

Invasive insect pests in India: Current scenario and future perspective

Naveena, N.L., Shashank, P.R., Devaramane Raghavendra and Mallikarjuna Jeer

Abstract: Abundant biological diversity of India is more vulnerable to the invasion of new insects. The entry of invasive insects is increased across the globe due to the liberalization of trade and increased movement of human beings across the continents. There are 23 different invasive insect pests recorded in India. The exact monetary values of the losses caused by these are not properly known. Directorate of Plant Protection, Quarantine and Storage (DPPQ&S) is the National Plant Protection Organization (NPPO) for India and works to restrict the entry of any invasive species. Strict implementation of import regulations and international cooperation in trade and commerce, early detection and taxonomic identification at the entry points will make India secure from such invasive species.

Key words: invasive pests, quarantine, India, plant protection

A species that has established and spread or has the potential to do so outside of its natural distribution range, and which then threatens ecosystems, habitats and/or other species, potentially causing economic and/or environmental damage, or harm to human health is called Invasive species (Invasive species specialist group (ISSG) module, IUCN, 2012).

The majority of invasive species are alien (non-native species or non-indigenous species), but some native species may also become invasive. So, Invasive alien species (IAS) can be defined as "An alien species whose introduction and/or spread threaten biological diversity" (Convention on Biological Diversity, 2019). This is also referred to as Alien invasive species and IUCN defined it as, "an alien species which

becomes established in natural or semi-natural ecosystems or habitat, is an agent of change, and threatens native biological diversity".

These IAS are always a threat to local biodiversity. It may cause the extinction of native species, change in habitats, affecting human health and economic loss (Tu, 2009). Invasive alien species of Insects and microorganisms are a major threats to agriculture across the globe and in particular, underdeveloped and developing countries. They cause economic damage to crops, further, it leads to a change in cropping pattern in the area and affect agro-ecosystem and food security (Paini et al., 2016).

In general, the process of invasion includes Introduction, Establishment and

Spread. However, few species having Lag phase between establishment and spread. Where they occur in low densities and accumulate over a period (months/years) and rapidly explode as they reach the carrying capacity of the environment (Fig.1).

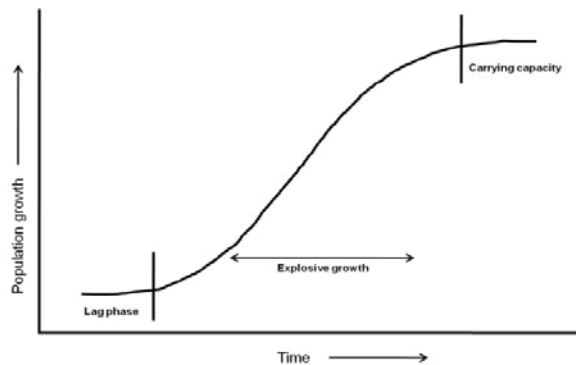


Fig.1. Stages of an Invasion (modified from the module by ISSG, 2012)

There are legal controls for the movement of these species across the world. International Plant Protection Convention (IPPC), 1951 of FAO, United Nations and its Regional Plant protection organizations (RPPOs). IPPC provides international framework for plant protection which includes, development of International Standards for Phytosanitary Measures (ISPMs) for safeguarding plant resources (guidelines for issuing Phytosanitary certificates (PSCs) for export purpose, PRA, Post entry quarantine guidelines, etc.), information exchange on pest status and regulated pest in each country and Sanitary and Phytosanitary (SPS) Agreement under WTO are mainly involved in protecting pest introductions and outbreaks across the globe.

India enacted and adopted various Acts and rules to avoid the entry of these IAS to the country and was amended based on the situation and time-to-time.

Invasive insect pests in India

Due to changes in climate, increase in international trade, modernization in agriculture - changes in cropping patterns/agro-ecosystem, loss of forest cover, expansion of host range and acclimatization to varied climatic conditions by insects. India's rich biodiversity is highly susceptible to invasive species.

India witnessed the first invasion of San Jose scale, *Quadraspidiotus perniciosus* (Comstock) [Hemiptera: Diaspididae] in 1879 from china and recorded a total of twenty-three species as on today (2019) and affects agro-ecosystem of the country and causes a huge economic loss over the years. Table 1 depicts the invasive alien insect species and their biological control recorded in India.

