

Recent Exotic Invasive Whiteflies Succession in Coconut

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Coconut *Cocos nucifera* L. (Arecaceae) is an important plantation crop and millions of people depend on this directly or indirectly for their livelihood. India is one of the leaders in coconut farming and stands third largest coconut producing country in the world. In India, coconut is cultivated in 2.17 million ha with production of 20,308 million nuts with an average productivity of 9,345 nuts/ha during 2019-2020. Among all the coconut producing states, Tamil Nadu, Kerala, Karnataka and Andhra Pradesh are the leading coconut producing states which account for more than 90% of the total coconut produced in the country.

The coconut palm is attacked by several insect and mite pests all around the year from the seedling stage to matured palm. Among them, Eriophid mite, *Aceria guerreronis* Keifer, rhinoceros beetle, *Oryctes rhinoceros* L, red palm weevil, *Rhynchophorus ferrugineus* Olivier, black headed caterpillar, *Opisina arenosella* Walker and white-grub, *Leucopholis coneophora* Burmeister are considered as the major pests of coconut. While the two whiteflies viz., areca nut whitefly, *Aleurocanthus arecae* David and Manjunatha and invasive spiralling whitefly, *Aleurodicus dispersus* Russell recorded on coconut in India are considered as minor pests (Josephraj Kumar et al., 2012) (Fig.1). Since 2016, coconut ecosystem is facing continuous succession of several invasive whiteflies causing great threat to its production and productivity.

Between 2015-2019, the following four exotic, highly polyphagous whiteflies viz., rugose spiralling whitefly, *Aleurodicus rugipercolatus* Martin during

2016 (Sundararaj and Selvaraj, 2017); Bondar's nesting whitefly, *Paraleyrodes bondari* Peracchi during 2018 (Josephraj Kumar et al., 2019); nesting whitefly, *P. minei* Iaccarino during 2018 (Mohan et al., 2019) and palm infesting whitefly, *Aleurotrachelus atratus* Hempel during 2019 (Selvaraj et al., 2019) invaded rapid succession on coconut. These invasive species are native to the Neotropical region, mostly from Central America and the Caribbean.

The most insidious spread of these species in India is likely mediated by humans through the movement of infested seedlings and planting materials. Extensive surveys revealed that these species spread rapidly in the large geographical region of India mostly through transportation of infested seedlings. Extensive spread along the coastal regions and gardens near the backwater of India is predicted owing to the favorable weather factors and availability of host plants. Species of exotic whiteflies with similar habits co-exist in more or less the same niche and have a similar pattern of growth and development.

Systematic and continuous surveys were conducted from January 2016 to December, 2021 in different states viz., Karnataka, Tamil Nadu, Kerala, Andhra Pradesh, Maharashtra, West Bengal, Goa, Maharashtra, Telangana, Meghalaya, Gujarat and Lakshadweep islands of India to investigate the spatial range, host range, patterns of co-occurrence, intensity of infestation of whiteflies and their natural enemies in India. To study the distribution of these invasives at least 5-10 locations in each district and 5-12 districts in each state were chosen for sampling. Pest occurrence was recorded in each location and

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Fig. 1. Infestation of *Aleurodicus dispersus* and *Aleurocanthus arcae* on coconut

their damage was categorized into different grades by visual observation on all the active/live life stages.

An assessment of their population level was carried out using the following qualitative scale i.e Low (=less than 10 live egg spirals or adults/leaflet), moderate = (11-20 live egg spirals or adults/leaflet) and severe= (more than 20 live egg spirals or adults/leaflet). The coexistence of these invasive whiteflies with other insect species at each location was also determined. Part of infested with immature stages and puparium were placed in rearing jar (21×10 cm) for the emergence of parasitoids. The diagnostic characteristics, distribution, symptoms of damage, co-occurrence, associated natural enemies and management strategies with special reference to biological control are briefed in details.

