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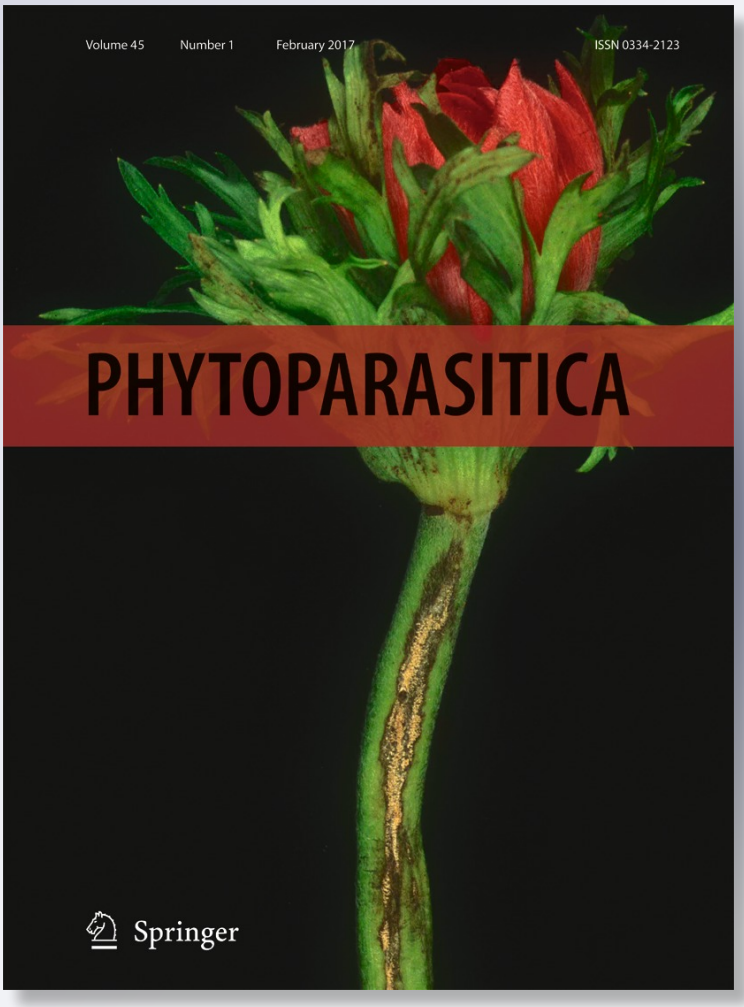
Phytoparasitica

ISSN 0334-2123
Volume 45
Number 1

Phytoparasitica (2017) 45:71-74
DOI 10.1007/s12600-017-0567-0



Springer

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Invasion of rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae): a potential threat to coconut in India

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Received: 12 December 2016 / Accepted: 2 February 2017 / Published online: 16 February 2017

Abstract The invasion and infestation of the Rugose spiraling whitefly (RSW), *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae) on coconut palm (*Cocos nucifera* L.) (Arecales: Arecaceae) in India is reported for the first time from Indian as well as from Oriental region. The severity of its infestations and impact on coconut cultivation in India is discussed.

Keywords Rugose spiraling whitefly · *Aleurodicus rugioperculatus* · Coconut · India · Invasive

The agricultural economy of India is vulnerable to the threat posed from the introduction of exotic pests/diseases. Mandal (2011) listed 116 exotic insect species in India. Among the insect pests, exotic whiteflies have invaded several countries causing direct losses in agriculture, horticulture and forestry. Currently, there are 442 species of whiteflies belonging to 63 genera known from India; of these, a few are economically important. Two invasive whiteflies *viz*., the spiraling whitefly *Aleurodicus dispersus* Russell (Hemiptera: Aleyrodidae) (David and Regu 1995) and the solanum whitefly *Aleurothrixus trachoides* (Back) (Hemiptera: Aleyrodidae) (Dubey and Sundararaj 2015) invaded India in 1995 and 2014, respectively. Recently, an infestation of yet another invasive species, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae), commonly known as the rugose spiraling whitefly (RSW), was observed on coconut palm (*Cocos nucifera* L) in Pollachi, Tamil Nadu, India and the details are provided herein.

The study is based on the puparia of *Aleurodicus rugioperculatus* collected by the junior author and by Mr. John Mahesh, Deejay Coconut Nursery Farm in Pollachi (intensive coconut cultivation), Coimbatore (10° 39′ N; 77° 03′ E), India which were received by the senior author for identification. Subsequently, specimens received for identification from Tamil Nadu Agricultural University, Coimbatore were also studied. The puparia were slide mounted following the method of Dubey and David (2012) and the identity of the whitefly was confirmed. The studied specimens are in the collection of Institute of Wood Science and Technology, Bengaluru, India (IWST) as well as in the ICAR-National Bureau of Agricultural Insects Resources (NBAIR), Bengaluru, India. Further surveys were conducted to assess RSW population and intensity of damage on five randomly selected coconut palms per farm at three strata (upper, medium, lower

Editors' Note: During the editing process of this article, another report on *Aleurodicus rugioperculatus* was published by Shanas et al. (2016) (Shanas S, Joseph J, Tom J, Anju KG (2016) First report of the invasive rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae) from the Old World. Entomon 41: 365-368).