The loss caused by these species is immense and in India, there is no proper study or documentation of the extent of loss caused by them, except few studies i.e., Papaya mealybug, where some reports mentioned loss in the area but not in exact monetary values. India losses 117 US Billion dollars in 2001 due to Invasive Alien Species (ISSG module, 2012). We need to monitor the invasive insects once they reported to their spread and acclimatization and also cost involved in controlling that invasive insect.

In India Invasive insects/Invasive Alien Insects, are being monitored by Directorate of Plant Protection, Quarantine and Storage (DPPQ&S), ICAR-NBPGR, ICAR-NBAIR and other crop-specific institutes of ICAR, Ministry of Agriculture and farmer's welfare, Government of India. DPPQ&S works by adopting various laws viz., The Destructive Insects and Pests Act,

1914 and amendments, The Plant Quarantine (Regulation of Import into India) Order 2003 – Amendments, and adopting international guidelines from International Plant Protection Convention (IPPC, 1951), WTO-SPS Agreement, and International Standards on Phytosanitary Measures (ISPMs) to avoid/stop any entry of invasive insects/pathogens/weeds to the country via international Trade and commerce. For the export of Agricultural commodities, Phytosanitary Certificates (PSC) is being issued in accordance with the IPPC convention.

In India there are 35 plant quarantine stations at various international airports, seaports and land frontiers (Table 2), 35 Central Integrated Pest Management Centers (CIPMCs) for promoting IPM approaches in the country and one Central Insecticide Laboratory (CIL) established under section 5 of Insecticide Act 1968, and it functions as per the rule 5 of Insecticide rules 1971. It also establishes Central Insecticides Board and Registration Committee (CIB&RC) Under Section 4 and 5 of the Insecticides Act, 1968. CIB&RC mainly works on pesticide registration after scrutinizing the formulae for manufacture, import, and export in the country and also advises the central and state governments for effective management of pesticide related issues in the country (Anonymous, 2019).

Management of IAS

Phytosanitary treatments are carried out by pest control firms accredited by DPPQS for killing insects in the containers with produces. Various Phytosanitary Treatments viz., Fumigation, Forced Hot Air Treatment, Vapour Heat Treatment, Hot Water Immersion Treatment, Irradiation, Dry Heat Treatment and other methods

accepted by IPPC are more useful in managing quarantine pests in India.

In order to identify quarantine insect pests in the imported materials is examined at the entry points by various methods viz., Visual Examination, Microscopic Examination, X-ray, Fluoroscopy & Radiography. For examining nematodes washing and sieving test, Flootation test, and Baermann funnel apparatus are used in addition to visual and microscopic examination. For pathogens, Incubation test (Bacteria/fungi), Grow out test (Seed borne pathogens), Electron microscopic observation, and ELISA for viruses.

The present available methods/approaches for controlling invasive insects viz., Mechanical, chemical and biological approaches needs to be revised. Mechanical and chemical approaches are costly, laborious, and pro-environment, where as biological method is long-term and time consuming. So it is the time to re-think alternate management approaches.

1. Monitoring:

- a. Preparation of Pest Risk Analyses (PRA) helpful to identify the quarantine pest in advance, so that mitigation measures can be prepared.
- b. Prepare a complete document (mapping) of possible entry of invasive insects in to the country.

2. Prevention:

- a. Identify the species known to be invasive at the quarantine entry points.
- b. Early detection.

3. Management/Control:

- a. The efforts should be region oriented
- b. Taxonomic confirmation of the species, its origin.
- c. Should have knowledge about insect morphology, bio-ecology and place of origin.
- d. Find out availability of control agents in native place if any and also in the invaded location or importing from its native place.

Future Perspective

There is need of the hour to adopt modern technologies for detecting insect pests at various levels. There is a more scope for advanced research in use of Near-infrared spectroscopy (NIR) (Rapid method, no sample preparation), E-nose technology, Machine vision (Effective in detecting external insects), Electrical conductance (Hidden internal infestation can be identified), development of Sensor systems for early detection of insects and low cost DNA barcoding technology for easy and quick identification of insect pests. Further, there should be an international policy (other than PRA) to predict the possible invasion/incursion of the species to different countries and also to suggest mitigation measures every year will help to save the biodiversity, crop loss/food security and increase economy of the nation.

