CHAPTER
5

EMERGING INVASIVE INSECTS IN INDIA: DIAGNOSTIC FEATURES AND SUSTAINABLE MANAGEMENT STRATEGIES

R.K. Gokulakrishnaa
Department of Crop Protection, MIT College of Agriculture and Technology (Affiliated to TNAU), Musiri, Tamil Nadu
Email id: *entogokul230696@gmail.com*
Orcid Id: *http://orcid.org/0000-0002-0756-7793*

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Abstract
Invasive insect pests have become a major threat to agricultural productivity and ecological stability worldwide. India, due to its diverse climatic zones, extensive trade activities, and expanding horticultural and field crop systems, has witnessed the rapid establishment of several alien pests during the past decade. This chapter provides a consolidated overview of fourteen invasive insect pests of current importance, including the Fall Armyworm (Spodoptera frugiperda), Tobacco Thrips (Thrips parvispinus), multiple invasive whitefly species (Paraleyrodes minei, P. bondari, Aleurothrixus floccosus, Aleurotrachelus atratus, A. anonae), scale insects (Aulacaspis madiunensis, Aulacaspis elettaria, Fistulococcus pokfulamensis), the Cassava Mealybug (Phenacoccus manihoti), and invasive lepidopteran miners such as Acrolepiopsis assectella and Leucoptera malifoliella. The chapter summarizes their taxonomy, origin, host range, invasion pathways, symptoms of injury, and current distribution patterns. Emphasis is placed on the biological and ecological traits that facilitate their establishment and spread in Indian agroecosystems. Current management options, including surveillance, cultural practices, biological control, and selective chemical approaches are discussed with reference to sustainable Integrated Pest Management (IPM) principles. The synthesis presented here aims to support researchers, extension personnel, and policymakers in implementing timely interventions, reducing crop losses, and strengthening national preparedness against emerging invasive pest threats.
Keywords: *Invasive insects, Integrated Pest Management, Fall Armyworm, Tobacco Thrips, Cassava Mealybug*

Introduction

Invasive insect pests have emerged as a major constraint to global agricultural production, biodiversity conservation, and sustainable ecosystem functioning. Increasing international trade, global transport networks, climate change, and the expansion of intensive crop systems have collectively accelerated the unintentional movement of non-native arthropods across borders. Once introduced, these species often establish rapidly due to favourable climatic conditions, wide host adaptability, high reproductive potential, and,

most importantly, the absence of their natural enemies. Their sudden establishment in new habitats can cause severe yield losses, increased production costs, and disruption of local ecological balance. India, owing to its diverse agroecological landscapes and expanding horticultural and plantation crop sectors, has become increasingly susceptible to biological invasions. Over the past decade, several exotic pests from the Neotropical, Afrotropical, and Mediterranean regions have successfully established in Indian cropping systems. Their rapid spread and ability to colonize economically important crops underline the limitations of quarantine barriers and highlight the need for enhanced surveillance and early-warning mechanisms (Singh et al., 2020).

Among the most damaging invasive pests recorded recently is the Fall Armyworm, *Spodoptera frugiperda* (Noctuidae; Lepidoptera), a highly polyphagous pest that has rapidly spread across India and Asia, infesting maize and several alternate hosts. Similarly, the Tobacco Thrips, *Thrips parvispinus* (Thripidae; Thysanoptera) has become a serious threat to vegetables and ornamentals due to its rapid multiplication and ability to cause leaf bronzing, scarring, and deformation. A significant concern is the increasing incidence of invasive whiteflies, a group capable of causing heavy direct and indirect damage. Species such as the Nesting Whitefly, *Paraleyrodes minei*, Bondars Nesting Whitefly, *P. bondari*, Woolly Whitefly, *Aleurothrixus floccosus*, Neotropical Whitefly, *Aleurotrachelus atratus*, and the Annona Whitefly, *Aleurotrachelus anonae* are now prevalent in fruit orchards, coconut and ornamental systems. These pests cause sap depletion, wilting, chlorosis, honeydew deposition, and severe sooty mould development, leading to reduced photosynthetic efficiency and quality deterioration. Their cryptic habits, overlapping generations, and high dispersal ability complicate conventional management approaches.

Equally challenging is the establishment of invasive scale insects and mealybugs. The Cassava Mealybug, *Phenacoccus manihoti* (Pseudococcidae), originally from Africa, poses a threat to cassava-based farming systems due to its ability to cause stunting, wilting, and plant dieback. The Mango Soft Scale, *Fistulococcus pokfulamensis* (Coccidae) and the armoured scales *Aulacaspis madiunensis* and *Aulacaspis elettaria* have been increasingly reported on mango, cardamom, and plantation crops. These species are difficult to manage because their protective waxy coverings reduce insecticide penetration and provide natural resistance to harsh environmental conditions. Invasive moth pests have also gained prominence. The Leek/Onion Moth, *Acrolepiopsis assectella* (Acrolepiidae) causes severe damage to Allium crops through mining and feeding on foliage and bulbs, while the Apple Leaf Blotch Miner, *Leucoptera malifoliella* (Lyonetiidae) reduces canopy strength and fruit quality, particularly in temperate horticultural regions.