1. Spiralling whitefly, *Aleurodicus dispersus* Russell

Distribution: Spiralling whitefly, *Aleurodicus dispersus* is the first invasive whitefly to India which is native to the Caribbean islands in Central America and the species was first found on coconut in Florida. In India, it was first reported in 1993 in Kerala and later, it was reported in Tamil Nadu, Karnataka, Maharashtra, Lakshadweep, Orissa and North East Region in India. Presently this pest is almost distributed throughout the country on many horticultural, plantation and avenue plantation.

Host plants: *Aleurodicus dispersus* is highly polyphagous affecting on a wide range of host plants and is known to feed on 320 plant species belonging to 225 genera and 73 families. In coconut, the pest occurs in sporatically and its infestation mostly negligible to low reported.

Diagnostic characteristics: Presence of spiralling mealy wax, white waxy flocculens materials and dark sooty mould on infested plants. Nymphs and adults are congregated generally on the lower surface of leaves and secrete copious white, waxy flocculent materials which are readily spread elsewhere by wind and create a very unsightly nuisance (Fig.2). By sucking the sap which depletes nutrients and water from host plants and causes premature drying under severe infestation. Sticky honeydew is excreted which serves as a substrate for dense growth of sooty mould which may interfere with photosynthesis. Female whitefly lays elliptical, smooth surfaced yellowish white eggs in a typical spiral pattern. There are four nymphal instars, which are greenish, white and oval which are covered with heavy white wax material. Adults are larger coated with a fine dust like waxy secretion and fore wings with characteristic dark spots and live for 13 to 22 days (Fig.2).



Fig.2. Life stages of *Aleurodicus dispersus* and its infestation on coconut

2. Rugose spiralling whitefly, *Aleurodicus rugiperculatus* Martin

Distribution: Rugose spiralling whitefly was described from coconut in Belize and believed to have originated from Central America. In India, its incidence was recorded on coconut during 2016 at Pollachi, Tamil Nadu. Subsequently it has spread to different districts of Karnataka, Kerala, Andhra Pradesh, Goa, Assam and West Bengal, Lakshadweep islands, Maharashtra, Gujarat, Telangana, Odisha, Chhattisgarh, and few districts of Meghalaya (Fig.3).

Host plants: Rugose spiralling whitefly is a highly polyphagous pest reported to feed on about 120 plant species including economically important cultivated crops and palms. In India, Rugose spiralling whitefly was found to feed on about 45 host plants. Pest prepares to feed on plants under Arecaeae family. Pest incidence was severe in dwarf as well as hybrid coconut palms. Infestation of rugose spiralling



Fig.4. Diagnostic characters of rugose spiralling whitefly

whitefly reaches to outbreak situation especially during summer months if necessary management strategies are not initiated on time.

Diagnostic characteristics: The typical concentric waxy spiraling symptoms are noticed on various parts of host plants including on leaf petiole and tender nuts. Nymphs and adults suck the sap from the leaves by direct feeding especially on the underside of the leaflets. Adults excrete the prodigious quantities of honey dew which in turn completely is darkened by the development of sooty mold on the upper surface of leaves and also on understory crops (Fig.4). Waxy flocculent material produced by nymphs and adults causes' nuisance to human being in heavily infested areas.

Adults are about three times larger than the commonly found whiteflies and are lethargic by nature. Adults can be distinguished by the presence of a pair of irregular light brown bands across the wings. Males have long pincer-like structures at the distal end of the abdomen. This whitefly is closely related to the giant whitefly, *Aleurodicus dugesii* Cockerell.

3. Bondar's nesting whitefly, *Paraleyrodes bondari* Peracchi

Distribution: *Paraleyrodes bondari* described on citrus from Brazil in 1971 and this species is native to the Neotropical region. It was first reported in India on coconut palms in Kerala during 2018 (Josephraj Kumar et al., 2019), Karnataka and The Andaman & Nicobar Islands, Lakshadweep islands, Tamil Nadu and Andhra Pradesh.