References

Anonymous. 2019. <http://ppqs.gov.in/about-us/organization-chart>. accessed on 6th September, 2019.

Chandrika Mohan, Josephraj Kumar, A, Merin Babu, Arya Krishna, Prathibha P S, Krishnakumar V, Vinayaka Hegde. 2019. Non-native Neotropical nesting whitefly,

Paraleyrodes minei Iaccarino on coconut palms in India and its co-existence with Bondar's nesting whitefly, *Paraleyrodes bondari* Peracchi. Current science 117(3): 515-519.

Convention on Biological Diversity. 2019. <https://www.cbd.int/invasive/terms.shtml> retrieved on 5th September, 2019.

Faizal M H, Prathapan K D, Anith K N, Mary C A, Lekha M, Rini C R. 2006. Erythrina gall wasp *Quadrastichus erythrinae*, yet another invasive pest new to India. Current Science 90(8): 1061-1062.

Fotedar M R. 1941. San Jose scale and its control in Kashmir. Indian Farming 5:234-237.

ISSG module. 2012. http://www.issg.org/pdf/publications/GISP/GISP_TrainingCourseMaterials/Management/ManaginginvasiveModule1.pdf retrieved on 5th September, 2019.

Jacob J P, Devaraj R, Natarajan R. 2007. Outbreak of the invasive gall inducing wasp *Leptocybe invasa* on eucalypts in India. Invasives 8: 4.

Josephraj kumar, A, Mohan C, Babu M. et al. 2019. First record of the invasive Bondar's nesting whitefly, *Paraleyrodes bondari* Peracchi on coconut from India. Phytoparasitica 47: 333. <https://doi.org/10.1007/s12600-019-00741-2>

Kumar P K V, Prakasan C B, Vijayalakshmi C K. 1990. Coffee berry borer *Hypothenemus hampei* (Coleoptera: Scolytidae): first record from India. Journal of Coffee Research 20 (2):161-164.

Lefroy H M. 1907. The potato tuber moth. Indian Agriculture J. 2: 294-295.

- McAvoy T J, Zilahi-Balogh G M G, Salom S M, Kok LT, Guoliang Z. 2007. Development and feeding of *Tetrableps galchanooides*, a predator of the hemlock woolly adelgid. *BioControl* 52:339-350.
- Paini D R, Sheppard A W, Cook D C, Barroe P J, Worners S P, Thomas M B. 2016. Global threat to agriculture from invasive species. *Proceedings of the National Academy of Sciences* 113 (27): 7575–7579.
- Palaniswami M S, Pillai K S, Nair R R, Mohandas C. 1995. A new cassava pest in India, *Cassava Newsletter* 19: 6-7.
- Prathapan K D, Shameem K M. 2015. *Wallacea* sp. (Coleoptera: Chrysomelidae) – A new spindle infesting leaf beetle on coconut palm in the Andaman and Nicobar Islands. *Journal of Plantation Crops* 43(2):162-164.
- Rao V P. 1951. Iceryine scale insects recorded from the Orient. *Indian Journal of Entomology* 12:39-66.
- Sathiamma B, Nair C P R, Koshy P K. 1998. Outbreak of a nut infesting eriophyid mite *Eriophyes guerreronis* (K.) in coconut plantations in India. *Indian Coconut Journal* 29(2):1-3.
- Selvaraj K, Sundararaj R, Sumalatha B V. 2019. Invasion of the palm infesting whitefly, *Aleurotrachelus atratus* Hempel (Hemiptera: Aleyrodidae) in the Oriental region. *Phytoparasitica* 47:327–332. <https://doi.org/10.1007/s12600-019-00742-1>.
- Sharanabasappa, Kalleshwara swamy C M. 2018. Presence of Fall Armyworm, *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae), an Invasive Pest on Maize in University jurisdiction. University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India. <https://drive.google.com/file/d/1hEW58nhZViHPnRduCjRHVIfWhGASHLSH/> (published on 20/07/2018).
- Shashank P R, Chandrashekar K, Naresh M, Sreedevi K. 2015. Occurrence of *Tuta absoluta* (Lepidoptera: Gelechiidae): An invasive pest from India. *Indian Journal Entomology* 77(4):323-329.
- Shylesh A N. 2013. Host range of invasive Jack Beardsley mealybug, *Pseudococcus jackbeardsleyi* Gimpel and Miller in Karnataka. *Pest Management in Horticultural Ecosystems* 19(1): 106-107.
- Shylesha A N, Sunil Joshi. 2012. Occurrence of Madeira mealybug, *Phenacoccus madeirensis* Green (Hemiptera: Pseudococcidae) on cotton in India and record of associated parasitoids. *Journal of Biological Control* 26(3): 272-273.
- Srinivasan T, Saravanan P A, Josephraj Kumar A, Rajamanickam K, Sridharan S, David P M M, Natarajan N, Shoba N. 2016. Invasion of the rugose spiralling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae) in Pollachi tract of Tamil Nadu, India. *Madras Agricultural Journal* 103(10/12): 349-353.
- Tanwar R K, Jeyakumar P, Monga D. 2007. Mealybugs and their management. National Centre for Integrated Pest Management, New Delhi, *Technical Bulletin* 19:1-16
- Tanwar R K, Jeyakumar P, Vennila S. 2010. Papaya mealybug and its management strategies. *Technical Bulletin* 22. National

