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***Cover Page:**
Diaphania indica **Fam: Crambidae**
Photo by Dr. M. A. Rashmi

Insect Environment

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The first issue of Insect Environment was published in 1996. The sole objective of Insect Environment is to popularize insect study through popular, semi-technical and technical research notes, extension notes for managing insect pests, photographs, short blogs and essays on all aspects of insects. The journal is published quarterly, in March, June, September, and December.

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Editorial

Need for revamping agricultural scientific meets: less of keynotes and more of original research

Dubai is always a wonder to me, an ultra-modern "urban oasis" in the midst of a desert! Yet it has excellent pavement lawns and blooming flowers all over, constantly watered by south Asian work-force. So, it was a surprise, to read Dubai in flood, on 9th March. Small spells of rains do occur in winter in Dubai, but floods are not the norm- again characteristic of climate-spike, an aspect I have been writing in my earlier editorials. But wait! Cloud seeding has been going on around UAE and this is perhaps a fallout of that and that is bound to affect desert insect life.

In the last one year, there have been a post-covid boom of several conferences, symposia and workshops across much of India, that these jaunts seemed more to meet, exchange bonhomie and perhaps ideate a little. What irked me were the keynote and lead addresses by "agricultural experts". In most cases their talks were text bookish or Google-mined and worst non-adherence to time, thus robbing time slots meant for original research from oral presenters, especially of young and middle level researchers. In one case, where I chaired, the oral presentations of 20 minutes were reduced to five minutes each with no discussions! Imagine if a test cricket is squeezed to a 20-20 not even a 50-over one-dayer! Meetings have to be conducted with clear time adherence maximising original and topical scientific discussions and clearly avoiding wasting time on felicitations, lighting lamps, unconnected inaugural address, presidential speech, keynotes, lead speaks, etc. Our scientific deliberations should evolve.

So, it was like a whiff of fresh air when we attended an International Women's Day function on 10th March, 2024 at Nexus Mall, Whitefield, Bangalore where a dozen women were honoured with excellence awards (including Dr. M. A. Rashmi, our Editor) The theme was "Clean environment and healthy residue free food through terrace gardening," with a panel of four, each strictly speaking only for 15 minutes. The programme was flashed open- guess how? All panellists and organizers watered a potted plant, in turns with a rose can using minimal water (symbolic of Bangalore reeling under water crisis!). The meet then was declared open.

There was no waste of time on any other trivialities. No shawls, garlands etc., and the audience of over 200 were seated in an amphitheatre and business went off well. Organized by the Greenotsav Forum, Sparsha Foundation, and Nexus Mall, and with Insect Environment Editors as part of the panel, we felt we need to take a leaf of learning out of their professional conduct of the whole meeting. Our professional meetings should leave out the stale and staid! If conventions are excessive, it makes scientific meetings boring and dull.

We thank NAAS for the liberal rating given to us. We will certainly promote insect science among scholars, students and scientists in our unique, professional and distinctive ways. We promote short notes, not-so-long reviews and photographs. Every quarter, Insect Environment buzzes on time, while many “clout” journals are in semi-doped state! Surely our editorial and web-team deserve a rich commendation. Therefore, I round up with an applause to this team and welcome the new Editorial Board entrants Dr. J. P. Singh, Dr. Balraj Singh, Dr. Baloda and Dr. Som Dutt.

Dr Abraham Verghese,
Editor-in Chief

Research articles

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Armyworm population dynamics and damage assessment in rice agroecosystems at Jampuijala, Tripura, India

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Abstract

Rice cultivation faces persistent challenges from various insect pests, including invasive species. The emergence of four armyworm species (rice swarming caterpillar, *Spodoptera mauritia* (Boisduval), common cutworm, *Spodoptera litura* (F.); rice ear-cutting caterpillar/paddy armyworm, *Mythimna separata* (Walker); and fall armyworm, *Spodoptera frugiperda* (J.E. Smith), along with other herbivores, poses significant threats to Asian rice ecosystems, causing considerable economic losses. This study investigates the occurrence and distribution of these armyworm species in rice agro-ecosystems across three Village Councils (VCs). Only *S. mauritia* larvae were observed, appearing in nursery fields approximately16-27 days after sowing and displaying sudden mass attacks primarily targeting seedlings at the 1-5 leaf stages. Damage manifestations included cutting leaf tips, creating shot holes on leaf blades, and occasionally severing seedlings at the base. The Ranjit variety in Kalaibari VC and the Gomati variety in Killa Verma VC showed the highest infestation rates (18.0%) and larval populations (1.7 larvae/m^2). These findings offer valuable insights for stakeholders involved in rice cultivation across Asian rice-producing nations.

Keywords: *Oryza sativa, Spodoptera mauritia, Spodoptera frugiperda, Spodoptera litura, Mythimna separata.*

Introduction

The North Eastern Region (NER) of India encompasses eight states and covers 26.2 million hectares (ha), known for its biodiversity and natural resources. Tripura, the third-smallest state in the northeast, lies between 22°56' and 24°32' North latitude and 90°09' and 92°02' East longitude. It falls within the Eastern Himalaya Region's agro-climatic zone, featuring a warm, humid tropical climate with high rainfall. Tripura comprises eight districts - South Tripura, Gomati, Sepahijala, West Tripura, Khowai, Dhalai, Unakoti, and North Tripura - spanning 1.05 million ha.

Rice (*Oryza sativa* L.) holds paramount agricultural significance in Tripura, notably in the Sepahijala district, where it is cultivated across 2.55 lakh ha and 0.48 lakh ha, respectively. Rice cultivation in Tripura is characterized by three distinct seasons: kharif or *aman* (June-July to November-December), *boro* or summer rice (November-December to May-June), and *aus* rice (February-March to July-August). However, rice production faces challenges from various biotic and abiotic factors. Among biotic factors, insect pests significantly limit yield, with an estimated loss of 27.9% (Mondal *et al.*, 2017). Common insect pests affecting rice in Tripura include the yellow stem borer, leaf folder, rice hispa, and ear head bugs (Bhattacharjee *et al.*, 2019). Invasive armyworms represent a considerable economic threat to cereals, legumes, and vegetables on a global scale. For instance, in the Philippines, the fall armyworm invasion presents a significant risk to rice crops (Valdez *et al.*, 2023), despite corn being their preferred host plant. To evaluate the damage caused by armyworms in rice crops, a survey was carried out.

Materials and Methods

The study area comprised villages within the Jampuijala block, Sepahijala district, Tripura, India, located approximately between 23°45' and 23°75' North latitude and 90°30' and 92°50' East longitude, with a focus on three Village Councils (VCs): Kalaibari VC, Killa Verma VC, and Twima VC (Fig. 1).

A sampling strategy involved purposefully selecting four farmers from each VC, with an additional four farmers chosen randomly, totalling 8 farmers per VC. Data collection included random sampling to assess armyworm larvae infestation within a one square meter nursery area in each farmer's field. Observations were made on damaged plants, and larvae presence near affected plants was noted. Damage extent was evaluated using the quadrat (1m x 1m) sampling method, recording data from three quadrants within each farmer's field, thus totalling nine quadrants per village.

Larvae were collected from various rice-growing areas using random sampling techniques and reared in controlled environments for species identification, diversity, and proportion determination. The period of study was for a month starting August 2023.

Results and Discussion

A systematic survey across three village councils (VCs) assessed the population dynamics of armyworm insect pests, revealing the presence of only the rice swarming caterpillar, *Spodoptera mauritia* (Boisduval). The study found that *S. mauritia* larvae mass attacked young seedlings suddenly during the 1-5 leaf stages and displayed extensive migration. Survey results confirmed the presence of *S. mauritia* larvae in all three villages (Fig. 1 & Table 1). Symptoms were detected in nursery fields between 16-27 days after sowing (Fig. 2 & Table 1). Various rice varieties were susceptible to *S. mauritia* infestation (Fig. 1 & Table 1). The larvae primarily targeted seedlings, severing them at the base (Fig. 3), and skeletonizing leaf tips along the margins. Additionally, young larvae were observed feeding on leaf tips and creating shot holes on the leaf blades (Fig.4). Most of the attacks were concentrated in nursery fields, consistent with findings reported by Sarma *et al.* (2021). The affected fields exhibited a distinctive appearance akin to cattle grazing, indicating extensive damage caused by the *S. mauritia* larvae. Maximum average infestation and larval population were recorded in Kalaibari VC (17.8% and 1.7 larvae/m²), closely followed by Killa Verma VC (17.7% and 1.7 larvae/m²) (Table 2). Previous research emphasized the peak incidence during the third week of August (Ramaiah *et al.*, 2018), and sporadic occurrences in India and Asian countries which cause losses intermittently (Guru *et al.*, 2021). Furthermore, Tanwar *et al*. (2010) documented occurrences of *S. mauritia* in India and other countries. Remarkably, during the 2016 kharif season, the Northeastern region, especially Assam, faced an outbreak of *S. mauritia*, affecting over 34,650 ha. across 28 districts (Sarma and Salam, 2018; Banu *et al*., 2022).

