



## Invasion and establishment of Bondar's nesting whitefly, *Paraleyrodes bondari* Peracchi (Hemiptera: Aleyrodidae) in Indian mainland and Andaman and Nicobar Islands

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**ABSTRACT:** Invasion and establishment of Bondar's nesting whitefly, *Paraleyrodes bondari* Peracchi in Indian mainland and Andaman & Nicobar Islands is reported. This forms the first report of *P. bondari* from Andaman & Nicobar Islands. Host range of Bondar's nesting whitefly in India is discussed. Partial sequence of cytochrome *c* oxidase I gene for *P. bondari* is submitted to GenBank (MK333262). © 2019 Association for Advancement of Entomology

**KEYWORDS:** Bondar's nesting whitefly, *Paraleyrodes bondari*, India, invasive species

Plants, animals, and microbes are introduced more frequently into regions that had never hosted them in an increasingly globalized world (Venkataraman *et al.*, 2016). The agricultural economy in India is vulnerable to threat from exotic pests and there are 116 alien insect species (Mandal, 2011). Among the insect pests, globally over the past 25 years, exotic whiteflies invaded several countries causing direct losses in agriculture, horticulture and forestry. Such reported invasive whiteflies in India are the spiraling whitefly, *Aleurodicus dispersus* Russell, which is known to breed on 320 host plants belonging to 225 genera and 73 families (Sundararaj and Pushpa, 2012); solanum whitefly, *Aleurothrixus trachoides* (Back) reported to breed on 24 plant species including medicinal plants (Sundararaj

*et al.*, 2018) and rugose spiraling whitefly (RSW), *Aleurodicus rugioperculatus* Martin that invaded in 2016 (Shanas *et al.*, 2016; Sundararaj and Selvaraj, 2017) and found breeding on more than 20 host plants including coconut. In December 2018, Central Plantation Crops Research Institute (CPCRI) recorded two exotic whitefly species, *Paraleyrodes bondari* Peracchi and *P. minei* Iaccarino on coconut palms of Kerala and issued a pest alert (CPCRI, 2019).

The present study is based on the whiteflies collected from Karnataka during April 2018, Kerala during October-November 2018 and Andaman and Nicobar Islands during May 2017 and November 2018 on different host plants (Table 1). Both

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conventional taxonomy as well as cytochrome *c* oxidase I (COI) based molecular method were followed for species identification. Mounted puparia and male adults were studied for morphological identification. Observations, micro-measurements and photomicrographs were made by using Nikon Optiphot T-2 EFD (Japan) and Labomed LX400 microscope at Andaman and Nicobar Regional Centre, Zoological Survey of India, Port Blair and the identity of the whitefly was confirmed. Molecular identification was done after the extraction of DNA from adult insect using Qiagen DNeasy® Kit, following the manufacturer's protocols. PCR amplification of 5' end of the COI gene was carried out following standard protocols. The amplified product was sequenced by Sanger sequencing method at AgriGenome Labs. Pvt. Ltd., Kochi, Kerala. Based on the morphological and molecular methods, the species was identified as *P. bondari*.

**Diagnosis:** Genus *Paraleyrodes* is physically much smaller than most other aleurodicines; puparium with 5 or 6 compound pores in which the anterior 1 or 2 pairs much smaller than the remaining 4 abdominal pairs and the cephalic pair; thorax with two pairs of cicatrices and a pair of submedian setae; outer submargin with a row of 14 pairs of hair-like setae. Adults with all wing veins unbranched; females have 4 articulated antennal segments; males have only 3 articulated antennal segments and complex aedeagal apices. The larvae and puparia secrete long waxy filaments that often form an annulus surrounding the feeding insects. Adults remain inside a nest like mealy wax and females usually secrete so much wax around them while ovipositing and hence the members of this genus are appropriately known as “nesting whiteflies” (Martin, 2004).

The puparia of *P. bondari* are characterized by the presence of 14 pairs of submarginal setae and