Collectively, these invasive insects impose heavy losses on crop productivity, disrupt pest management calendars, and increase dependency on chemical pesticides. Their invasions highlight the importance of strong quarantine enforcement, species-specific monitoring tools, molecular diagnostics, and ecologically sound Integrated Pest Management (IPM) strategies. Biological control, cultural practices, botanicals, and selective insecticides compatible with natural enemies should be prioritized to ensure long-term sustainability. This chapter provides an updated and consolidated account of fourteen

invasive insect pests of current significance, covering their taxonomy, invasion pathways, biological characteristics, host range, symptoms of injury, and management strategies. By compiling recent findings and field observations, the chapter aims to support researchers, students, extension personnel, and policymakers in understanding the emerging invasive pest scenario and adopting timely interventions to minimize economic losses and safeguard crop production systems.

Fall Armyworm, *Spodoptera frugiperda*, Noctuidae, Lepidoptera

Native Place: North and South America.

- Noticed in May, 2018 at Shivamogga, Karnataka.

Damage symptoms

- Young worms gregariously feed by scrapping the leaves led to the transparent patches in the leaves.
- Caterpillars enter the cob and feed on developing kernels.
- One to two larvae can be seen in each whorl.

Biology

- Females may lay up to 300 to 1000 eggs in their life time depending upon the environmental condition.
- Eggs hatch in two to four days.
- There are totally of six larval instars.
- Larval period completes in 13 to 20 days and the pupal period in 7 to 10 days.
- Total life cycle completes in 25 to 33 days depending upon the climatic conditions.

Management

- Cyantraniliprole 19.8 % + Thiamethoxam 19.8 % FS at the rate of 6 ml/Kg of seeds will offer protection for up to 15 to 20 days.
- Intercropping pulses and using the Napier grass as a trap crop – 3 to 4 rows.
- Installation of pheromone trap at the rate of 10 Nos/acre after the emergence of seedlings.

Management Schedule (Varshney *et al.,* 2020)

For the first two weeks

- *Trichogramma chilonis*/ *T. Pretiosum* at the rate of 1 lakh/ha or *Telenomus remus* at the rate of 15000 to 20000/ha at the weekly interval - 3 to 4 releases, when one to two adults were noticed in the trap.
- Neem oil at the rate of 3 ml/lit or NSKE at the rate of 5 ml/lit.
- Spray NBAIR Bt 25 at the rate of 20 ml/lit, if required after the neem spray.

From the second to fourth week

- Release *Bracon sp* @ 4000 adults/ha.
- NBAIR Ma 35 at the rate of 5 g/lit or Spfr NPV at the rate of 4 ml/lit.
- Spray any one of the chemicals – Chlorantraniliprole 18.5 Sc at the rate of 80 ml/acre / Thiamethoxam 12.6 % + Lambda Cyhalothrin 9.5 % at the rate of 0.25 ml/lit / Spinetoram 11.7 % Sc at the rate of 100 ml/acre.

From mid-whorl to late whorl stage

- If a new brood is noticed in the field, follow the recommended practices as mentioned for the second to fourth week.

From tassel to harvest stage

- Strictly no usage of insecticides.

Note

If parasitoids are released in the field, it is recommended to take no action by means of any insecticides/Ma/Bt/NPV for a minimum period of one week.

***S. frugiperda* larvae**

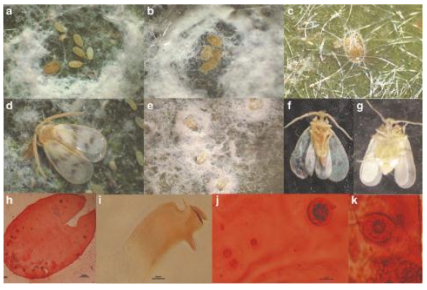
***S. frugiperda* adult**

Nesting Whitefly, *Paraleyrodes minei* and Bondars Nesting Whitefly, *Paraleyrodes bondari*, Aleyrodidae, Homoptera

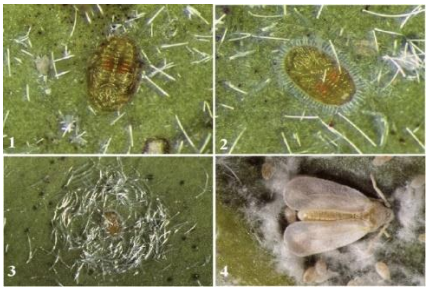
In 2018, these two exotic whitefly species have been recorded in Kerala.