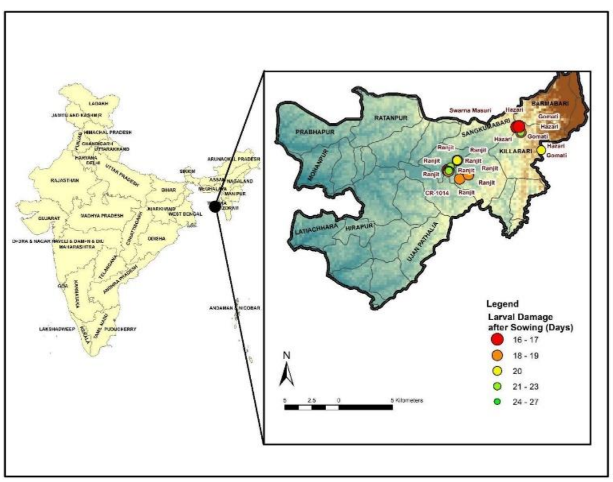

Figure 1. Map indicating sites of Rice Swarming Caterpillar, *Spodoptera mauritia* (Boisduval) presence on rice varieties and corresponding larval damage observed days after sowing, at village councils, Jampuijala, Tripura, India.

Table 1. Damage by Rice Swarming Caterpillar (*Spodoptera mauritia*) on Rice Varieties in Three Village Councils, Jampuijala Block, Sepahijala District, Tripura, India.

Village Council	Longitude	Latitude	Rice Variety	Larval Damage observed after Sowing (Days)
Kalaibari	91.469412^0	23.694755^0	CR-1014	20
Kalaibari	91.467367^0	23.710374^0	Ranjit	18
Kalaibari	91.467001^0	23.710402^0	Swarna Masuri	27
Kalaibari	91.467139^0	23.710227^0	Ranjit	20
Kalaibari	91.467189^0	23.710304^0	Ranjit	20
Kalaibari	91.46933^0	23.694747^0	Ranjit	18
Kalaibari	91.476608^0	23.698288^0	Ranjit	18
Kalaibari	91.47666^0	23.698206^0	Ranjit	19
Killa Verma	91.516975^0	23.738342^0	Hazari	17
Killa Verma	91.537500^0	23.718888^0	Gomati	22
Killa Verma	91.537509^0	23.718892^0	Hazari	20
Killa Verma	91.52049^0	23.733821^0	Gomati	19
Killa Verma	91.520499^0	23.733826^0	Swarna Masuri	23
Killa Verma	91.51878^0	23.738921^0	Hazari	17
Killa Verma	91.518919^0	23.738901^0	Hazari	16
Killa Verma	91.518871^0	23.738664^0	Gomati	16
Twima	91.459627^0	23.702102^0	Ranjit	17
Twima	91.45975^0	23.701428^0	Ranjit	20
Twima	91.461747^0	23.705282^0	Ranjit	22
Twima	91.459574^0	23.702141^0	Ranjit	25
Twima	91.45982^0	23.702496^0	Ranjit	22
Twima	91.459934^0	23.701209^0	Ranjit	18
Twima	91.459889^0	23.702382^0	Ranjit	22
Twima	91.460236^0	23.701578^0	Ranjit	23

Fig. 2. Survey for Armyworms in rice conducted with farmers' participation across various Village Councils in Sepahijala District, Tripura, India (Photo credits: Dharma Singh Jamatia, India).

Fig. 3. (A) Larva of *S. mauritia*, and (B) Feeding behavior observed in rice field (Photo credits: Utpal Dey, India).

Fig. 4. (A) *S. mauritia* larvae skeletonizing leaf tips of young rice seedlings, and (B) Young larvae creating shot holes on rice leaf blades (Photo credits: Utpal Dey, India).

Table 2. Rice Swarming Caterpillar (*Spodoptera mauritia*) Larval Population and Average Damage in Village Councils, Jampuijala Block, Sepahijala District, Tripura, India.

Village Council	Larval population /m²	Average Damage (%)
Kalaibari	1.7	17.4
Kalaibari	0.7	13.5
Kalaibari	1.3	15.1
Kalaibari	1.3	15.2
Kalaibari	1.7	18.0
Kalaibari	1.3	15.1
Kalaibari	1.0	16.2
Kalaibari	1.3	15.2
Killa Verma	1.3	16.2
Killa Verma	1.0	16.0
Killa Verma	0.7	13.6
Killa Verma	1.3	15.0
Killa Verma	1.3	14.5
Killa Verma	0.7	14.0
Killa Verma	1.3	14.5
Killa Verma	1.7	18.0
Twima	1.3	14.0
Twima	1.3	13.1
Twima	1.3	14.2
Twima	1.3	12.5
Twima	1.3	13.5
Twima	1.3	13.0
Twima	1.0	16.2
Twima	1.3	12.5

Field surveys observed *S. mauritia* damaging rice crops, alongside other species like common cutworm, *Spodoptera litura* (F.), rice ear-cutting caterpillar/paddy armyworm, *Mythimna separata* (Walker), and fall armyworm, *Spodoptera frugiperda* (J.E. Smith), occurring in the same fields, affecting various crops including corn, rice, sorghum, and sugarcane. Confusion among field workers regarding accurate species identification arises due to similarities in both larval and adult stages among different armyworm species. Hence, there is a need for a concise illustrated guide to help field workers and non-specialists identify these species accurately based on their adult, egg, larval, and pupal stages.

The larvae of *S. Mauritia* were found in Kalaibari VC, Killa Verma VC, and all three councils after rains following a dry spell. Climate change exacerbates armyworm outbreaks (Mochida *et al.,* 1987). Warmer temperatures, especially above 29°C, accelerate their growth, while minimum temperatures over 10°C spur voracious feeding (Palumbo, 2011; Pogue, 2002). Severe outbreaks often follow dry spells, concentrating egg-laying moths and providing ample food for caterpillars (Goergen *et al.*, 2016). Rainy seasons see peak populations, while dry periods promote survival and growth (Silvain and TiA-Hing, 1985). Increased rainfall fosters infestation (Murua *et al.*,2006). Climate change also affects natural pest control (Thomson *et al.,* 2010; *Sikha et al.*, 2011). Future research should identify specific climate-related risk factors for each species to develop sustainable management solutions, reducing pesticide reliance.

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Record of new pests of curry leaves (*Murraya koenigii* (L.) Spreng.) from Kerala, India

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Curry leaf (*Murraya koenigii* (L.) Spreng.) is a member of the Rutaceae family, which includes other plants such as citrus and bael. Curry leaf plants are fast-growing shrubs, and due to the classic fragrance of the leaves, they are an ineluctable crop in almost every South Indian homestead. However, the record of pests, which are the major constraint in the successful production of curry leaves, is lacking in Kerala, and there are only a few studies about the same in India as well. Therefore, a documentation study was undertaken from December 2021–November 2022 in Kerala which revealed new pests attacking curry leaves. This article discusses the description of the pests and their nature of damage and symptoms in curry leaves.

Apart from natural forest and homestead gardens, large-scale commercial cultivation of curry leaf is seen in Coimbatore, Tiruppur, Selem and Thoothukudi districts of Tamil Nadu, Sanga Reddy, Medak, Siddipet, Kama Reddy and Nizamabad districts of Telangana and Guntur, Nellore, Anantapur and Krishna districts of Andhra Pradesh (Mohan, 2012). There are very few homesteads in Kerala that do not have a curry plant. Tara and Sharma (2010) from Jammu have reported that despite being insecticidal in nature, curry leaves are attacked by several insect pests, which decrease the economic value of the plant. They also observed that the plants are mostly attacked by insects belonging to the order Hemiptera, followed by Lepidoptera and Coleoptera. Despite being the most common spice ingredient in Kerala's home gardens, there is no information available regarding the pests associated with curry leaf in the region.

A documentation study conducted for one year from December 2021-November 2022 in 20 homesteads of Thiruvananthapuram district (8.5307° N, 77.1025° E) in Kerala revealed new pests in curry leaves. The nature of the damage and its symptoms were carefully observed and documented. The collected pests were preserved in 70% alcohol for identification. The morphological characters of the insects were also noted under ZEISS Stemi 508 stereomicroscope available at the Department of Agricultural Entomology, College of Agriculture, Vellayani. The pests recorded are documented below:

Black looper *Hyposidra talaca* (Walker) (Lepidoptera: Geometridae)

The caterpillar was initially black in colour with rings of white spots (Fig. 1a). Later instars developed in size and turned plain brown in colour. This pest is reported to feed on several plants like *Ixora* sp. (Majumder and Ghosh, 2004), *Ipomoea batatas*, *Persia americana* (French, 2006) and *Glycine hispida* (Goyal, 2011) apart from *M. koenigii*. Early instars nibbled the tender leaves, at the leaf tips and made pin holes on the leaves. Later instars were voracious feeders and preferred matured leaves. Their population was however very scanty in the plants.