Table 1. Host plants of *Paraleyrodes bondari* in India

Plant species	Host family	Economic importance	Distribution	Whiteflies intermingled on infested leaf
<i>Annona</i> sp.	Annonaceae	Fruit crop	Kerala	<i>Pealius nagerkoilensis</i> Jesudasan & David
<i>Artocarpus heterophyllus</i>	Moraceae	Fruit crop	Kerala	<i>Dialeuropora decempuncta</i> Quaintance & Baker
<i>Bridelia retusa</i>	Euphorbiaceae	Medicinal and Timber	Kerala	-
<i>Capsicum annum</i>	Solanaceae	Spice crop	Kerala	<i>Aleurodicus dispersus</i> Russell
<i>Cinnamomum verum</i>	Lauraceae	Spice crop	Andaman & Nicobar Islands	-
<i>Cocos nucifera</i>	Arecaceae	Plantation crop	Kerala	<i>Aleurodicus rugioperculatus</i> Martin
<i>Leucaena leucocephala</i>	Fabaceae	Fodder and Paper pulp	Karnataka	<i>Tetraleurodes acaciae</i> (Quaintance)
<i>Macaranga peltata</i>	Euphorbiaceae	Timber	Kerala	<i>Dialeuropora decempuncta</i> Quaintance & Baker <i>Martiniella fletcheri</i> Sundararaj & David
<i>Mangifera indica</i>	Anacardiaceae	Fruit crop	Kerala	-
<i>Morinda citrifolia</i>	Rubiaceae	Medicinal plant	Karnataka	<i>Dialeurodes kirkaldyi</i> (Kotinsky)
<i>Musa</i> sp.	Musaceae	Fruit crop	Kerala	<i>Aleurodicus dispersus</i> Russell
<i>Psidium guajava</i>	Myrtaceae	Fruit crop	Kerala	<i>Aleurodicus dispersus</i> Russell
<i>Tectona grandis</i>	Verbenaceae	Timber	Kerala	<i>Martiniella fletcheri</i> Sundararaj & David

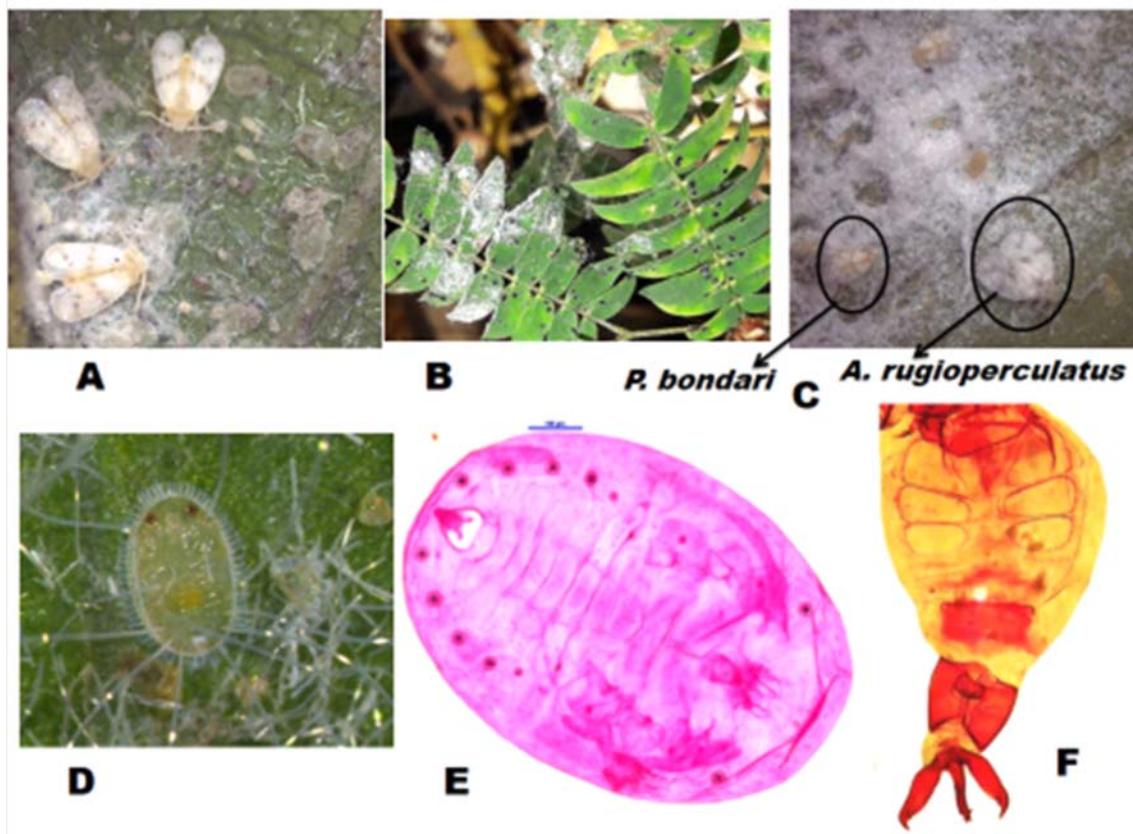


Fig. 1. A-D. Infestation of *P. bondari* on different host plants, A. on *Annona* sp.; B. on *Leucaena leucocephala* along with *Tetraleyrodes acaciae*; C. on *C. nucifera* along with *A. rugioeperculatus*, D. III instar nymph on *M. citrifolia*, E. Mounted puparium, F. Abdomen with claspers and aedeagus

anterior two of six abdominal compound pores reduced in size and with a rim of chitinous splines (Fig. 1E). In life, the adult fore-wings are with two rows of mottlings. The aedeagus of *P. bondari* is unique and easily distinguishable from other *Paraleyrodes* species in having three subapical aedeagal process of which two are in one direction and one opposite to them, and one process near mid-length of it (Fig. 1F).