Distinguishing morphology characters of P.bondari and P.minei

P. bondari	*P .minei*
Construct dense woven nest.	Construct loose woven nest.
Eggs are staked inside the nest without waxy covering.	
Crawlers: Yellow, flat margin – band of setae/wax all around the body.	**Crawlers:** Cream in colour with wax on the dorsal surface.
Later instars – Transparent yellow with short filaments on margin.	**Later instars –** Cream colour with fiberglass like wax rods**.**
Adults: Oblique grey band on fore wings, when both wings united forms like X-band.	**Adults:** Yellow colour with no band.



Bondars Nesting Whitefly



Nesting Whitefly

In 2019, another two whitefly species have invaded into our country, one is Woolly whitefly, *Aleurothrixus floccocus* and another one is Neotropical whitefly, *Aleurotrachelus atratus* (Selvaraj *et al*., 2020).

Woolly whitefly – *Aleurothrixus floccosus* (Maskell) (Hemiptera: Aleyrodidae)

It was noticed in guava at Kozhikode and Malapuram, Kerala. In guava, co-occurrence of *Aleurodicus dispersus, A. rugioperculatus, P.bondari* and *P.minei* have been reported. But this exotic whitefly species dominates all the existing species and replace all. It is polyphagous in nature prefer mainly citrus but in India it prefers guava.

Diagnostic characters

- Eggs (before hatch), later instars and mature pupae are brown in colour.
- Eggs are laid in circular pattern; due to concrete nature of whiteflies it is difficult to distinguish. Eggs are at upright position/at an angle, granular powder wax was noticed in all around the eggs.

Damage symptoms

- Nymphs and adults suck the sap from phloem leads to wilt, yellow and leaf fouling.
- Severe infestation leads to complete blackening leads to leaf fall, senescence and death.

Biology

- Sausage shaped, pale white eggs at under surface of leaf changes to brown colour before hatch.
- 1st instar – light green, flat, oval and little marginal wax.
- Subsequent instar – sedentary and brown.
- Late instars – completely obscured by copious amount of wax (many times thicker than body).
- Egg to nymph – around 3 weeks.
- Adult longevity – 30 days. Total life cycle around – 51 to 57 days.

Management

- Follow the stringent quarantine protocols.
- Yellow sticky traps at the rate of 10/ha.
- *Pseudomallada astur* at the rate of 1000 eggs/ha/15 days interval.
- Two sprays of *Isaria fumosorosea* at the rate of 5g/lit/15 days interval.
- In case of severe outbreaks, use neem oil 1%.
- No natural parasitism has been recorded so far, but *Cales noacki* been noticed in the vicinity.

Aleurothrixus floccocus

Cales noacki

Neotropical whitefly – *Aleurotrachelus atratus* (Hempel) (Hemiptera: Aleyrodidae)

- It is also called as Oil-palm whitefly, because though it is a polyphagous species preferred to colonize on coconut, oil palm and ornamental palm trees.
- It is reported in Karnataka in 2019.

Biology

- Eggs are stacked in semi-circular pattern, black in colour before hatch.
- All the nymphal and pupal stages are black in colour.
- Total life cycle completed in 36 to 41 days in coconut.

Management

- Follow the stringent quarantine protocols.
- Yellow sticky traps at the rate of 10/ha.
- *Pseudomallada astur* at the rate of 1000 eggs/ha/15 days interval.
- Two sprays of *Isaria fumosorosea* at the rate of 5g/lit/15 days interval using high volume sprayer with medium droplet size nozzle preferably in evening hours.
- Beetle, *Cybocephalus indicus* have been noticed to feed whiteflies.
- Parasitisation rate of 46 to 68% by *Encarsia cubensis* (Solitary endoparasitoid on puparium) on *A. atratus* was reported by NBAIR in different locations of Karnataka.
- *Encarsia cubensis* might invaded along with Solanum Whitefly, *Aleurotrachelus trachoides* in 2015 and *A. flocosus* in 2019.

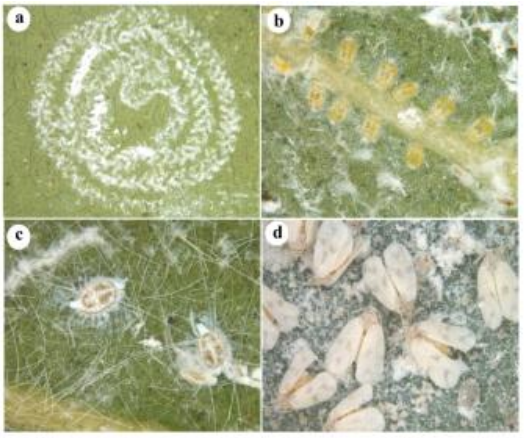
Note

Isaria fumosorosea is safe to *Encarsia guadeloupae i.e.,* using of *Isaria* + *Encarsia* at the same time is feasible. *Encarsia* adult emergence was recorded in whitefly nymph sprayed with *Isaria.* It is also safe to other beneficials like *Pseudomallada astur, Bombyx mori and Goniozus nephantidis*.