Centre for Integrated Pest Management,
New Delhi.

Thakur J R, Dogra G S. 1980. Woolly Apple Aphid, *Eriosoma lanigerum*, Research in India. Tropical Pest Management 26(1):8-12. DOI: [10.1080/09670878009414276](https://doi.org/10.1080/09670878009414276)

Tu M. 2009. "Assessing and Managing Invasive Species within Protected Areas." Protected Area Quick Guide Series. Editor, J. Ervin. Arlington, VA. The Nature Conservancy 40 pp.

Veeresh G K. 1990. The status of leucaena psyllid, *Heteropsylla cubana* Crawford in India. in B Napompeth and K G MacDicken, eds. Leucaena psyllid: Problems and Management. Winrock International/IDRC/NFTA/F-FRED, Bangkok, Thailand, 14-16 pp.

Viraktamath C A, Tewari G C, Srinivasan K, Gupta M. 1993. American serpentine leaf miner is a new threat to crops. Indian Farming 43: 10-12.

AUTHORS

Naveena N.L., (Corresponding author) – DPPQ&S, Faridabad - 121001, Haryana, India. Email: nlnaveena@gmail.com

Shashank, P.R - Division of Entomology, ICAR –Indian Agricultural Research Institute, New Delhi - 110012, India

Devaramane Raghavendra - ICAR – National Centre for Insect Pest Management, New Delhi-110012, India

Mallikarjuna Jeer - ICAR – National Institute of Biotic Stresses Management, Raipur- 493225, Chhattisgarh, India