The partial COI sequence of *P. bondari* generated was submitted to GenBank and received the accession number (MK333262). Homology search of sequence generated with NCBI database showed 100 per cent similarity with *P. bondari* accessions from Uganda (MH178372) and Florida (KP032215), which confirmed the identity of the species.

*Paraleyrodes bondari* was found to infest both monocot and dicot plants and host range from India

include 13 plants (Fig.1A-D). The whitefly usually infests the lower surface of leaves, but occasionally occurs on upper surfaces. Sooty mould was found in association with the infested plant leaves. In Kerala, *P. bondari* was found infesting economically important plants like coconut, banana, guava, teak etc. On guava and banana, it was found infesting along with another invasive spiraling whitefly, *A. dispersus* whereas on coconut, it was found with the invasive whitefly, *A. rugioeperculatus*. In many instances, population of *P. bondari* was more (8.04 nymphs per 30 cm leaflet) than that of *A. rugioeperculatus* (4.4 nymphs per 30 cm leaflet) on coconut. In Karnataka, it was found infesting subabul (*Leucaena leucocephala*) along with *Tetraleyrodes acacia* (Quaintance), and *Morinda citrifolia* along with *Dialeurodes kirkaldyi* (Kotinsky). However, in Nicobar Islands *P. bondari* was found to infest alone on *Cinnamomum verum*.

The whitefly fauna of India comprises 455 species under 66 genera in which the subfamily Aleyrodinae Westwood is represented by 64 genera and the subfamily Aleurodicinae Quaintance & Baker by 2 genera *viz.*, *Aleurodicus* Douglas and *Palaealeurodicus* Martin. The genus *Aleurodicus* is represented by *A. dispersus* and *A. rugioferulatus*, both invasive to India. The other genus *Palaealeurodicus* is represented by three species. David and Dubey (2006) reported 20 species of whiteflies from Andaman Islands, but no whitefly records from the Nicobar Islands. Thus, it is the first report of a whitefly from the Nicobar Island, the Great Nicobar Biosphere Reserve. The occurrence of nesting whitefly was noticed in Bhati Basti, Port Blair, Andaman during May 2017. This indicates possible route of invasion of *P. bondari* to India. Geographically, the Andaman & Nicobar Islands are placed close to Indonesia than mainland India. Occurrence of *P. bondari* in these islands indicates possible availability of this species in neighboring countries. The invasion and establishment of *P. bondari* in India brings the total number of genus under the subfamily Aleurodicinae known from India to three and the number of species to six.

*Paraleyrodes* Quaintance is a Neotropical genus which comprises 17 species in the world (Martin and Mound, 2007). *Paraleyrodes bondari* was first described in 1971 on *Citrus* species from Brazil (Peracchi, 1971). It may be assumed that this species occurred in the Neotropical region only till 1990s. Later, it was recorded from Madeira during 1995 (Martin, 1996), then spread to Oriental region, and in 1998 reported as a pest of fruit trees from Taiwan on host trees of 17 families (Wen and Chen, 2001). This species had spread to Hawaii by around 2003 (Stocks, 2012). Florida Department of Agriculture and Consumer Science gave a 'pest alert' for *P. bondari* as a new pest of *Ficus* species in 2011 (Stocks, 2012), though it was known earlier from Florida and California (Martin, 2004). Omango *et al.* (2018) reported that *P. bondari* was present in Uganda on cassava from 2006. *Paraleyrodes* present in the Old World may be introductions of New World species into this region (Evans, 2007).

*Paraleyrodes bondari* is establishing invasive pest status in India as it infests on economically important fruit/ medicinal crops and timber yielding trees and also on many alternative hosts. Unlike *A. rugioferulatus*, where 50 to 60 per cent natural parasitisation by *Encarsia guadeloupae* Viggiani (Hymenoptera: Aphelinidae) was reported (Shanas *et al.*, 2016), no parasitisation was noticed on *P. bondari*. The invasion of this species to India corroborate the comment of Martin (2004) that within the genus *Paraleyrodes*, *P. minei* and *P. bondari* are most geographically mobile species. Its breeding in association with other whiteflies on many hosts confirms the fact that members of this genus have a marked propensity for ovipositing amongst the puparia or colony remains of other whitefly species (Martin, 2004). *Paraleyrodes bondari* may cause economic loss for horticulture farmers and tree growers due to its polyphagous nature coupled with unexplored native parasitoids. Further, there is a spurt in the invasion of exotic whiteflies to India. Hence, efforts must be undertaken for the prevention /management of alien whitefly species on a long-term basis and strengthening of the plant quarantine measures.