Host plants: *Paraleyrodes bondari* is a polyphagous species that has been reported to feed on more than 25 host plants including coconut.



Fig. 5. Diagnostic characters of *Paraleyrodes bondari*

Diagnostic characteristics: *Paraleyrodes bondari* adult are smaller than *Aleurodicus rugioperculatus* and it constructs nests with loosely woven, irregular layer of fiberglass-like woolly wax strands. Adults lay yellowish stalked eggs in clusters in the woolly wax nest without wax covering. Early instar nymphs are creamy yellow, transparent, oval shaped and absolutely flat. Excessive de-sapping by the adults and nymphs in severe condition produces honey dew leading to deposits of sooty mould on plant surface which may affect the photosynthetic efficiency.

The feeding damage is not so intense like rugose spiralling whitefly with minimal honey dew excretion and sooty mould deposits. Adult whiteflies are with in dull yellow body with whitefly wings. Two oblique grey bands occur on each forewing, and converge toward the midline is such that it appears to form an "X"-pattern (Fig.5).

Nesting whitefly, *Paraleyrodes minei* Iaccarino

Distribution: *Paraleyrodes minei* Iaccarino described from Syria on citrus in 1990 is considered a native of the Neotropical region. In India, it was reported on coconut in Kerala during 2018 (Mohan et al., 2019) and in Andaman & Nicobar Islands, Karnataka, Tamil Nadu.

Host plants: Nesting whitefly is highly polyphagous and found to colonize on more than 35 plants including coconut palm.

Diagnostic characteristics: *Paraleyrodes minei* nymphs and adults feed from abaxial leaf surface and produce honeydew which in turn leads to sooty mould deposits and interfere with photosynthetic efficiency of the palms. Female adults constructs loosely woven, woolly wax nest and this characteristic feature helps in differentiating nesting whitefly from the Bondar's nesting whitefly that constructs



Fig.6. Infestation of nesting whiteflies on coconut

conspicuous dense woolly wax nest (Fig.6). Eggs are cream-coloured laid in clusters with short stalks that turn slight pinkish upon eclosion on the lower surface of leaflets bending inwards towards the leaf surface.

4. Palm infesting whitefly, *Aleurotrachelus atratus* Hempel

Distribution: This is a Neotropical whitefly, originally described by Hempel from Brazil and distributed in Africa, North America, South America, Central America, the Caribbean and Europe. In India, this pest was first recorded on coconut and ornamental palms during 2019 in Mandya district of Karnataka (Selvaraj et al., 2019) and subsequently spread to other districts in Karnataka and Tamil Nadu.

Host plants: Palm infesting whitefly colonizes on more than 110 plant species including coconut. In India, so far it was found to feed on coconut, areca nut, oil palm and ornamental areca palm belonging to Arecaceae family.

Diagnostic characteristics: *Aleurotrachelus atratus* colonizes on the under surface of leaflets in groups and produce white wax mass from second nymphal instar onwards. Both nymphs and adults suck the sap continuously and deplete nutrients from host plants resulting in necrosis, loss of vigour, drying and drooping of leaflets. Indirect damage is caused by the excreted honeydew that serves as a medium for the growth of sooty mould (Fig.7).

Eggs are stalked and laid in semicircular pattern in groups, initially creamy white and turn to black before hatching. All the nymphal instars are black in colour with a long marginal white wax fringe and filaments completely cover the pupae. Adults differ from the other invasive whiteflies infesting palms; smaller than *A. rugioperculatus* but larger than *P. bondari* and *P. minei* and without any wavy marking on the wings.