A. atratus **nymph**

Aleurotrchelus atratus **adult**

Cybocephalus indicus



***Aleurodicus rugioperculatus* infestation before spraying**

(a) Eggs, (b,c) Third & fourth nymphal instars, (d) Adults

***Isaria fumosorosea* fungal mycelium on**

e) Eggs, (f, g) Third & fourth nymphal instar, (h) Adult

Cassava mealybugs, *Phenacoccus manihoti*, Pseudococcidae, Homoptera

It was reported in May, 2020 from Thrissur, Kerala (Joshi et al., 2020).

Biology

- Ovoid, pink with wax dust/ short lateral and caudal filaments (swell like tooth).
- Thelytokous parthenogenesis have been observed.
- Females lay 500 eggs at shoot tip and lower leaf.
- Eggs are golden yellow; 1st instar is mobile while subsequent instars are sedentary.
- In optimum conditions, total life cycle completed in 20 days.

Damage symptoms

- Chlorosis, stunt, dry/wilt, multiple shoot (bunchy top).
- In Salem, Tamil Nadu more than 1000 nymph/shoot tip have been recorded in severe condition.

Management

- Avoid using of Thailand white, MVD, H-165, Sree Vijaya and Sree athulya as these cultivars are highly susceptible to mealybugs.
- Cultivar, H-226 found to be less infected.
- Field release of *Scymnus coccivora* at the rate of 500 to 2000/acre depends on the level of infestation.
- *Verticilium lecani* at the rate of 5 g/lit with tween 80.
- Neem Seed Kernel Extract at the rate of 5 ml/lit.
- Any azadirachtin (Min 1000 ppm) at the rate of 2 ml/lit.
- Fish Oil Rosin Soap (FORS) at the rate of 25 g/lit.
- Spray any one of chemical insecticides like Buprofezin 50 EC at the rate of 0.75 ml/lit or Profenophos at the rate of 2 ml/lit or Thiamethoxam at the rate of 0.6 g/lit.
- NBAIR has received the culture of parasitoid, *Anagyrus lopezi* from Thailand and IITA, Benin for mass production and distribution to tapioca growing farmers (Sampathkumar *et al.,* 2020).

Phenacoccus manihoti ***Anagyrus lopezi* parasitizing mealybug**

Tobacco thrips, *Thrips parvispinus,* Thripidea, Thysanoptera

A cosmopolitan species reported for the first time in India on *Carica papaya* – Brugmansia *sp* and Dahlia rosea in 2015. It is polyphagous pest recorded on vegetables like beans, eggplant and potato and fruits like papaya and strawberry etc. Severe infestation has been reported in chilli growing areas of Andhra Pradesh, Karnataka and Telangana in 2021-2022 (Tyagi *et al.,* 2015).

Damage symptoms

- Shedding of flowers, malformation of fruits and fruit drop. In chilli, 90 to 95 % flower damage, 18.20 thrips/flower have been recorded.

- It attacks the *Capsicum annum* in Andhra Pradesh, Karnataka and Chhattisgarh.
- In Tamil Nadu, infestation have been noticed in *Mangifera indica*.

Management

- Use neem and pungam oil if heavy infestation is noticed.
- Erection of blue sticky traps @ 25-30 per acre for mass trapping in thrips infested fields.
- Spraying of botanical based insecticides like Neem Seed Kernel Extract (NSKE) 5% or Neem oil 3% @ 2 ml/l or Pongamia oil @ 3 ml/l or Vitex negundo extract @ 50-80 ml/l.
- Microbial based insecticides like *Beauveria bassiana* @ 4 g or ml/l (spore load - $1x10^8$ cfu/g or ml) or *Pseudomonas fluorescence* – NBAIR PFDWD @ 20g/l or *Bacillus albus* – NBAIR-BATP @ 20 g/l uniformly covering whole plant.
- Conserve predators such as predatory mite (*Amblyseius swirskii*) and insidious flower bugs (*Orius insidiosus*) etc.

Thrips parvispinus

***Thrips parvispinus* on chilli flower**

Apple Leaf Blotch Miner - *Leucoptera malifoliella*, Lyonetidae, Lepidoptera

Recently invaded India in Union Territory of Jammu and Kashmir in 2023. According to the survey conducted in four districts (Shopian, Anantnag, Pulwama and Kulgam) by the NBAIR scientists, it was revealed that South Kashmir is severely affected. This insect is also called as Pear Leaf Blister Moth (PLBM) and Ribbed Apple Leaf Miner (RALM) (Sampathkumar *et al.,* 2023).

Biology

- Eggs are 0.3 mm in discoid shape; larva head and prothoracic shield yellow in colour; larval body green turn into darker while nearing the pupation.
- Thoracic segments and abdominal segments from 1 to 7 are broadly rounded – gives moniliform appearance.
- Metallic grey coloured adults prefer to lay eggs on shade areas in leaves.