## REFERENCES

- CPCRI (2019) Pest alert - A new invasive Bondar's nesting whitefly reported on coconut from Kerala, India and First record of invasive nesting whitefly, *Paraleyrodes minei* Iaccarino (Homoptera: Aleyrodidae). [http://www.cpcri.gov.in/images/images/news/ICAR-CPCRI/PestAlert/Paraleyrodes\\_bondari1.pdf](http://www.cpcri.gov.in/images/images/news/ICAR-CPCRI/PestAlert/Paraleyrodes_bondari1.pdf) and [http://www.cpcri.gov.in/images/images/news/Pest\\_alert/whitefly.pdf](http://www.cpcri.gov.in/images/images/news/Pest_alert/whitefly.pdf) (Accessed on 14 January 2019).
- David B. V. and Dubey A. K. (2006) Whitefly fauna of Andaman and Nicobar Islands, India with description of a new species. *Entomon* 31(3): 191–205.
- Evans G. A. (2007) The whiteflies (Hemiptera: Aleyrodidae) of the world and their host plants and natural enemies. [http://keys.lucidcentral.org/keys/v3/whitefly/PDF\\_PwP/ETC/world-whitefly-catalog-Evans.pdf](http://keys.lucidcentral.org/keys/v3/whitefly/PDF_PwP/ETC/world-whitefly-catalog-Evans.pdf) (Accessed on 1 December 2018).
- Mandal F. B. (2011) The management of alien species in India. *International Journal of Biodiversity and Conservation* 3(9): 467–473.

- Martin J. H. (1996) Neotropical whiteflies of the subfamily Aleurodicinae established in the western Palearctic (Homoptera: Aleyrodidae). *Journal of Natural History* 30: 1849–1859.
- Martin J. H. (2004) Whiteflies of Belize (Hemiptera: Aleyrodidae). Part 1—Introduction and account of the subfamily Aleurodicinae Quaintance & Baker. *Zootaxa* 681: 1–119.
- Martin J. H. and Mound L. A. (2007) An annotated checklist of world's whiteflies (Insecta: Hemiptera: Aleyrodidae). *Zootaxa* 1492: 1–84.
- Omongo C. A., Namuddu A., Okao-Okuja G., Alicai T., van Brunschot S., Ouvrard D. and Colvin J. (2018) Occurrence of Bondar's Nesting Whitefly, *Paraleyrodes bondari* (Hemiptera: Aleyrodidae), on cassava in Uganda. *Revista Brasileira de Entomologia* 62: 257–259.
- Peracchi A. L. (1971) Dois aleirodideos pragas de *Citrus* no Brasil (Homoptera, Aleyrodidae). *Arquivos do Museu Nacional, Rio de Janeiro* 54: 145–151.
- Shanas S., Job J., Joseph T. and Krishnan G. A. (2016) First report of the invasive rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae) from the Old World. *Entomon* 41 (4): 365–368.
- Stocks I. C. (2012) Pest Alert: Bondar's Nesting Whitefly, *Paraleyrodes bondari*, a whitefly (Hemiptera: Aleyrodidae) new to Florida attacking *Ficus* and other hosts, [https://www.freshfromflorida.com/content/download/68185/1612813/Pest\\_AlertParaleyrodes\\_bondari,\\_Bondar's\\_Nesting\\_Whitefly.pdf](https://www.freshfromflorida.com/content/download/68185/1612813/Pest_AlertParaleyrodes_bondari,_Bondar's_Nesting_Whitefly.pdf) (Accessed 22 Nov 2014).
- Sundararaj R. and Selvaraj K. (2017) Invasion of rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae): a potential threat to coconut in India. *Phytoparasitica* 45: 71–74.
- Sundararaj R., Amuthavalli T. and Vimala D. (2018) Invasion and establishment of the solanum whitefly *Aleurothrixus trachoides* (Back) (Hemiptera: Aleyrodidae) in South India. *Current Science* 115 (1): 29–31.
- Sundararaj R. and Pushpa R. (2012) *Aleurodicus dispersus* Russell - The invasive spiraling whitefly, (Hemiptera: Aleyrodidae). In: *The Whitefly or Mealy wing Bugs: Bioecology, Host specificity and Management.* (Ed, Vasantharaj David), Lambert Academic Publishing, Germany, pp. 20–57.
- Venkataraman K., Raghunathan C., Satyanarayana C. and Rajkumar R. (2016) Invasion of Snowflake Coral, *Carijoariisei* (Duchassaing & Michelotti, 1860), in Indian Seas: Threats to Coral Reef Ecosystem. *Indian Journal of Geo Marine Sciences* 45 (11): 1403–1408.
- Wen H.C. and Chen C.N. (2001) Occurrence and control of nesting whitefly (*Paraleyrodes bondari* Peracchi) in southern Taiwan. *Journal of Agriculture Research China* 50: 59–65.

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