Co-existence of whiteflies in coconut: *Aleurodicus rugioperculatus* co-existing with *Aleurotrachelus*



Fig.7. Infestation of *Aleurotrachelus atratus* on coconut

atratus, *P. bondari*, *A. dispersus* and *P. minei* were observed to simultaneous coexistence on coconut. Infestations of *A. atratus* and *A. rugioperculatus* along with *Aleurocanthus arecae*, a native whitefly species were commonly observed on coconut (Fig.8). Such co-occurrence has been observed among these invasive species, in which one species occupies the breeding and feeding niche of another species under optimum weather parameters and attempts to displace one or more of its competitors gradually which leads to temporal variation.

Natural enemies of the invasive whiteflies: Explorative surveys revealed the occurrence of several biological control agents to develop the biocontrol strategies for management of these invasive whiteflies. Two parasitoids, *Encarsia guadeloupae* Viggiani and *E. dispersa* Polaszek (Hymenoptera: Aphelinidae) were found to colonize *A. dispersus* and *A. rugioperculatus* (Fig.9). Among, *Encarsia guadeloupae* was the dominant parasitoid which parasitized 62-95% and 56-82% of *A. dispersus* and *A. rugioperculatus*, respectively whereas *E. dispersa* parasitized 28-92% and 5-10% of *A. dispersus* and *A. rugioperculatus*, respectively. Predators such as *Pseudomallada astur* (Neuroptera: Chrysopidae), *Jauravia pallidula*, *Cheilomenes sexmaculata* (Coleoptera: Coccinellidae) and *Cybocephalus indicus* (Coleoptera: Nitidulidae) were also observed to be feeding on *A. rugioperculatus*, *A. atratus* and *A. dispersus* (Fig.9). In addition, entomopathogenic fungi, *Isaria fumosorosea* (Hypocreales: Clavicipitaceae) was found to be effective against *A. rugioperculatus*, *P. bondari*, *P. minei* and *A. atratus*. Neither parasitoids nor native predators were recorded for the other invasive whitefly species.

Economic importance of invasive whiteflies in coconut: Invasive whiteflies pose a challenge to the Indian economy as biologists and the public worldwide increasingly recognize the damage caused by invasive non-indigenous species. Non-native species can achieve major pest status when they



Fig.8. Co-existence/co-occurring of whiteflies in coconut



Fig. 9. Natural enemies associated with invasive whiteflies infesting coconut

are accidentally introduced to new locations and are separated from their natural enemy complexes. Coconut is an important crop grown mainly in the tropical and subtropical regions of the world. Host preference of these invasive whiteflies towards coconut in the country of their origin leads to quicker establishment on these host plants in the newly introduced regions. Out of the eight invasive species new to India, *A. dispersus*, *A. rugioperculatus*, *A. floccosus*, *P. bondari* and *P. minei* were found to infest coconut.

The global invasive species program proposes three major management options: prevention, early detection, and eradication for the management of alien species. Prevention of an invasion is the most economical option as it contains pest to spread to neo geographical regions. Post incursion management mostly through timely implementation of classical biocontrol programme using potential natural enemies by importation. Fortunately, most of such invasions, especially those of hemipteran species of the suborder Sternorrhyncha, which includes whiteflies, scale insects, aphids are amenable for classical biological control. Effective biological

control programme has been implemented for *A. rugioperculatus* and *A. dispersus* resulting in saving millions of rupees by mitigating their adverse impacts on agriculture.

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Obituary



Dr. M Aravindakshan, former Chairman of Coconut Development Board expired on 27th December 2021. He was the Chairman of the Board for two years from September 1995. As the Chairman of the Board, he was instrumental in the implementation of various coconut development programmes during the 8th Plan period and has played a significant role in formulating schemes of the Board for the 9th Plan period. Prior to his appointment as Chairman, CDB he was employed with Kerala Agriculture University in various posts for 28 years. Dr. M Aravindakshan did his post doctoral training in the University of Hawaii, USA during 1995. He was the visiting professor of the University of Paraiba, Brazil during 1979-80. Dr. M. Aravindakshan had over 40 years of experience in teaching, research and extension activities in tropical horticulture.