on RSW (Selvaraj *et al.*, 2016). Furthermore, the COI gene of the parasitoid was amplified, sequenced and matched 99% with the available sequence of *E. guadeloupae* (AY359237) and previously submitted NBAIR sequence (KY223606).

The other parasitoid species bred from RSW, *E. dispersa* has following demarcating characters: body orange-yellow except scuto-scutellar transverse suture distinctly pigmented dark brown-black; antennal scape testaceous, pedicel yellow, flagellum pale yellowish brown, F6 usually darker than rest of flagellar segments. Wings hyaline. Legs, including coxae, yellowish except tarsal apices pale brown. Antennal formula 1133, F1 shorter than pedicel and F2, F2 subequal to F3 (Fig.2). *Encarsia guadeloupae* and *E. dispersa* were recorded as potential parasitoids of many whiteflies including RSW and spiraling whitefly (Ramani *et al.*, 2002; Evans, 2008; Taravati *et al.*, 2013; Francis *et al.*, 2016).

During present studies, percent natural parasitism ranged from 5-15% in coconut, 7-18% in banana and 22-30% in sapota. Besides these parasitoids, other commonly found natural enemies *viz.*, *Stethorus* sp. (Coleoptera: Coccinellidae) associated with mites and *Dichochrysa astur* Banks (Neuroptera: Chrysopidae) were found (Fig.2). Selvaraj *et al.* (2016) enlisted *E. guadeloupae*, *Mallada* spp. and *Cybocephalus* spp. as common natural enemies of RSW in Tamil Nadu, Andhra Pradesh and Kerala, and *E. guadeloupae* was found as a dominant one with highest parasitism (20.0-60.0%). Similarly, Taravati *et al.* (2013) and Francis *et al.* (2016) documented many natural enemies such as parasitoids, *E. guadeloupae*, *E. noyesi*, *Aleuroctonus* spp.; predators *viz.*, *Nephaspis oculata*, *Azya orbiger orbiger*, *Chilocorus cacti*, *Cryptolaemus montrouzieri*, *Delphastus pallidus*, *Harmonia axyridis*, *Hyperaspis bigeminata*, *Cybocephalus* sp. and chrysopid, *Ceraeochrysa* spp. in Florida associated with RSW.

After the accidental introduction of this pest species in India, the pest has spread on many host plants across the peninsular India in a short time which shows the economical importance of the pest. Along with the pest, the natural enemies were also spread almost every place wherever pest occurs. Although, visible reduction in pest population was witnessed across the locations due to action of the apheli-

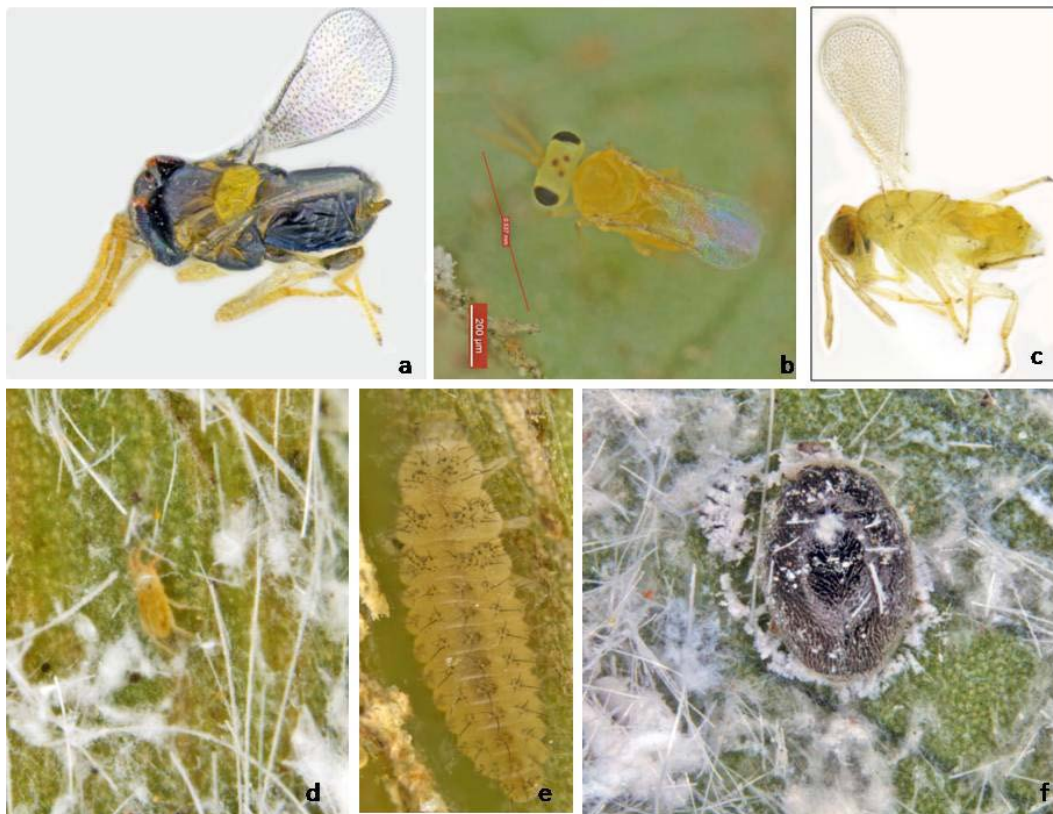


Fig. 2. Natural enemies a). *Encarsia guadeloupae*, b-c). *E. dispersa* d). Predatory mite, e). indeterminate grub f). *Stethorus* sp. associated with mites.

nid parasitoids, however, its population was significantly found less in comparison to pest. Therefore, there is a need to conserve the natural enemies especially *E. goudelou-pae* and *E. dispersa* to suppress the RSW. Further, farmers may be sensitized about the importance of these biocontrol agents and may be advised not to spray any insecticides for the management of RSW which would help in conserving the parasitoids against RSW. Already pesticide holiday has been declared in Tamil Nadu against RSW on coconut and similar strategies may be adopted by other states. Efforts also may be made to mass produce the potential natural enemies in the laboratory and the same may be augmented against RSW.

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