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leaves) at three different locations in Pollachi. The RSW population was determined on five randomly selected leaflets per leaves per palm. The results were presented as mean numbers of nymphs per square cm.

RSW was described from Belize by Martin on coconut (*Cocos nucifera* L) by Martin (2004) and since no illustration of the entire puparium was available, it is illustrated here (Fig. 1a). This species is typically characterised by broadly cordate vasiform orifice, operculum ventro-basally spinulose and dorsally characteristically rugose, with a pair of ventro-median fine setae; lingula head protruding beyond vasiform orifice, finely spinulose, apically acute, its four setae situated close to apex. Anterior marginal, cephalic and first abdominal setae absent, Posterior marginal, and 12 pairs of outer submarginal setae present (including nominal caudal pair); single submedian pairs of pro-, meso, and metathroacic setae and eighth abdominal setae situated fully anterior to vasiform orifice, opposite anterior corners of operculum present. Cephalic and anterior 4 pairs of abdominal compound pores distinct, 2 pairs of much smaller pores present on abdominal segments VII and VIII. Submargin defined by zone of crowded, wide-rimmed pores that stand proud from puparial surface, inner boundary of zone forming mesally-directed lobes, the pore band interrupted immediately posterior to lingular apex. Though the illustration of the species by Martin (2004) showed body reticulation, it was not prominently visible in the mounted slides as it varies with the level of bleaching and reticulation/ tuberculation are known to vary within a species (Dubey et al. 2008). The puparium of this species can be easily distinguishable from *A. dispersus*, the other known species of *Aleurodicus* in India by the presence of a pair of small compound pores on each of abdominal segments VII and VIII, characteristically rugose operculum and atypically narrowly acute lingula apex.

Subsequently, it was reported as a pest on gumbo limbo (*Bursera simaruba* L) in Miami-Dade county (South Florida) in 2009 by Florida Department of Agriculture and Consumer Services (FDACS), which referred to it as the gumbo limbo spiraling whitefly. This pest has been classified as the serious threat for coconut palm including many other host plants in Florida (Stocks and Hodges 2012; Kumar et al. 2013). This whitefly is believed to have originated from Central America and its incidence limited to Belize, Mexico, Guatemala and Florida in Central and North America (Evans 2008). In Florida (USA), it has been found in Broward, Collier, Indian River, Lee, Martin, Miami-Dade, Monroe, Palm Beach, Polk, and St. Lucie counties (Taravati et al. 2013). Recent reports suggest it has invaded Orlando, located in central Florida. Based on its dispersal potential, RSW may establish in eight other adjacent counties of Florida in the near future (Kumar et al. 2013). Based on records from 2009 to 2015, RSW has been identified on at least 118 host plants. These hosts included edible plants, ornamentals, palms, fruits and weeds of both native and non-native species (Mannion 2010; Stocks 2012; Francis et al. 2016). Until now, it has not reported from Oriental region, therefore, this record represents its first record of its presence in India as well as in the Oriental region.

Initially, this whitefly was observed in several coconut farms in the Coimbatore district, Tamil Nadu, India during the month of September, 2016. Subsequently, the whitefly population increased greatly and spread across the coconut palm growing areas of Pollachi region mostly on high yielding hybrid varieties of coconuts. The infestation was very severe (Fig. 1b, c, d) on lower leaves as compared to that of the middle and upper young leaves in dwarf and hybrid coconut palm which are about 4 to 6 years old. Populations completely covered some leaflets and were even observed on the inflorescence, pedicle and exocarp which resulted in a reduction in fruit set and nut yield/tree. Population (immature stages) ranged from 18 to 37 nymphs/cm^2 of leaflet (Fig. 1c). The infestation resulted in the premature drying of leaflets (Fig. 1d). RSW adults are about three times larger (approx. 2.5 mm) than the commonly found whiteflies and are lethargic by nature. It is closely related to giant whitefly, *Aleurodicus dugesii* Cockerell. RSW adults can be distinguished by their large size and the presence of a pair of irregular light brown bands across the wings. Males have long pincer like structures at the end of their abdomen (Stocks and Hodges 2012) (Fig. 1e). The continuous dry spell, availability of host plants in large area and absence of natural enemies might have favoured its multiplication.