Damage Symptoms

- Concentric circular mines that are initially small and whitish and become larger with brown spots.
- All the larval development occurs in the mines and excrement becomes visible as dark circles within the mines.
- It is difficult to control, as the spray cant able to reach the pest; besides it kills all the natural enemies.

Blotch Miner Damage Symptoms

Blotch Miner Larva

Adult

Management

- Strong or heavy pruning techniques leads to the vigorous growth, which reduces the susceptibility of pest. Weak pruning corelated with heavy infestations of this pest.
- Scraping and removing old, loose bark along with cocoons.
- Yellow sticky traps @ 0.5 m above ground level.
- Spreading of gunny bags and paddy straw on trunk which serves as a substrate for pupation, later destroy it.
- NSKE and neem leaf extracts affords more than 80% management.
- Apply insecticides like Metaflumizone or Chlorantraniliprole or Chlorfenapyr at the recommended dose before the larvae enter leaf mines.

Mango Soft Scale, *Fistulococcus pokfulamensis*; Coccidea; Hemiptera

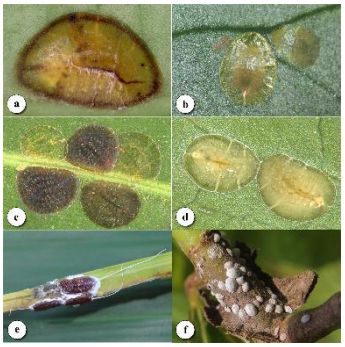
In 2023, the pest entered the India from Hong Kong infesting gymnosperms. In our country more than 80 percent it feeds on Umbrella and Jamun tree. It is noticed that it shifts

its host range faster in horticultural crops. In august, 2023 heavy infestation in mango was reported from Bengaluru. Also, high infestation in four unrelated family indicated the polyphagous ability of this pest (Joshi *et al.,* 2023).

Biology

- Females usually broader; dorsum covered with wax; by removing wax, able to see the transparent yellow body with brown alimentary canal.
- The term Fistulococcus derived from Latin – pipe like duct; so, it has pipe like ducts arranged in the periphery of the body.

Fistulococcus pokfulamensis



Mango soft scale – different stages

Damage Symptoms

- Initially feeds on undersurface of leaves, later spread to branches, which resulted into accumulation of sooty mould finally drooping of leaves.

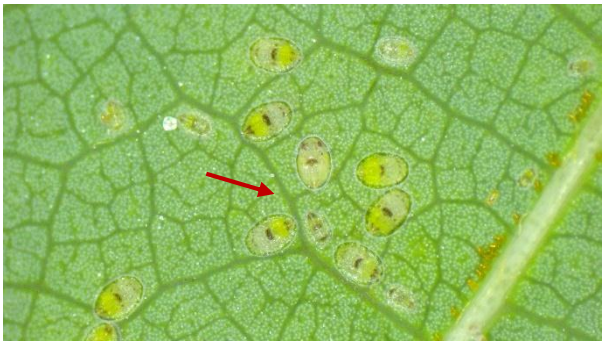
Management

- Collection and destruction of affected plant parts along with scales.
- Use of botanicals like Neem oil (3 to 5%), Neem leaf extract (5 to 10%) and NSKE (5%).
- Entomopathogens like *Beaveria bassiana* (Mycotrol; Naturalis) and *Verticillium lecani* (Vertilac) at the rate of 5 g/ml per litre of water.
- Coccinellids like *Chilocoris nigrita* and *Cryptolaemus montrouzieri,* and *Spalgis epius* feed on both nymphs and adults.
- There is no record of parasitoid association with this pest in India, as well as from Hong Kong, to date.
- Insecticides like Diafenthiuron, Flonicamid, Pymetrozine and Thiamethoxam at the recommended dose in rotations afford protection.

Annona Whitefly, *Aleurotrachelus anonae*; Aleyrodidae; Hemiptera

First reported from Bengaluru in July, 2024. This species prefers to colonize on plants under the family, Annonaceae. In custard apple, 20 to 35%, Cherimoya 5 to 10% and in Indian shot, less than 5% damage was recorded. Globally, this species is of quarantine

importance. It also coexists with recently invaded and native whitefly species. Non-anona plants like mulberry, cinnamon, avocado, elephant foot yam, banana and ginger are also in the list of hosts of this insect (Selvaraj and Sushil, 2024).



Aleurotrachelus anonae

Brown arrow indicates - Three dorsal brown patches look like mid-dorsal horizontal stripe on the body

Biology

- Adults prefer to colonize and lay stalked eggs on terminal leaves, which is initially creamy white turn dark before hatch.
- *Distinct pattern on nymph* – three dorsal brown patches look like mid-dorsal horizontal stripe on the body.
- *Diagnostic characters* - Puparium yellow, elongate, marginal teeth square shaped which is broadly separated with incision. Eyes spot absent, presence of meso and metathoracic setae, pores along lateral longitudinal fold. Puparium distinguished from other species by its white colour except *A. fici.* It is differentiated by lack of wax from *A. fici*.