Hairy caterpillar *Olene mendosa* Hübner (Lepidoptera: Erebidae)

The caterpillar was hairy and greyish brown with a crimson-red head with reddish stripes. It also had four white tussocks on the dorsal side of the first four abdominal segments and a black hair pencil on the tail (Fig. 1b). Attacked plants included citrus (Nagalingam and Savithri, 1980), *Cedrus deodara* (Kalia *et al*., 2002), cinnamon (Rajapakse and Wasantha Kumara, 2007), cauliflower, potato (Chandel *et al*., 2011), *Flemingia semialata* (Meena *et al*., 2014), pigeon pea (Nair *et al*., 2017) and many other plant species apart from curry leaves. Caterpillars were severe defoliators and actively fed on the leaves of the curry plant resulting in characteristic geometric cuts on the leaves.

Tortoise beetle *Cassida exilis* Boheman (Lepidoptera: Chrysomelidae)

The adults were convex, metallic yellow-coloured beetles (Fig. 1c). Host plant records for *C. exilis* are *Amaranthus viridis*, *Celosia cristata*, *Digera muricata*, *Zizyphus jujuba* (Sultan *et al*., 2008) and kinnow mandarin (Singh and Sharma, 2014). The beetles scrapped from the lower surface of the leaves linearly and caused mine-like pattern in the leaves. Attacked leaves were easily recognizable because of this typical feeding symptom.

Ash weevil *Myllocerus brevirostris* Marshall (Coleoptera: Curculionidae)

Adult weevil was light greyish to white with two black spots on the elytral covers (Figure 1d). They fed on the leaves and resulted in the notching of leaf margins.

Scale insects: Lesser snow scale insect *Pinnaspis strachani* (Cooley) (Hemiptera: Diaspididae) and Giant scale insect *Icerya aegyptiaca* (Douglas) (Hemiptera: Monophlebidae)

Males of *P. strachani* were snow white and were commonly known as lesser snow scale. They were white, long, and slender, and had armor. The armor had three longitudinal ridges; one prominent center ridge and two marginal ridges (Fig. 1e). The females had no wings, legs, or eyes, and had an oval-shaped, yellowish, and flat body. It is reported to attack on plants such as hibiscus, tamarind, citrus, black pepper, arecanut, olives (Miller and Davidson 2005), neem (de Castro *et al*., 2020) and a variety of wild plants.

Adults of *I. aegyptiaca* were orange-red and covered with white wax. They are commonly known as giant scales (Figure 1f). Other hosts include *Persea americana, Musa* sp., *Citrus* spp., *Coccos nucifera, Pyrus communis, Ficus* spp., *Psidium guajava, Zea mays, Mangifera indica, Morus alba*, and *Vitis vinifera* (Bragard *et al*., 2023).

Numerous scale insects were seen colonizing the stem and under the surface of the leaves of curry plants, feeding on plant juices. Mostly plants in the seedling stage were attacked by these pests. Severe attacks resulted in reduced vigour and the death of seedlings.

Whitefly *Aleuroclava complex* Singh (Hemiptera: Aleyrodidae)

The adults were minute whiteflies that were seen on the ventral surface of curry leaves (Fig.1g). The nymphs were yellowish in colour which were also present on the lower surface of leaves. The infested leaves became yellow and eventually turned black due to the development of sooty mould. This resulted in reduced photosynthesis and vigour of the plant.

Leafhopper *Empoasca* sp. (Hemipetra: Cicadellidae)

Adults were homogenously green in colour with black eyes. The wings were hyaline and yellowish-green. Legs were pale yellow to green in colour. Nymphs and adults were mainly found on the tender plant parts, sucking sap (Fig. 1h).

Unidentified pests

Bagworms (Lepidoptera: Psychidae)

Bagworms were seen attached to the stems or leaves of the plants. They extended their head and thorax from their case to devour the leaves of the curry plant. On even slight disturbance, they withdrew the body parts into the case and stopped any movement (Fig. 1i).

Slug Caterpillar (Lepidoptera: Limacodidae)

Larvae were slug-like, with stinging hairs all over their body. They actively fed on the leaves (Fig. 1j).

Cowbug (Hemiptera: Membracidae)

Adults were seen on tender stems of the plant, sucking sap (Fig. 1k).

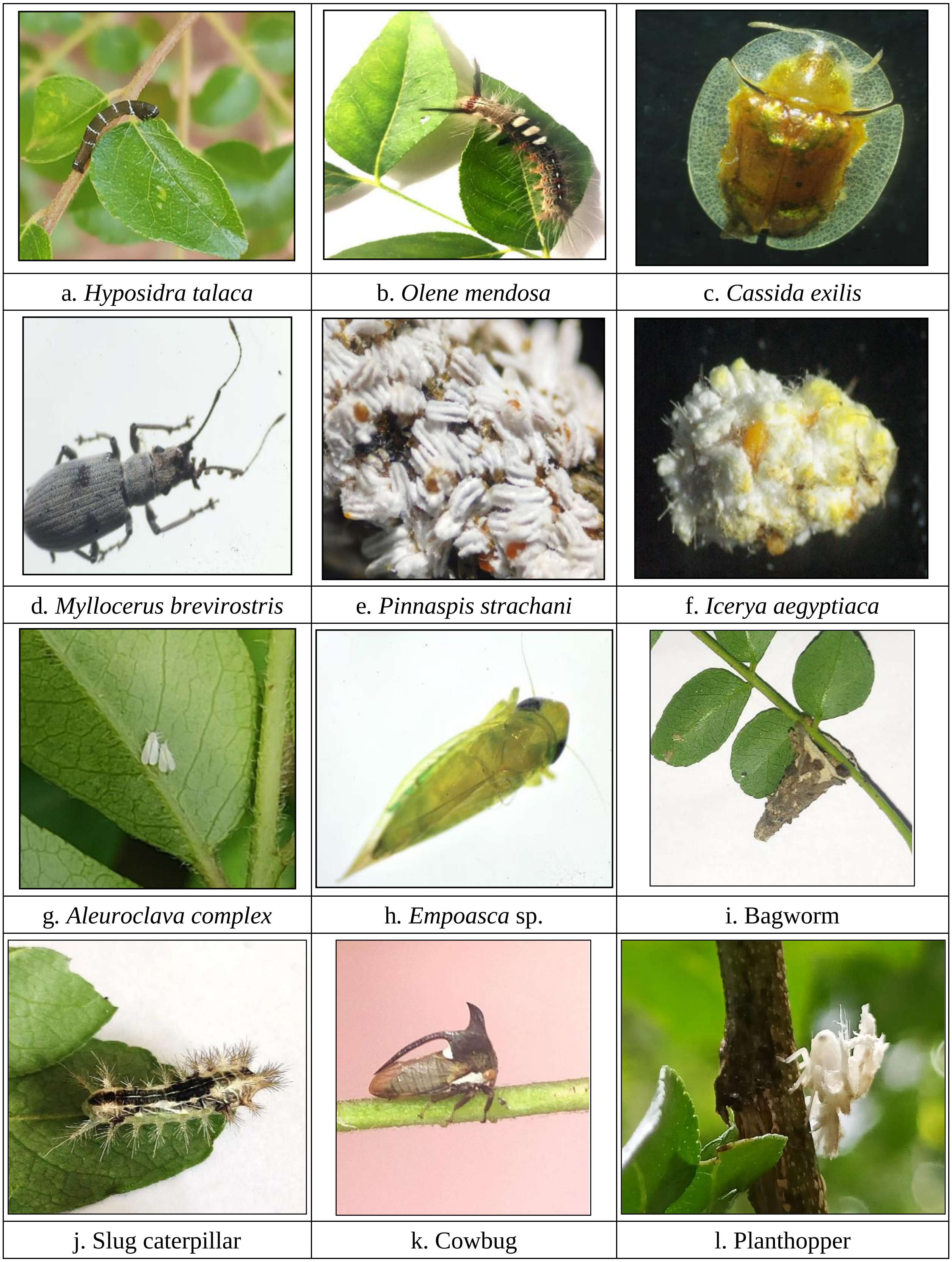
Planthopper (Hemiptera: Flattidae)

Nymphs and adults of hoppers were seen distributed on the tender parts of the curry plant, sucking sap (Fig. 1l).

The present study discovered eleven new pests associated with the curry leaf ecosystem from Kerala, India. Out of them, six were defoliators and rest were sucking pests. This is the first attempt at a consolidated documentation study of curry leaf pests from Kerala. As the curry leaf is emerging as a prominent export commodity in India, further studies should be carried out to identify pests that pose a threat to its successful cultivation.