Coconut plays a significant role in the agrarian economy of India and is the third largest producer of coconut with 19.20% share of the world's production. It is grown on 1.94 million ha in 19 states and 3 Union Territories of India producing 15,730 million nuts with an average productivity of 44.27 nuts/ palm/ year (NABARD 2016). An eriophid mite, the rhinoceros beetle, red palm weevil, black headed caterpillar and white-grub are considered as the major pests of coconut in India while

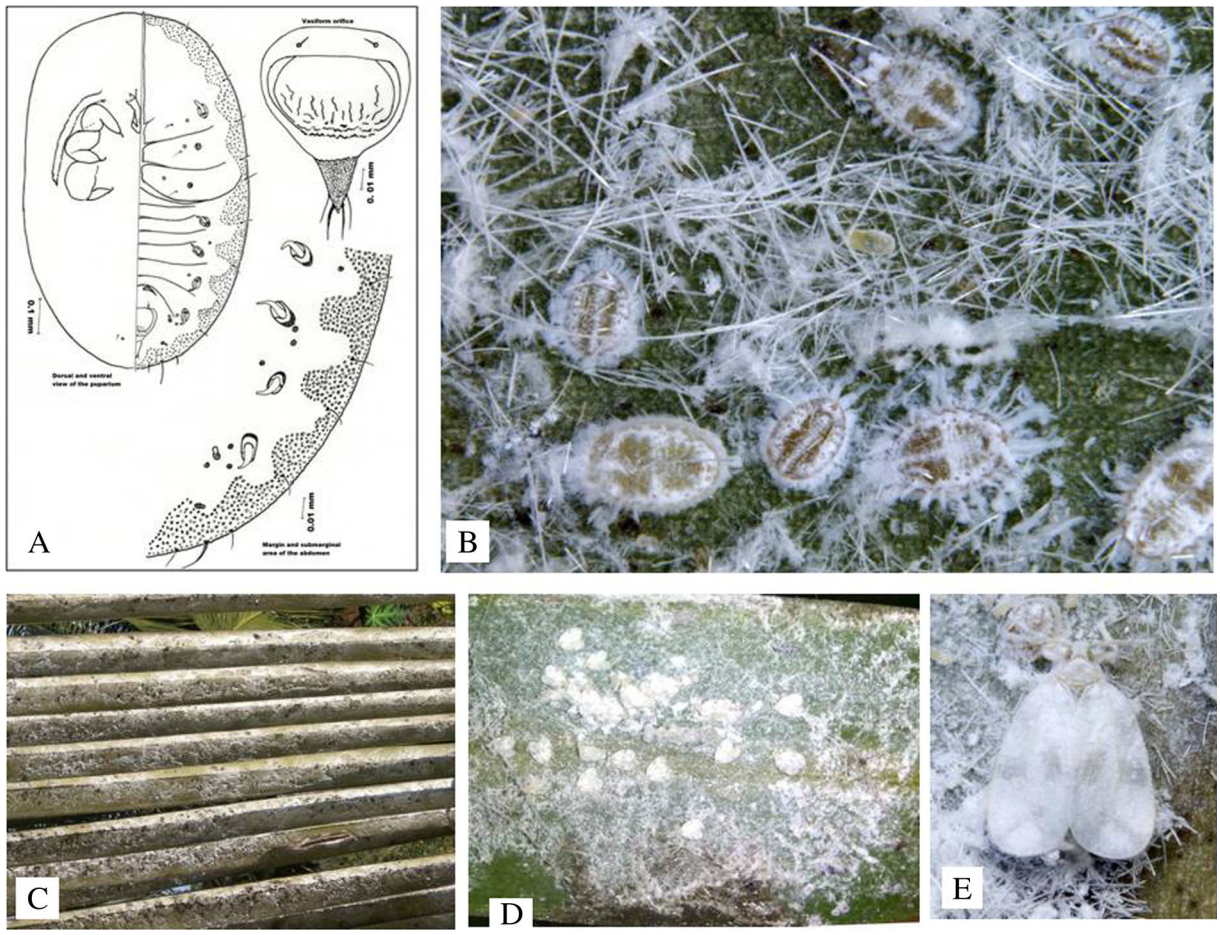

Fig. 1 Rugose spiraling whitefly: **a**. Line diagram; **b**. Nymphs of leaflet; **c**. Severity of infestation; **d**. Drying of leaflet; E. Habitus adult

the two whiteflies viz., *Aleurocanthus arecae* David and Manjunatha (Hemiptera: Aleyrodidae) and *Aleurodicus dispersus*, recorded on coconut in India are considered as minor pests (Josephrajkumar et al. 2012). The invasion and establishment of RSW will further jeopardize the coconut industry in India in terms of reduction in coconut production, quality of nuts and increased production cost due to more insecticides application for management of the pest. Currently, it has only been found in Tamil Nadu, but is likely to spread to other coconut growing coastal states as well as on other potential host plants in the country. The current incidence of RSW in India is alarming due to its polyphagous nature and hence it has a great potential to extend its host range and spread to other coconut growing countries in the Oriental region. Non-native species can achieve invasive pest status when they are accidentally introduced to areas where they are separated from their natural enemies and if local (indigenous) beneficial species (predators and/or parasitoids) are unable to suppress pest population (Duan et al. 2015). Therefore, a holistic approach is needed for the adaptation of rapid response strategies against its invasion by educating farmers, creating awareness and extension entomologists working along with other stakeholders. A coordinated programme involving coconut growing countries to contain its spread and develop suitable management strategies is needed.

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