Damage symptoms

- Nymphs and adults colonize on the underside of the leaves which resulted into depletion of nutrients and water due to which the leaves turn yellow finally premature defoliation occurs.
- All nymphs are light coloured, without flocculent wax.

Management

- Follow the stringent quarantine protocols.
- Yellow sticky traps at the rate of 10/ha.
- *Pseudomallada astur* at the rate of 1000 eggs/ha/15 days interval.
- Entomopathogens like *Beaveria bassiana* (Mycotrol; Naturalis), *Verticillium lecani* (Vertilac) and *Isaria fumosorosea* at the rate of 5g/lit at 15 days interval.
- In case of severe outbreaks, use neem oil 1%.

- Utilization of *Encarsia Formosa* and *Eretmocerus sp* recorded 5 to 10% parasitisation.
- Coccinellid, *Scymnus latemaculatus* may be used.
- Insecticides like Diafenthiuron, Flonicamid, Pymetrozine and Thiamethoxam at recommended dose in rotations affords protection.

Eretmocerus sp

Scymnus latemaculatus

Leek moth / Onion moth - *Acrolepiopsis assectella*, Family: Acrolepiidae, Order: Lepidoptera

Leek (*Allium spp*) serves as the primary host for the leek moth, although several other Allium crops including onion, garlic, chives, and shallot are also susceptible. The pest was first reported in 2020. *Acrolepiopsis assectella*, widely distributed across Europe and present in certain Asian regions, has been introduced into parts of Canada as well. The larvae predominantly feed on cultivated Allium species, especially leek and onion, but they can also infest garlic and chives (Dewangan and Deole, 2021).

Life cycle and appearance of the Leek moth

The leek moth (*Acrolepiopsis assectella*) completes its life cycle through eight distinct stages: egg, five larval instars, pupa, and adult. The eggs are small, white, elliptical, and are laid singly on the leaves of Allium plants. After hatching, the first-instar larvae wander briefly on the leaf surface before penetrating the green tissues, where they create slender galleries. As the larvae progress to the third, fourth, and fifth instars, they move towards the central yellow leaves of the leek, causing the most severe damage by boring extensively into the plant.

First-instar larvae measure approximately 1 mm in length, while mature larvae reach about 10 mm and possess a brown head capsule with a yellowish-white body. Pupation occurs within a cream-coloured, silk cocoon, about 10 mm long, composed of characteristic mesh-like threads and typically attached to the leaf surface or the flower stalk of the host plant. The pupa itself measures 7–8 mm, beginning light yellow in colour and gradually turning brown as adult emergence approaches.

Adult males and females are 8–9 mm long with a wingspan of 15–16 mm. They exhibit a grey-brown body and forewings marked by a distinctive white triangular patch at the posterior edge, while the hindwings are uniformly grey. The moth is nocturnal, remaining inactive during the day. Its development is strongly temperature dependent: at 25°C, eggs

hatch in 3–4 days, larval development is completed in about 2 weeks, pupation lasts around 1 week, and adults typically survive 7–10 days. Overwintering occurs in the adult stage, during which the moth enters diapause.

Damage symptoms

The leek moth primarily damages plants during the vegetative and flowering stages, although the seedling stage may also be affected in nursery beds. In addition, stored onions and garlic can suffer injury. After hatching, the young larvae initially explore the leaf surface and begin mining the green tissues. By the third instar, they penetrate deeper into the plant, attacking young leaves, the flower stalk, or the inflorescence. Larval feeding disrupts normal leaf function, reduces plant vigour, and, when infestations are heavy, can cause significant weakening or even withering. On older leaves, open galleries become visible and substantially reduce the market value of the crop. Severe damage is often observed in seed-production fields, where larvae feed within inflorescences, leading to the destruction of floral structures and considerable seed loss.

Specific damage symptoms include the following:

On leeks: Larvae mine the central leaves, resulting in long, longitudinal grooves as the plant grows.

On onions: Larvae feed on the parenchyma inside the hollow leaves, producing characteristic white "windows" beneath the intact epidermis. Feeding at the base of the hollow flower stalk weakens the structure, making it susceptible to breakage.

On inflorescences: Feeding on the floral peduncles causes flowers to drop, significantly reducing seed set.

Leaf mine by Larvae

Net like Cocoon

Adult moth

Management

Lambda cyhalothrin (Warrior® II), Spinetoram (Radiant® SC), Chlorantraniliprole (Coragen®), and Spinosad (Entrust®) significantly reduce the pest population below ETL.