Table 1. List of invasive alien insect pests in India

Sl. No	Common name	Scientific Name	Entry to India (Place)	From/Native	Biological control	References
1	San Jose scale	<i>Quadraspidiotus perniciosus</i> (Comstock) (Hemiptera : Diaspididae)	1879 / (1921- Kashmir)	China	<i>Aphytis</i> (proclia group)- ectoparasitoid, <i>Encarsia perniciosi</i> Tower -endoparasitoid and <i>Coccinella infernalis</i> Mulsant -predator	Fotedar, 1941
2	Woolly apple aphid	<i>Eriosoma lanigerum</i> (Hausmann) (Hemiptera: Aphididae)	1889 Coonoor, Tamil Nadu/ 1909 Uttarpradesh	China / America	<i>Aphelinus mali</i> (Haldeman)	Thakur and Dogra, 1980
3	Potato tuber moth	<i>Phthorimaea operculella</i> Zeller (Lepidoptera: Gelechiidae)	1906 (East Bengal- Now in Bangladesh)	Italy	<i>Copidosoma koehleri</i> , an egg - larval parasitoid; <i>Chelonus blackburnii</i> - exotic parasitoid	Lefroy, 1907
4	Cottony cushion scale	<i>Icerya purchasi</i> Maskell (Hemiptera: Margarodidae)	1920 Tamil Nadu	Australia	Predator- <i>Rodolia cardinalis</i>	Rao, 1951
5	Pine woolly aphid	<i>Pineus pini</i> (Macquart) (Hemiptera: Adelgidae)	1970/ Nilgiris, Tamil Nadu	Western & Central Europe	Anthocorid bugs- <i>Tetrableps raoi</i> , <i>T. abdulghanii</i> Ghauri	McAvoy et al. 2007
6	Subabul psyllid	<i>Heteropsylla cubana</i> Crawford (Hemiptera: Psyllidae)	1988 Tamil Nadu & Bangalore	Central America	Lady beetle, <i>Curinus coeruleus</i> Mulsant from Mexico	Veeresh, 1990
7	Coffee berry borer	<i>Hypothenemus hampei</i> Ferrari (Coleoptera: Curculionidae)	1990 Gudalur, Tamilnadu	Northeast Africa	<i>Prorops nasuta</i> Waterston; <i>Cephalonomia stephanoderis</i> Betrem (Hymenoptera: Bethyridae) from Mexico and <i>Phymastichus coffea</i> Lasalle (Eulophidae) from Colombia	Kumar et al. 1990
8	Serpentine leaf miner	<i>Liriomyza trifolii</i> (Burgess) (Diptera: Agromyzidae)	1991 Hyderabad, Telangana	Florida (U.S.A.)	Chalcidoidea, Pteromalidae and Braconidae - <i>Diglyphus begina</i> , <i>D. intermedius</i>	Viraktamath et al. 1993
9	Spiralling white fly	<i>Aleurodicus disperses</i> Russell (Hemiptera: Aleyrodidae)	1993 Kerala	Central America	<i>Encarsia haitiensis</i> and <i>E. Guadeloupe</i> Viggiani (Hymenoptera: Aphelinidae) -Lakshadweep Islands; <i>Axinoscymnus puttardiahii</i> Kapur (Coccinellidae) and <i>Cybocephalus</i> sp. (Coleoptera: Nitidulidae)	Palaniswami et al. 1995
10	Coconut Eriophid mite	<i>Aceria gurreronis</i> Keifer (Arachnida: Eriophyidae)	1997 Enakulam, Kerala	Mexico	Predatory mites- <i>Amblyseius largoensis</i> Muma, <i>Neoseiulus mumai</i> , <i>Neoseiulus baraki</i> and Fungi- <i>Hirsutella thompsonii</i>	Sathiamma et al. 1998
11	Eucalyptus gall wasp /Blue gum chalcid	<i>Leptocybe invasa</i> Fisher & La Salle (Hymenoptera: Eulophidae)	2001 Karnataka/ Tamil Nadu	Australia	<i>Megastigmus</i> sp. and <i>Aprostocetus gala</i> Walker	Jacob et al. 2007
12	Erythrina gall wasp	<i>Quadrastichus erythrinae</i> Kim (Hymenoptera: Eulophidae)	2006 Kerala	Tanzania, East Africa	Eulophids - <i>Quadrastichus ingens</i> , <i>Q. gallicola</i> , <i>Q. bardus</i> , <i>Aprostocetus nitens</i>	Faizal et al. 2006
13	Cotton mealy bug	<i>Phenacoccus solenopsis</i>	2006 Gujarat	Central america	<i>Aenasius bambawalei</i> Hayat (Hymenoptera:	Tanwar et al. 2007