Table 1: New pests attacking *Murraya koenigii* documented from Kerala, India

Sl. No.	Common name	Scientific name	Order: Family	Nature of damage
1.	Black looper	*Hyposidra talaca* (Walker)	Lepidoptera: Geometridae	Defoliator
2.	Hairy caterpillar	*Olene mendosa* Hübner	Lepidoptera: Erebidae	Defoliator
3.	Tortoise beetle	*Cassida exilis* Boheman	Lepidoptera: Chrysomelidae	Defoliator
4.	Ash weevil	*Myllocerus brevirostris* Marshall	Coleoptera: Curculionidae	Defoliator
5.	Scale insects	*Pinnaspis strachani* (Cooley)	Hemiptera: Diaspididae	Sap feeder
		Icerya aegyptiaca (Douglas)	Hemiptera: Monophlebidae	
6.	Whitefly	*Aleuroclava complex* Singh	Hemiptera: Aleyrodidae	Sap feeder
7.	Leafhopper	*Empoasca* sp.	Hemiptera: Cicadellidae	Sap feeder
8.	Bagworms	Unidentified	Lepidoptera: Psychidae	Defoliator
9.	Slug caterpillar	Unidentified	Lepidoptera: Limacodidae	Defoliator
10.	Cow bug	Unidentified	Hemiptera: Membracidae	Sap feeder
11.	Planthopper	Unidentified	Hemiptera: Flattidae	Sap feeder



a. *Hyposidra talaca* b. *Olene mendosa* c. *Cassida exilis*

d. *Myllocerus brevirostris* e. *Pinnaspis strachani* f. *Icerya aegyptiaca*

g. *Aleuroclava complex* h. *Empoasca* sp. i. Bagworm

j. Slug caterpillar k. Cowbug l. Planthopper

Fig. 1a to 1l. New pests documented from curry leaf

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First report of the occurrence of red palm weevil, *Rhynchophorus ferrugineus* (Olivier) (Coleoptera: Curculionidae) on banana in Kerala, India

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The red palm weevil (RPW), *Rhynchophorus ferrugineus* (Olivier) (Coleoptera: Curculionidae) originated in South Asia. It is a devastating pest of over 26 palm species and was initially reported as the pest of coconut (*Cocos nucifera* L.) (Dembilio and Jaques, 2012). Recently, an RPW attack on the banana cultivar '*Asomiya Malbhog*' was reported in Assam in India (Kalita *et al*., 2023). Now, for the first time in Kerala, the occurrence of RPW on banana cultivar '*Nendran*' from Thrissur district in Kerala, India has been observed. This sign of expanding host range requires special focus to prevent further spread of the pest.

In Kerala, banana is grown extensively in an area of 57695 ha with a production of 544189 tonnes contributing considerably to the state's economy (GOK, 2023). A few common insect pests of bananas are the banana pseudostem weevil (*Odoiporus longicollis* Olivier), banana rhizome weevil (*Cosmopoloitus sordidus* Germar), and banana aphid (*Pentalonia nigronervosa* Coquerel) (Krishnan*et al*., 2020). A major pest of coconut, *Oryctes rhinoceros* Linnaeus also attacks banana plants of various stages, in the state (Sivakumar and Mohan, 2013). Invasion of red palm weevil to the new feeding niche will severely impair crop production.

Incidence of RPW on banana cultivar '*Nendran*' in a banana plantation (10.517303° N, 76.255684°E) in Krishnapuram village, Thrissur district, Kerala was recorded as a part of a survey documenting pests of banana. This banana plantation has coconut plantations in its vicinity and the RPW infestation on banana plants is suspected to have spread from infested coconut palms. Both the adults and grubs of RPW were collected from severely infested plants. Taxonomic identification of adults was done following the key of Wattanapongsiri (1966). RPW infestation in the field was around 2% and the dominant pest seen in the field was banana pseudostem weevil (BPW). But the chances are high for the displacement of BPW by RPW in the long run.

Characteristic medium-sized holes and gummy exudation are the major symptoms of RPW attack on bananas. Voracious feeding of RPW grubs hollows out banana pseudostems from the inside. This causes yellowing and withering of leaves and immature fruit ripening. In advanced stages of attack, the pseudostem breaks at the apical region. Fermented odour emanates from infested plants. Adult RPW also feed on banana pseudostem.

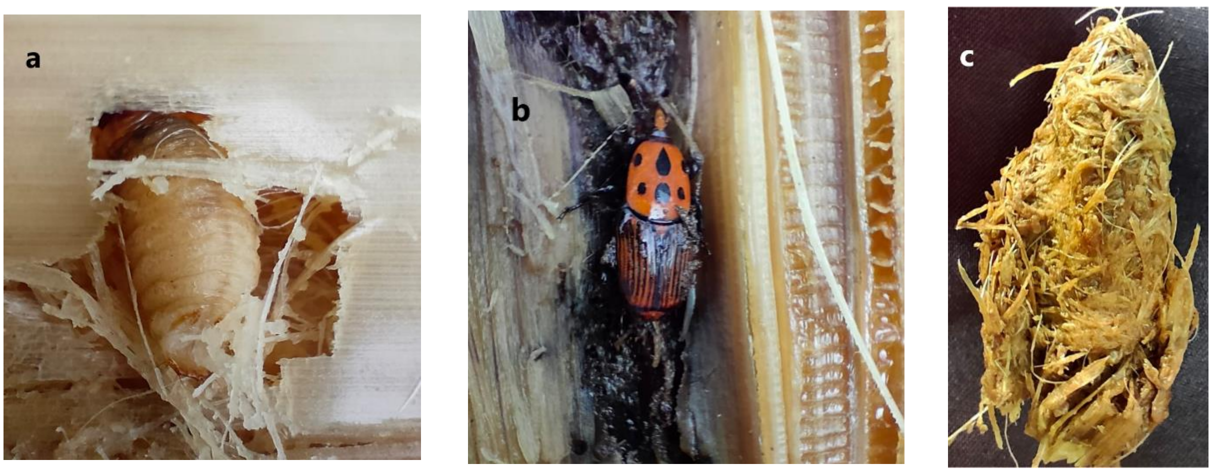

Fig. 1. ***a, b,*** *Rhynchophorus ferrugineus* grub and weevil feeding on banana pseudostem; **c,** *Rhynchophorus ferrugineus* pupation on banana pseudostem

Fig. 2. Severe infestation of *Rhynchophorus ferrugineus* on banana

This is the first report of RPW infestation on bananas in Kerala. Surveys must be conducted in different banana growing belts of the state to study the extent of invasion of the pest on bananas. Early pest detection is inevitable for successful pest management. Integrated pest management operations with a specific emphasis on environment-friendly strategies are advisable for RPW management in bananas. Intensive research is needed to study the biology, population dynamics, nature of damage, extent of infestation, and effective management strategies in bananas.

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Biology, morphometrics and mating behaviour of reduviid predator, *Rhynocoris marginatus* (Fab.)

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Abstract:

A biology study of *Rhynocoris marginatus* revealed that eggs of this species had a length of 2.65mm and breadth of 0.72mm, incubated for 8.07 days with an average 89% hatching rate. Average durations of first to fifth nymphal instars were 9.3, 9.5, 8.25, 11.4 and 19.45 days, respectively. The size of nymphs increased with successive nymphal instars with the first instar of 2.02 mm in length and the fifth instar being 9.4 mm in length. The average nymphal developmental period was 57.9±2.5 days. Female adults were easily distinguishable due to their broader size measuring a length of 15.2 mm and abdominal width of 5.92 mm, while male adults measured 12.3 mm in length and 4.2 mm in abdominal width. The sex ratio was female-biased (0.89:1). Pre-oviposition, oviposition and post-oviposition period lasted for 12.9, 44.6 and 5.6 days, respectively. Fecundity was 279±48.2 with an average of 45.5 eggs per batch. Female adults survived (63.1 days) more than males (42.1 days). Total generation time was found longer in females (129.3 days) than in males (108.8 days).

Keywords: Reduviid bug, Morphometrics, *Rhynocoris marginatus*,

Introduction:

In India, the reduviid bug, *Rhynocoris marginatus* (Fab.) (Hemiptera: Reduviidae) is a predator of a wide host range, with higher feeding potential and high longevity, which makes it an active biological control agent (Sahayaraj, 2014; Rahate *et al.*, 2023). Interestingly, reduviid bugs are famous for killing more prey than they need to satiate their life; therefore, they are counted as superior natural enemies (Sahayaraj, 2014). A detailedr ecord of morphometrics can be helpful for farmers and researchers to recognise random specimens of this species (Srikumar *et. al*, 2014). Therefore, this present investigation was carried out to study biology, morphometrics and mating behaviour of *R. marginatus*.