Invasive armoured scale – *Aulacaspis madiunensis* (Takagi) (Hemiptera: Diaspididae)

A severe infestation of the armoured scale insect Aulacaspis madiunensis (Zehntner) was recorded for the first time in India on the endemic cycad species Cycas circinalis in northern Kerala in March 2023. This invasive pest poses a significant threat to the ecologically important cycad palms (Dileep et al., 2024)

Nature of Damage and Symptoms

Infestation typically begins at the base of the rachis and gradually spreads across both the upper and lower surfaces of the leaflets, which become densely covered with female and male scale insects. As the population builds up, the pest spreads to the megasporophylls and the surface of the nuts. In advanced stages, encrustation can extend over the entire stem, covering the full length of the palm.

Continuous sap extraction from parenchyma tissues leads to drying and desiccation of leaflets, nuts, and even the entire crown. Under severe infestation, the crown decays, ultimately resulting in the death of the tree. The symptoms often resemble those caused by pathogenic infections, but close inspection reveals characteristic scale encrustation on the leaves, petioles, rachis, nuts, and stem (Joshi et al., 2023).

Biology

Adult females are elongate to oval, pale yellow, and remain concealed beneath a circular or oval greyish-white waxy cover. This cover is not attached to the body hence the term "armoured scale" and can be removed to expose the insect beneath. Adult males are elongate, parallel-sided, bright white, and lack any protective cover.

Eggs, which are reddish-yellow, are present on the ventral side of the female. After hatching, the first-instar nymphs (crawlers) actively search for new feeding sites. Once they settle, they moult into sedentary later instars that feed continuously on plant sap. Unlike soft scales, armoured scales do not excrete honeydew and therefore do not lead to sooty mould development**.**

Management strategy:

- Immediate phytosanitary measure to be adopted to deal with the severely infested palms include cutting and burning of the fronds, rachis and other parts showing encrustation of the scale.
- The nymph and adult scale insect is protected by waxy covering. The contact insecticides will not be effective as the insecticides cannot penetrate the waxy covering. Hence timing of spray treatment should coincide with the crawler stage, where waxy covering is absent.

- Spraying of Botanical insecticides like neem oil from 3 to 5%.
- Use insecticides like Dinotefuran 20 SG (0.2 g/L), Thiamethoxam 25 WG (0.2 g/L), Flonicamid, Diafenthiuron etc.

Scale infesting the different parts ***Aulacaspis sp***

Cardamom scale, *Aulacaspis elettaria* (Green): Hemiptera: Sternorrhyncha: Coccoidea: Diaspididae

Aulacaspis elettaria was recently described as a new diaspidid species from cardamom plantations in Kerala, India (Joshi & Nafeesa 2023). The species was collected from Elettaria cardamomum (green cardamom) and identified by distinct morphological characteristics, particularly in adult females.

Host Range and Distribution

The pest is currently known only from India, with confirmed presence in the Cardamom Hill Reserves (CHR) of Kerala (Nafeesa & Murugan 2025). Its sole verified host is Elettaria cardamomum (Joshi & Nafeesa, 2023). Extensive surveys conducted between 2021 and 2023 demonstrated a steady spread of the scale insect across major cardamom-growing blocks in Idukki district, indicating an emerging and expanding threat to commercial cardamom cultivation (Nafeesa & Murugan 2025).

Aulacaspis Elettaria

Biology and Life History

The life cycle of *A. elettaria* follows typical diaspidid patterns:

- Adult females are sessile and remain protected beneath a waxy, shield-like "test" (Garcia-Morales et al. 2016).
- Males, when produced, are fragile, short-lived, and winged (Garcia-Morales et al. 2016).
- Eggs are laid within the maternal test, and the crawler stage the only mobile instar serves as the principal stage for dispersal and management targeting (Garcia-Morales et al. 2016).
- In cardamom plantations, colonies establish on pseudostem, swollen basal stem regions, and leaf sheaths (Nafeesa & Murugan, 2025).
- The shaded and humid microclimate of cardamom agroecosystems supports continuous reproduction, resulting in multiple overlapping generations per year (Nafeesa & Murugan 2025).

Damage Symptoms

Infestations develop as dense, white, crust-like colonies on pseudostem and leaf sheaths. Characteristic symptoms include:

- Yellowing and discoloration of affected pseudostem (Nafeesa & Murugan 2025)
- Browning and drying of clumps
- Reduced plant vigour and stunted growth
- Necrotic patches beneath scale crusts
- Market-quality reduction due to infested capsules turning from glossy green to dull brown (Nafeesa & Murugan 2025)

Field assessments recorded an average infestation rate of 22.4%, with approximately 9.6 adult females per 5 cm pseudostem segment in heavily infested fields (Nafeesa & Murugan, 2025).

Monitoring and Sampling

Regular surveillance is critical given the concealed nature of diaspidid scales. Effective monitoring approaches include:

- Inspecting pseudostem and leaf sheaths for early crawler settlement (Nafeesa & Murugan, 2025)
- Enumerating adult females per 5 cm pseudostem segment as a standardized sampling method
- Focusing monitoring efforts during comparatively drier months, when crawler activity peaks (Garcia-Morales et al. 2016)

Economic thresholds for *A. elettaria* have not yet been established; therefore, management decisions are currently based on trend analysis and severity indicators (Nafeesa & Murugan 2025). Field studies recorded an average infestation rate of 22.4% and approximately 9.6 adult females per 5 cm pseudostem segment in heavily infested plantations (Nafeesa & Murugan, 2025).