		<i>Tinsley</i> (Hemiptera: Pseudococcidae)			Encyrtidae).	
14	Papaya mealy bug	<i>Paracoccus marginatus</i> Williams and Granara de Willink (Hemiptera: Pseudococcidae)	2007 Coimbatore, Tamil Nadu	Mexico	<i>Cryptolaemus montrouzieri</i> ; lepidopteran predator - <i>Spalgis epius</i> (Lycaenidae); <i>Anagyrus loecki</i> Noyes & Menazes, <i>Acerophagous papayae</i> Noyes & Schauff and <i>Pseudleptomastrix mexicana</i> Noyes and Schauff (Hymenoptera: Encyrtidae)	Tanwar et al. 2010
15	Jack Beardsley mealybug (Banana)	<i>Pseudococcus jackbeardsleyi</i> Gimpel and Miller. (Hemiptera: Pseudococcidae)	2012 Karnataka	America	<i>Cryptolaemus montrouzieri</i> , <i>Spalgis epius</i> and some species of gnats	Shylesh, 2013
16	Madeira mealybug (Hibiscus)	<i>Phenacoccus madeirensis</i> Green (Hemiptera: Pseudococcidae)	2012 Karnataka	Neotropical	---	Shylesha and Sunil Joshi, 2012
17	South American tomato pinworm/ Tomato leaf minor	<i>Tuta absoluta</i> (Meyrick, 1917) (Lepidoptera: Gelechiidae)	2014 Pune, Maharashtra	South America	<i>Nesidiocoris tenuis</i> Reuter; <i>Neochrysocharis formosa</i> (Westwood); <i>Habrobacon</i> sp.; <i>Goniozus</i> sp. <i>Trichogramma achaeae</i>	Shashank et al. 2015
18	Coconut Spindle infesting leaf beetle	<i>Wallacea</i> sp. (Coleoptera: Chrysomelidae)	2014/2015 Andaman islands	Oriental region - Australia	----	Prathapan and Shameem, 2015
19	Rugose spiraling whitefly (coconut)	<i>Aleurodicus rugioperculatus</i> Martin (Hemiptera: Aleyrodidae)	2016 Tamil Nadu	Central America	<i>Encarsia noyesi</i> , <i>E. guadeloupa</i>	Srinivasan et al. 2016
20	Fall armyworm (Maize)	<i>Spodoptera frugiperda</i> (JE Smith) (Lepidoptera: Noctuidae)	2018 Karnataka	America	Egg parasitoids- <i>Telenomus remus</i> Nixon (Hymenoptera: Platygasteridae); <i>Trichogramma</i> sp.; Gregarious larval parasitoid- <i>Glyptapanteles creatonoti</i> (Viereck) (Braconidae); Solitary larval parasitoid- <i>Campoletis chloridae</i> Uchida (Ichneumonidae).	Sharanabasappa and Kalleshwaraswamy, 2018
21	Nesting whitefly (Coconut)	<i>Paraleyrodies minei</i> Iaccarino (Hemiptera: Aleyrodidae)	2018 Kerala	Syria	--	Chandrika Mohan et al. 2019
22	Bondar's Nesting Whitefly (Coconut)	<i>Paraleyrodies bondari</i> Peracchi (Hemiptera : Aleyrodidae)	2018 Kerala	Central America	--	Josephraj Kumar et al. 2019
23	Neotropical Whitefly (Coconut)	<i>Aleurotrachelus atratus</i> Hempel (Hemiptera: Aleyrodidae)	2019 Mandya/ Bangalore	Brazil	Parasitoid, <i>Encarsia</i> spp. (Hymenoptera: Aphelinidae) and predators viz., <i>Dichochochrysa astour</i> (Neuroptera: Chrysopidae), <i>Cybocephalus</i> spp. (Coleoptera: Nitidulidae), <i>Chilocorus nigrita</i> and <i>Jauravia pallidula</i> (Coleoptera: Coccinellidae)	Selvaraj et al. 2019

Table 2. List of plant quarantine stations in India

Category I Stations	Category-II Stations	Category III Stations	Category IV Stations
Agartala	Panitanki	Kandla	New Delhi
Guwahati	Kalimpong	Visakhapatnam	Amritsar
Raxaul	Trivandrum	Tuticorin	Chennai
Sanauli	Tiruchirapalli	Cochin	Kolkata
Banbasa	Bhavnagar	Kakinada	Mumbai
Rupaidiha	Hyderabad	Nava Sheva	Bangalore
Jogbani	Attari-Wagah Border	Mangalore	
Attari-Wagah Border - Rly. Stn.	- LCS (working unit under RPQS, Amritsar)	Bongaon	
Amritsar Rly. Stn	Air Cargo, Mumbai		
ICD Tughlakabad (working unit under NPQS, Delhi)	Air Cargo, Kolkata		
Air Cargo, Delhi Airport			
Calicut Airport			