Materials and methods:

The primary culture of *R. marginatus* was obtained from the Regional Coconut Research Station, Bhatye, Ratnagiri, Maharashtra (16.9714^{O}N, 73.2987^{O}E). The nymphs were maintained in the laboratory and fed with the larvae of a factitious host, *Corcyra cephalonica* (Sahayaraj and Sathiamoorthi, 2002). Fresh-laid egg masses were collected and used for further study of biology at 25 ± 3^{0}C room temperature and 85±3% RH. During this study, various biological parameters were recorded. The mating behaviour of virgin males and female adults was documented by maintaining ten separate pairs in separate petri dishes provided with host larvae and optimum humidity (Sahayaraj, 2001; Sahayaraj, 2002). Morphometrics were recorded using a 'Dino-lite digital microscope'.

Results and Discussion:

Morphometrics and egg hatching

The eggs of *R. marginatus* were initially yellowish brown, elongated, curved to some extent, and cylindrical in shape with a slightly broader posterior end and narrower anterior end. Each egg had a white coloured bottle cap-like operculum on the anterior end. The eggs were found to change with progression into a reddish colour. The growth of the embryo inside the egg was evidently noticed due to the changing colour of the egg and a prominent blackish eye spot of developing nymph through transparent chorion. Further, the eggs observed were slightly shrivelled at the middle portion on the day of hatching. The length of the eggs was 2.45 to 2.87 mm and the breadth was 0.67 to 0.81 mm. Eggs hatched after 8.07 ± 0.08 days. The actual process of hatching was 2-3 hours from the opening of the operculum to the complete emergence of neonate nymph. Intermittent hatching with 70 to 100% success was recorded. Similar observations were recorded by Pravalika (2015) and Femi Mohasina (2017).

Nymphal developmental period and Morphometrics

Nymphal developmental period is explained in Table 1. The neonate nymphs (Instar I) of pale orange colour were congregated on egg mass itself for two to five hours. They avoid excessive movements of the body and change into reddish orange with a prominent oval black spot on the dorsal surface of the abdomen (Fig 1). Generally, 3 to 4 nymphs feed on a single larva of the host. The second instar nymph was bright orange with dark black legs. The anterior pronotal lobe was more prominently bulged than the first instar. The dorsal side of the abdomen was covered by a black oval spot. Moreover, the posterior end was black in colour. The third instar nymph was darker than earlier instars with elongated black band on both lateral sides of the abdomen. The pleural edges of the abdomen were slightly tilted upward. Fourth instar nymphs were dark orange in colour having reddish orange thorax and black coloured wing pads. Black oval abdominal spots enlarged progressively with their growth.

Fig. 1: First instar nymph

Fig. 2: Fifth instar nymph

Fig. 3: Freshly emerged adult

Fig. 4: Egg laying

Fig. 5: Mating

The fifth instar nymph was significantly reddish than earlier instars with a bulged anterior pronotal lobe and progressively developed black coloured wing pads on the pterothorax. The black oval spot covered almost the whole abdomen except the border area. Further, upward tilted pleural margins of the abdomen were dissolved and the abdomen took an oval shape (Fig 2). The size of the abdomen was normal at the beginning of this instar but it started increasing with successive feeding and was tapering toward the posterior end. The size of the abdomen was found to be larger in the nymphs which turned into female adults. Similar trends were recorded by Femi Mohasina (2017) with the average nymphal developmental period which was 32.96±1.91 days, when *R. margnatus* was reared on *S. litura*. Morphological differences were in confirmation with the findings of Petchidurai *et al.* (2000).

Morphometrics of adults and longevity: Soon after moulting, adults were bright orange in colour with black abdomen. Their body colour turned, after 5 to 7 hours, into dark black, except for the pronotum and scutellum which became bright red (Fig 3). Male and female were easily distinguishable, as the female was found to be broader in size than the male. Our findings are per George (1999) who observed the average adult longevity of 65.29±11.04 days.

Sex ratio: Sex ratio was worked out by examining 100 newly emerged adults, out of which average 47 were males and 53 were females with the male-to-female sex ratio indicating the predominance of females in the population (0.89:1), similar to Pravalika (2015), who recorded sex ratio of 0.8:1.

Table 1: Morphometrics of reduviid bug, *Rhynocoris marginatus* (Fab.)

Stage	Body length (mm)	Head length (mm)	Thorax length (mm)	Abdomen		Longevity of nymphs/adults (days)
				length (mm)	breadth (mm)	
I instar	2.02±0.09 (1.86-2.14)*	0.46±0.05 (0.39-0.54)	0.34±0.03 (0.29-0.40)	1.21±0.07 (1.12-1.32)	0.49±0.02 (0.45-0.51)	9.3±0.64 (8 - 11)
II instar	3.68±0.17 (3.46-3.94)	0.84±0.11 (0.71-1.02)	0.63±0.06 (0.56-0.75)	2.21±0.11 (1.96-2.33)	1.35±0.29 (1.06-0.91)	9.5±1.07 (8 – 12)
III instar	5.41±0.44 (4.71-5.98)	1.24±0.15 (0.99-1.54)	0.92±0.09 (0.74-1.04)	3.25±0.34 (2.73-3.75)	1.76±0.12 (1.56-1.98)	8.25±1.18 (7 – 11)
IV instar	8.05±0.68 (6.97-8.82)	1.84±0.23 (1.48-2.16)	1.38±0.17 (1.12-1.69)	4.83±0.48 (4.04-5.51)	2.56±0.28 (2.24-3.13)	11.4±1.93 (8 – 15)
V instar	9.47±0.46 (8.71-10.18)	2.17±0.30 (1.83-2.58)	1.62±0.15 (1.45-1.95)	5.68±0.31 (5.09-6.06)	4.37±0.77 (3.46-5.69)	19.45±2.29 (15 - 23)
Adult male	12.34±0.89 (10.95-13.62)	2.23±0.50 (1.86-2.66)	3.47±0.50 (2.85-4.47)	6.64±0.52 (5.76-7.3)	4.23±0.71 (3.16-5.47)	42.8±6.73 (34 – 52)
Adult female	15.22±1.20 (13.80-16.78)	2.67±0.29 (2.21-3.11)	3.99±0.46 (3.31-4.8)	8.57±0.75 (7.39-9.77)	5.92±0.78 (4.19-6.84)	63.1±9.56 (48 – 79)

*Range

Pre-oviposition, oviposition and post-oviposition period: The pre-oviposition, oviposition and post-oviposition period was presented in Table 2. Pre-oviposition period lasted for 9 to 17 days (Average of 12.9 ± 3.14 days). Females were observed to lay eggs for 33 to 54 days (Average 44.6 ± 6.31 days). Female adults died within 2 to 9 days (average 5.6 ± 2.12 days) after cessation of egg laying. These observations conform with the findings of Pravalika (2015), who reported a pre-oviposition period of 18.8 ± 0.37 days and an oviposition period of 58.5 ± 2.5 days.

Fecundity: Female laid eggs in batches, preferably on rough substrate. Eggs were glued to the substrate basally as well as to each other (Fig 4). The numbers of eggs laid in each batch by a female were more or less similar in number. Similar fecundity was noted by Pravalika (2015) (380±11.92 eggs) and Femi Mohasina (2017) (377.2 ± 45.52 with 44.33 ± 4.57 eggs per batch).

Life cycle: Precipitates of observations on life cycle of *R. marginatus* are presented in Table 2, which clearly indicates the multivoltine nature of *R. marginatus*, as discussed by Sahayaraj (2004) in his study.

Table 2: Life cycle of reduviid bug, *Rhynocoris marginatus* (Fab.)

Parameter	Range	Average
Incubation period (days)	8 - 8.2	8.07 ± 0.08
Hatching percentage	70 - 100	89 ± 9.94
Life cycle (egg to adult emergence) (days)	62 - 70	57.9 ± 2.59
Generation time – Male (days)	98 - 121	108.8 ± 8.77
Generation time – Male (days)	116 - 146	129.3 ± 9.96
Sex ratio (M:F)	-	0.89:1
Pre-oviposition period (days)	9 - 17	12.9 ± 3.14
Oviposition period (days)	33 - 54	44.6 ± 6.31
Post-oviposition period (days)	2 - 9	5.6 ± 2.12
Total no. of eggs batches/female	5 - 8	6.3 ± 1.06
Average no. of eggs per batch	27.63 - 64	45.54 ± 11.56
Total fecundity (days)	215 - 354	279 ± 48.2

Mating behaviour: All the mating adults were observed to follow same sequential act of mating. Male and female adults started walking around the arena just after they got introduced to each other. The approach was first done by males by extending the antennae followed by a significant extension of the rostrum than that observed during predation. Then the female became less active in submitting herself for the act of mating and the male began touching her antennae. Excited movements of male like riding over position were followed by antennal extension of both. Particularly, the male was using its extended rostrum for pressing thorax of female from upper side. Further, the male held dorsolateral position with the female for copulation. Female was gripped using fore and hind pair of legs by male and she became motionless. Male started copulation using aedeagus at female genitalia after having proper grip (Fig 5). Sometimes female walked around with the male on her body during copulation. Antennae of both were found dropped down at end of copulation. Post-copulatory cannibalism was not observed in any case. Both the partners move away from each other after completion of mating process. These observations are in conformity with the records on mating behaviour by Ambrose and Livingstone (1983).