Management

- Newer molecules like Spirotetramat, Cyantraniliprole and Flupyradifurone affords better control.

Invasive Nesting Whitefly – *Paraleyrodes pseudonaranjae* Martin (Hemiptera: Aleyrodidae)

Paraleyrodes pseudonaranjae was recorded for the first time in the Indian subcontinent in February 2025. Native to the Neotropics (Brazil), this species is highly polyphagous and is known to infest a wide range of hosts including coconut, areca nut, guava, mango, custard apple, citrus, litchi, Ficus spp., and numerous ornamental plants. Over the past decade, India has already witnessed the invasion of two related nesting whiteflies *Paraleyrodes bondari* Peracchi and *P. minei* Iaccarino both detected in 2018. Members of this genus are commonly referred to as "nesting whiteflies" due to the distinctive waxy patterns they produce around the puparia on leaf surfaces (Selvaraj and Sushil, 2025).

Paraleyrodes pseudonaranjae

Damage Symptoms and Coexistence

Both adults and nymphs of *P. pseudonaranjae* colonize the abaxial (underside) leaf surface, where they feed by extracting plant sap. This feeding results in nutrient loss, leaf yellowing, and vigour reduction. The insect secretes large quantities of wax and honeydew, which promote the development of sooty mould subsequently reducing photosynthesis and overall plant health.

On *Duranta erecta*, colonies were observed at moderate infestation levels. Notably, *P. pseudonaranjae* frequently coexisted with other invasive whiteflies, including Bondar's nesting whitefly (*P. bondari*) and the solanum whitefly (*Aleurothrixus trachoides*). The concurrent presence of multiple *Paraleyrodes* species suggests the possibility of a simultaneous introduction of these Neotropical whiteflies into India.

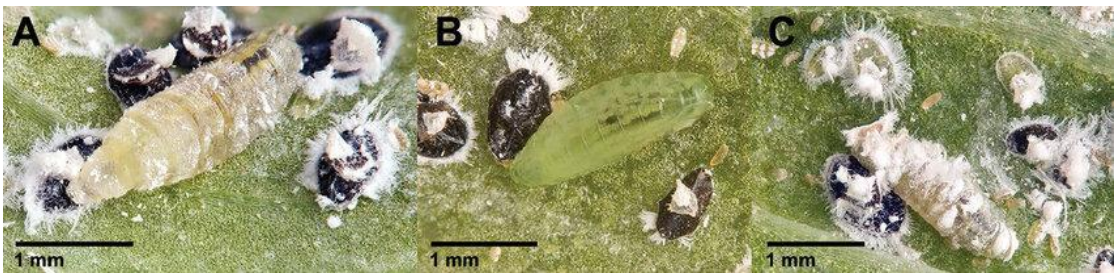
Life Stages

Adult whiteflies prefer the underside of leaves for colonisation and oviposition. Eggs are stalked, creamy white when freshly laid, and gradually darken to brown before hatching.

Nymphs are pale yellow and bear fine wax filaments, with their colonies characterized by patches of broken white filaments forming the typical "nesting" pattern around the pupal stage. In field conditions, colonies of *P. pseudonaranjae* closely resemble those of *P. bondari* and P. *minei,* making species-level identification challenging without microscopic examination. The complete life cycle is completed in approximately 25–32 days, depending on environmental conditions.

Occurrence of Natural Enemies in India

Currently, no parasitoids have been recorded parasitizing *P. pseudonaranjae* in India. However, the generalist predator *Acletoxenus indicus* was observed feeding on the nymphal stages of this newly invasive species, indicating potential for natural regulation.



Acletoxenus indicus larvae feeding on

Conclusion

Invasive insect pests continue to reshape modern agricultural ecosystems by altering pest dynamics, displacing native species, and imposing substantial economic burdens on farmers. The rapid establishment of species such as *Spodoptera frugiperda*, *Thrips parvispinus*, invasive whiteflies, scales, and mealybugs demonstrate the vulnerability of Indian cropping systems to biological invasions. These pests thrive due to favourable climatic conditions, broad host ranges, and the lack of co-evolved natural enemies, making their management increasingly complex. Strengthening surveillance networks, improving diagnostic capabilities, and enforcing quarantine regulations are essential to preventing new invasions. At the same time, sustainable pest management must emphasize integrated approaches biological control, ecological engineering, cultural practices, and rational insecticide use—to maintain productivity while safeguarding environmental health. The insights compiled in this chapter aim to support early detection, evidence-based decision-making, and long-term preparedness against emerging invasive insect threats.

Disclosure Statement

The authors reported no potential conflict of interest.

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