Conclusions

The present study suggests that the life cycle of the reduviid predator can survive for a comparatively longer duration than many other natural enemies. Therefore, conservation and augmentation of this predator in the field can be helpful to protect the crop from different kinds of pests for a long time.

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Seasonal incidence of insect-pests affecting Aonla (*Emblica officinalis* Gaertn.) in relation to abiotic factors

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Abstract

The observations were recorded at Sardarkrushinagar, Gujarat during 2021 at fortnightly intervals in field from 1st Standard Meteorological Week (SMW) to 52nd SMW. The damage due to *Betousa stylophora* Swinhoe ranged between 0.80 and 48.8 percent with its peak (48.8% twig damage) in the 35th SMW, while the leaflet damage due to leaf rolling caterpillar ranged between 0.11 and 12.48 percent and exhibited its peak (12.48%) during the 31st SMW. In the case of bark eating caterpillar, the infestation ranged between 2.00 and 10.00 percent branch damage and reached its peak level (10.00%) during 26th SMW. Commencement of aphid appearance was recorded from 15th SMW with 0.02 aphid index, which reached its first peak (2.78 index) during 24thSMW and second peak (1.12 index) during 31st SMW. Physical factors *viz.* minimum temperature (MinT), morning relative humidity (RH_1), evening relative humidity (RH_2), rainfall (RF) and bright sunshine (BSS) established significant correlation with 'r' value of 0.521**, 0.578**, 0.887**, 0.605** and -0.665**, respectively with gall forming black caterpillar. The infestation of leaf rolling caterpillar established significant correlation with MinT (r= 0.592**), RH1 (r= 0.636**), RH2 (r= 0.883**), wind speed (WS) (r= 0.395**), RF (r= 0.521**) and BSS (r= -0.770**). The activity of bark eating caterpillar established significant positive correlation with physical factors *viz*., MinT (r= 0.436*), RH2 (r= 0.404*) and WS (r= 0.663**) whereas, aphid showed positive association with MinT (r= 0.588*), RH1 (r= 0.424*), RH2 (r= 0.385*) and WS (r= 0.824**).

Key words- Aonla, *Betousa stylophora,Cerciaphis emblica,Gracillaria acidula, Inderbela tetraonis*,, Insects, Seasonal incidence

Introduction

An essential crop for India's horticulture is the Indian Gooseberry, also known as Aonla or *Emblica officinalis*. It is a deciduous tree of average height. In tanning and dyeing, the fruit, bark, and leaves are employed. It is one of the richest natural sources of vitamin C, (Ascorbic acid) which has sparked a lot of curiosity among scientists. The fruits can also be used to make pickles, marmalade, jam, and sauces(Shrivastava, 1990). Despite being regarded as a hardy fruit crop, not less than 30 insect and mite species from various locations, especially from India (Lakra, 1996) affect this crop. Among the insect pests, the aonla shoot gall maker (*Betousa stylophora*), leaf rolling caterpillar (*Gacillaria acidula*), bark eating caterpillar (*Inderbela quardinatata*), fruit borer (*Dueodorix isocrates*), fruit moth (*Otheris fullonica*), aphid (*Cerciaphis emblica*) and mealybug have been reported to be of major importance (Chadha, 2003). Farmers in Gujarat are struggling with insect problems as the area under aonla cultivation has grown over the years. Since the prevailing environmental conditions, such as temperature, relative humidity, and precipitation, have a significant impact on the occurrence and development of all insect pests. The present investigation is to generate baseline data and fill the existing information gaps.

Material and Methods

The observations were carried out at the Horticultural Instructional Farm, C. P. College of Agriculture, S. D. Agricultural University (24.327160, 72.305093), Sardarkrushinagar on aonla variety *NA 7* in the year 2021. A 60 m × 30 m section with 6 m × 6 m spacing was chosen for the experiment from the entire orchard. The trees were kept free from the application of any insecticides throughout the study period. Five trees were randomly selected and tagged. Observations on major insect pests were recorded at fortnightly intervals.

Observations on infestation due to apical twig gall maker, number of healthy and damaged twigs were recorded from twenty-five randomly selected twigs and percent twig damage was calculated. Damage due to leaf roller was recorded by counting total number of healthy and damaged leaflets from 10 cm length of ten compound leaves in each selected tree. Infestation due to bark and shoot borer was recorded by observing ten randomly selected branches of the tagged trees. The activity of aphids was recorded by using the 0 to 9 index given by Bharpoda *et al.* 2009.

Where,

0 = no aphid population,

1 = colony formed up to 1 cm length,

2= colony formed up to 2 cm length,

3 = colony formed up to 3 cm length,

4 = colony formed up to 4 cm length,

5= colony formed up to 5 cm length,

6 = colony formed up to 6 cm length,

7 = colony formed up to 7 cm length,

8 = colony formed up to 8 cm length,

9 = colony covered entire 10 cm length of terminal shoot/twig.

The data, were correlated with the weather parameters *viz.,* daily rainfall (mm), minimum and maximum temperatures (ºC), evaporation (mm), morning and evening relative humidity (%), bright sunshine (hr/day) and wind speed (km/hr) were collected from the Department of Agricultural meteorology, C.P. College of Agriculture, SDAU, Sardarkrushinagar and fortnightly values were computed.

Results and Discussion

1. Population dynamics

The results on the occurrence of gall forming black caterpillar, *B. stylophora*on aonla are presented in Table 1 and depicted in Fig. 1 revealing that the damage commenced from 1st Standard Meteorological Week (SMW) which recorded 2.4 percent twig damage due to gall forming black caterpillar. The infestation gradually decreased (0.8 % twig damage) during 5th SMW. No gall formation due to gall forming black caterpillar was observed during 7th SMW to 18th SMW. Thereafter, the infestation increased and reached its peak during 35th SMW with 48.8 percent twig damage. The infestation due to gall forming black caterpillar showed gradual decrease from 37th SMW till 50th SMW, which ranged from 3.2 to 44.8 percent twig damage. Thus, an average twig damage due to *B. stylophora* was recorded at 14.68 percent and higher activity of the pest was observed during 28th SMW (34.4 %) to 37th SMW (44.8 %) in aonla crop.

Infestation due to leaf rolling caterpillar, *G. acidula*on aonla revealed that the damage commenced from 1st SMW which recorded 0.63 percent leaflet damage due to leaf rolling caterpillar (Table 1 and Fig. 1). The infestation gradually decreased (0.11 % leaflet damage) during 7th SMW. There was no infestation due to leaf rolling caterpillar observed during 9th SMW to 18th SMW. The population gradually increased due to *G. acidula* from 20th SMW to 35th SMW, it ranged from 2.25 to 12.48 percent leaflet damage. Thereafter, the population started to decrease gradually after the 37th SMW to 50th SMW, it ranged from 0.32 to 6.47 percent leaflet damage. Thus, the average damage percent due to leaf roller was 2.98 percent leaflet damage and higher activity of the pest was observed during 28th SMW (9.61 %) to 31st SMW (12.48 %) during the crop period.

Infestation of bark eating caterpillars was observed throughout the year, which ranged from 2.00 to 10.00 percent branch damage (Table 1 and Fig. 1). The higher (6 % to 10 %) branch damage was recorded during 26th to 35th SMW. Whereas, the infestation was (2 % to 4 %) negligible during the rest of the crop period. Thus, the average branch damage was recorded as 3.75 percent in aonla throughout the crop period.

The results on occurrence of aonla aphid, *C. emblica* on aonla indicated that the population was commenced from 15th SMW which recorded 0.02 aphid index (Table 1 and

Fig. 4). The population gradually increased from 15th SMW and reached its first peak during 24th SMW (2.78 aphid index). Thereafter, the aphid population showed its second peak during 31st SMW which recorded 1.12 aphid index. Thus, the average population of aphid was 0.45 aphid index on aonla during the crop period.

Table 1: Incidence of major pests of Aonla during 2021

SMW	Insect Infestation			
	Gall forming black caterpillar (Twig damage %)	**Leaf roller (Leaflet damage %)**	**Bark eating caterpillar (Branch damage %)**	**Aphid Index (0-9)**
1	2.40	0.63	2.00	0.00
3	1.60	0.45	2.00	0.00
5	0.80	0.18	4.00	0.00
7	0.00	0.11	4.00	0.00
9	0.00	0.00	4.00	0.00
11	0.00	0.00	4.00	0.00
13	0.00	0.00	2.00	0.00
15	0.00	0.00	2.00	0.02
18	0.00	0.00	2.00	0.26
20	0.80	0.37	2.00	0.94
22	2.40	2.25	6.00	2.14
24	5.40	3.67	6.00	2.78
26	23.20	5.23	10.00	2.28
28	34.40	9.61	8.00	0.26
31	36.80	12.48	8.00	1.12
33	40.80	10.41	6.00	0.82
35	48.80	8.83	2.00	0.08
37	44.80	6.47	2.00	0.06
40	37.60	3.89	2.00	0.42
42	30.40	4.32	2.00	0.16
44	21.60	2.93	4.00	0.00
46	16.80	2.31	2.00	0.00
48	10.40	1.84	2.00	0.00
50	4.80	0.68	2.00	0.00
52	3.20	0.32	2.00	0.00
Mean	**14.68**	**2.98**	**3.75**	**0.45**
Note: SMW- Standard Meteorological Week				

2. Correlation with abiotic factors

The results presented in Table 2 indicated that the minimum temperature (MinT) exhibited a significant or highly significant positive correlation with major pests *viz*., gall forming black caterpillar (r=0.521**), leaf roller (r=0.592**), bark eating caterpillar (r=0.436*) and aphid (r = 0.588**) incidence. Further, relative humidity (RH_1) exhibited significant or highly significant positive correlation with major pests *viz*., gall forming black caterpillar (r=0.887**), leaf roller (r=0.883**), bark eating caterpillar (r=0.404*) and aphid (r= 0.385*) incidence. It is also evident from the result that the incidence of gall forming black caterpillar (r=0.658**), leaf rolling caterpillar (r= 0.883**) and aphid (r=0.429*) had a significant positive correlation with morning relative humidity (RH_1). Leaf rolling caterpillar (r= 0.395*), bark eating caterpillar (r=0.654**) and aphid (r=0.824**) were highly significant with the wind speed (WS). Rainfall (RF) was highly significant with gall forming black caterpillar (r= 0.605**) and leaf rolling caterpillar (r=0.521**) whereas, bright sunshine hours was highly significant but negative correlation with gall forming black caterpillar (r= -0.665**) and leaf rolling caterpillar (r= -0.770**). Bharpoda *et al.* (2009), Patel *et al.* (2013), Norboo *et al.* (2018), Sashidharan and Verma (2008) and Meshram *et al.* (2017) also studied pests of aonla in relation to abiotic factors.

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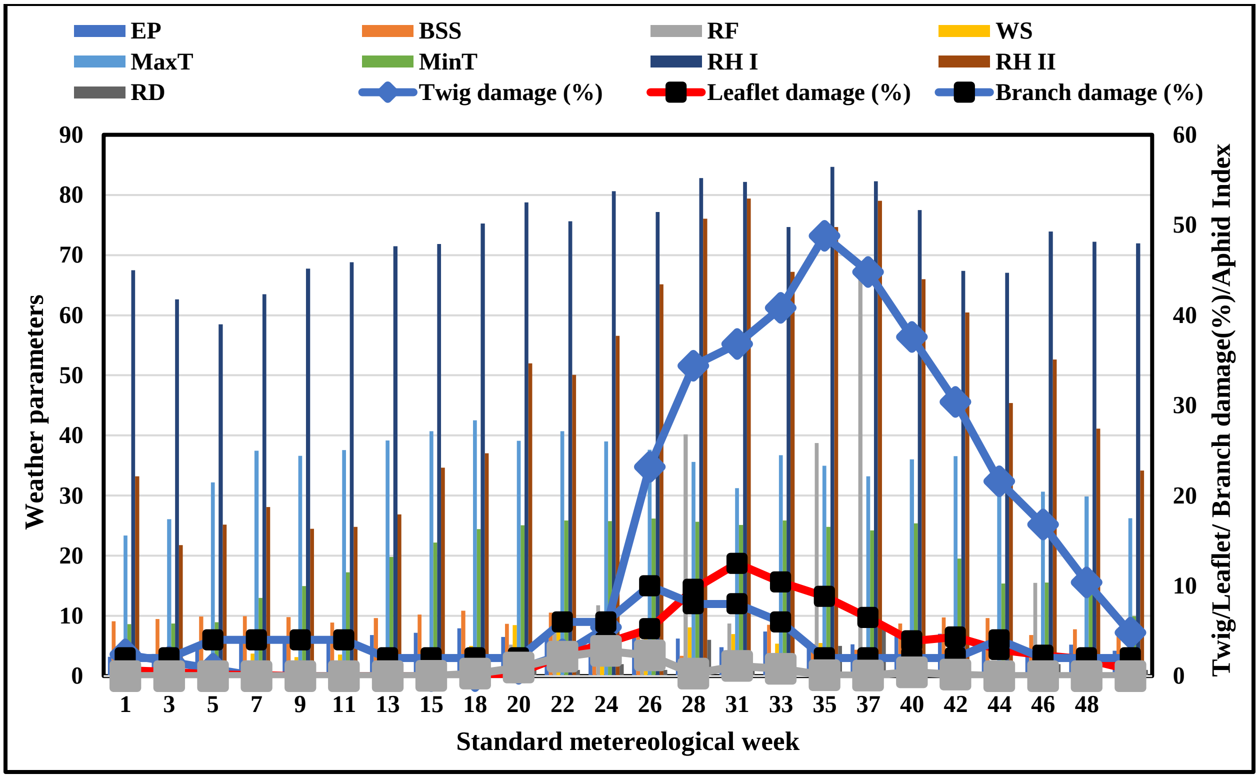

Fig. 1: Incidence of insect pests on aonla during 2021

Table 2: Correlation between major pests of aonla and weather parameters during 2021

Sr. No.	Pests	Weather parameters							
		Temperature		Relative Humidity		Wind speed	Rainfall	Evaporation	Bright sunshine
		Max	Min	Morning	Evening				
1	**Gall forming caterpillar**	-0.023	0.521**	0.578**	0.887**	0.116	0.605**	0.153	-0.665**
2	**Leaf rolling caterpillar**	0.019	0.592**	0.636**	0.883**	0.395*	0.521**	0.126	-0.770**
3	**Bark eating caterpillar**	0.247	0.436*	0.269	0.404*	0.663**	0.073	0.188	-0.354
4	**Aphid**	0.387	0.588**	0.424*	0.385*	0.824**	0.003	0.315	-0.114

Note: *Significant at 5 percent level (r = 0.381), **Significant at 1 percent level (r = 0.487),

Fig. 2. ***Betousa stylophora***

Fig. 3. ***Gracillaria acidula***

Fig. 4. ***Inderbela tetraonis***

Fig. 5. ***Cerciaphis emblica***

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Biology and morphometry of curry leaf tortoise beetle, *Silana farinosa* (Boheman) (Coleoptera: Chrysomelidae: Cassidinae)- an emerging pest in Kerala

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Abstract

Silana farinosa (Boheman), commonly known as curry leaf tortoise beetle, is a coleopteran pest of curry leaves and some other plants belonging to the Rutaceae family. It is an emerging major pest of curry leaves in India that can cause severe defoliation to the crop. A female lays an average of 5.00 $\pm$ 0.52 ootheca in her lifetime with a mean of 14.00 $\pm$ 0.33 eggs in it. The average duration of the egg stage was 5.30 $\pm$ 0.15 days, the grub stage was 16.80 $\pm$ 0.29 days, the pupal stage was 5.00 $\pm$ 0.21 and the adult stage was 81.10 $\pm$ 0.80 days.

Key words: Curry leaf, *Silana farinosa*, Kerala

Introduction

Curry leaf *Murraya koenigii* (L.) Spreng. (Rutaceae) is an important perennial leafy vegetable cum spice and an indispensable ingredient of Indian cuisines. The leaves are highly valued for their characteristic citrusy aroma and flavour. It is also a crop that is heavily focused on exports, with India being its top exporter globally, followed by Sri Lanka and Kenya (Volza, 2023). Curry leaves are an ineluctable crop in practically every South Indian homestead due to the fast growth of the shrub and the distinctive aroma of the leaves. Recently, the government of Kerala has taken the initiative to popularize curry leaf plants in every homestead. With increased area under cultivation, there is a shift in pest status of many species infesting curry leaf of which *S. farinosa* requires special attention.

Boheman first identified this species as *Cassida farinosa* in 1856 from Sri Lanka and later, Sapaeth established the genus *Silana* as the sole classification for this species in 1914 (Pathour *et al.*, 2021). It was earlier noticed causing heavy damage to curry leaves grown in Peninsular Malaysia (Sajap and Mohamedsaid, 1997) and Sri Lankan regions (Talagala and Manawadu, 1979). Takizawa (1980 and 1985) reported the occurrence of this beetle on *Ziziphus* sp. from Tamil Nadu, India. Pathour *et al*. (2021) reported a sporadic outbreak of this beetle in the Karnataka regions causing heavy loss to curry leaves grown there. Nowadays, the attack of *S. farinosa* is severe in Kerala. As a result of an increase in the cultivation of curry leaf in South Indian states, the curry leaf tortoise beetle attains the status of major pest and adversely affects the economy of curry leaf farmers. As detailed information on the lifecycle of a pest is essential to elucidate proper management measures, the biology, and morphometry of *S. farinosa* are studied in detail in this project.

Materials and Methods

The biology of *S. farinosa* was studied at the Department of Agricultural Entomology, College of Agriculture, Vellayani, Thiruvananthapuram (8°25'36.70410"N, 76°59'6.08759"E) Kerala during the year October 2021- September 2022. Ootheca of the beetles were collected from the field along with tender leaves on which they were laid and were kept for hatching in petri dishes lined with filter paper. The tip of the petiole was covered with a moist cotton plug to prevent drying up. Grubs hatched were transferred to another petri dish and were provided with fresh tender leaves twice daily (Fig.1). Last instar grubs were transferred to plastic containers for pupation and adult emergence. Adult pairs were transferred to separate containers to study fecundity and longevity (Fig.2). Leaves were provided daily and freshly laid ootheca were transferred to petri plates to study the biology of the insect. The biological and morphological parameters of the insects were studied during the period from October 2021 to September 2022. The biological parameters observed were egg, grub, adult and total life cycle, and fecundity of the females. Morphometric measurements recorded were ootheca diameter, grub, pupal and adult length, and width, under microscope using Zeis Zen 3.6 software.

Fig 1: Rearing of *S. farinosa*

Fig 2: Fecundity study

Results and Discussion

The adult beetles were hemispherical in shape like tortoises. The average size of the adults was 6.80 $\pm$ 0.14 and 4.81 $\pm$ 0.03 mm in length and width. Sajap and Mohamedsaid (1997) reported the size of the beetles as 6 and 5 mm in length and breadth, respectively. Hari (2020) observed the size of the beetles as 6.60-7.70 mm length and 5.30-6.00 mm in width. Teneral adults were light yellow in colour and about two to three hours later, their colour changed to brown. The beetles developed a white waxy coating on their body after two to three days of hatching. The average adult period recorded was 81.10 $\pm$ 0.80 days (Table 1). This was in contrast to the report by Sajap and Mohamedsaid (1997) in Peninsular Malaysia, where they recorded the average adult period as 45 days. This variation can be attributed to the varying climatic parameters in different regions. Another work by Talagala and Manawadu (1979) reports the adult's longevity to be four months.

Fig 3: Adult beetle

Fig 4: Mating

Male and female beetles were hard to distinguish superficially. Both were hemispherical in shape with a white-waxy coating on their body (Fig.3). Sometimes the male beetles were smaller than the females but that was not always the case. Males were identified by the position they assumed during the mating process. Mating usually started one week after the adult emergence and this was in tune with the observation by Sajap and Mohamedsaid (1997). Mating was observed during the morning hours and during mating, the males mounted on the top of the females, with their legs grasping their counterpart's elytra firmly (Fig.4). The fecundity was on an average 5.00 $\pm$ 0.52 ootheca per female under laboratory conditions. Sajap and Mohamedsaid (1997) also reported that the average fecundity of a female was three to four oothecas during her entire life.

The eggs were laid by the females on the ventral surface of leaves. The individual eggs were elliptical in shape and they were stacked to each other. After laying a batch of eggs, the female beetles secreted a clear fluid on the top of the eggs (Fig.5) which hardened to form a reddish-brown, dome shaped ootheca (Fig.6) within a few hours. The purpose of this secretion was to protect the eggs from natural enemies. The diameter of the ootheca was on average 3.96 ± 0.03 mm. Talagala and Manawadu (1979) recorded the average size of the eggs as 4.00 by 3.50 mm whereas Sajap and Mohamedsaid (1997) reported the average diameter of an ootheca as 3.00 mm. Ootheca was firmly attached to the lower surface of young leaves. The number of eggs in an ootheca was 14.00 ± 0.33 eggs. The average duration of the egg stage was 5.30 ± 0.15 days.

Fig 5: Freshly laid eggs

Fig 6: Hardened ootheca

The eggs hatched to give rise to grubs (Fig.7). Grubs were similar in form and they increased in size later (Fig.8). Their colour changed from yellowish green in the first instar to greenish black in the fifth instar during the development. The mean length and width of the instars are given in Table 2. The grubs were elongated and tapered distally. They had 8 pairs of spines on their thoracic and abdominal segments. The abdomen at its posterior end had caudal appendages, which consisted of a long anal tube and a dorsal forked process, called urogomphi, that were bent upward. The exuviae and faeces gathered at the urogomphi as a result of the larvae's incomplete cuticle shedding during moulting. Over the body, a black ball-like waste material gradually developed from the exuviae and the faeces. The larvae typically flicked the excreta in the shape of a ball up and down when threatened. The average grub period was 16.80 ± 0.29 days. Talagala and Manawadu (1979) recorded a mean grub period of 18 days and Sajap and Mohamedsaid (1997) recorded the average duration of each stadium as 3, 3, 3, 3 and 6 days, respectively.

Fig 7: Newly hatched grubs

Fig 8: Different instars of *S. farinosa* grubs

The pre-pupal period usually lasted for about one day, similar to that recorded by Sajap and Mohamedsaid (1997). The pupa appeared from the larval cuticle through a split in the median line of the thorax and pushed the exuviae to the caudal appendages. The pupal case was made of exuviae and faeces of the grubs. The pupa was initially yellow (Fig.9) and later changed to brown (Fig.10). It also had a broad pronotum. Abdominal segments also contained spines. Pupal period was about 5.00 $\pm$ 0.21 days and the mean length and width of the pupae were 6.84 ± 0.04 and 5.74 ± 0.11 mm, respectively. Sajap and Mohamedsaid (1997) recorded the mean length and width of the pupa as 7.00 and 5.00 mm, respectively and the pupal period as five to six days.

Fig 9: Pupal stage (initial)

Fig 10: Pupal stage (final)

Table 1: Biological parameters of curry leaf tortoise beetle, *Silana farinosa*

Parameters	No. of days		Mean ± SE
	Minimum	Maximum	
Egg period	5	6	5.30 ± 0.15
Grub period	16	18	16.80 ± 0.29
Pupal period	4	6	5.00 ± 0.21
Adult period	78	85	81.10 ± 0.80
Total period	104	111	108.20 ± 0.77
Fecundity	3	7	5.00 ± 0.52

N=10; SE- Standard error

Table 2: Morphological parameters of curry leaf tortoise beetle, *Silana farinosa*

Sl. No.	Particulars	Morphometric measurements (mm)		Mean ± SE
		Minimum	Maximum	
1.	**Ootheca**			
	Diameter	3.8	4.06	3.96 ± 0.03
2.	**First instar grub**			
	Length	2.29	2.65	2.46 ± 0.04
	Width	0.77	0.83	0.79 ± 0.01
3.	**Second instar grub**			
	Length	3.73	4.28	4.00± 0.06
	Width	1.43	1.49	1.46 ± 0.01
4.	**Third instar grub**			
	Length	5.78	6.14	5.99 ± 0.03
	Width	2.67	2.79	2.72 ± 0.02
5.	**Fourth instar grub**			
	Length	7.88	8.12	7.98 ± 0.03
	Width	3.55	3.59	3.58 ± 0.01
6.	**Fifth instar grub**			
	Length	9.78	10.13	9.96 ± 0.04
	Width	4.89	5.26	5.05 ± 0.04
7.	**Pupa**			
	Length	6.66	7.03	6.84 ± 0.04
	Width	5.35	6.25	5.74 ± 0.11
8.	**Adult**			
	Length	6.45	7.35	6.80 ± 0.14
	Width	4.68	4.88	4.81 ± 0.03

N=10; SE- Standard Error

Grubs and adults of *S. farinosa* are also reported to feed on other plants like *Ziziphus* sp. (Takizawa, 1980) and *Micromelum minutum* (Mohamedsaid, 2006). Grubs exhibited congregating behaviour whereas adults were found scattered on the leaves. Cycloalexy is the term used to describe this particular behaviour of the grubs. These coordinated movements are used to repel their natural enemies (Vasconcellos-Neto and Jolivet, 1994). *S. farinosa* upon hatching, moved to the ventral surface of leaves, in a gregarious manner and they fed by scrapping the epidermal layer of the leaves (Fig.11). As a result of their feeding, leaves were left with only a thin layer of membrane and hence the plants looked sickly and burnt in appearance. Kumari *et al.* (2017) reported that the grubs caused maximum damage to the plants, by scraping green matter from the ventral surface of leaves leaving behind only a net like leaf lamina. Pathour *et al.* (2021) also noticed similar symptoms caused by the beetle in Karnataka. The mode of feeding by adult beetles was however different. The adults completely ate up the leaves, similar to a caterpillar's mode of feeding (Fig.12). The attack by the pest also caused yellowing and defoliation of the plants. Since the beetle feeds on leaves, which is the main economic part of the plant, appropriate management strategies need to be followed against its outbreak.

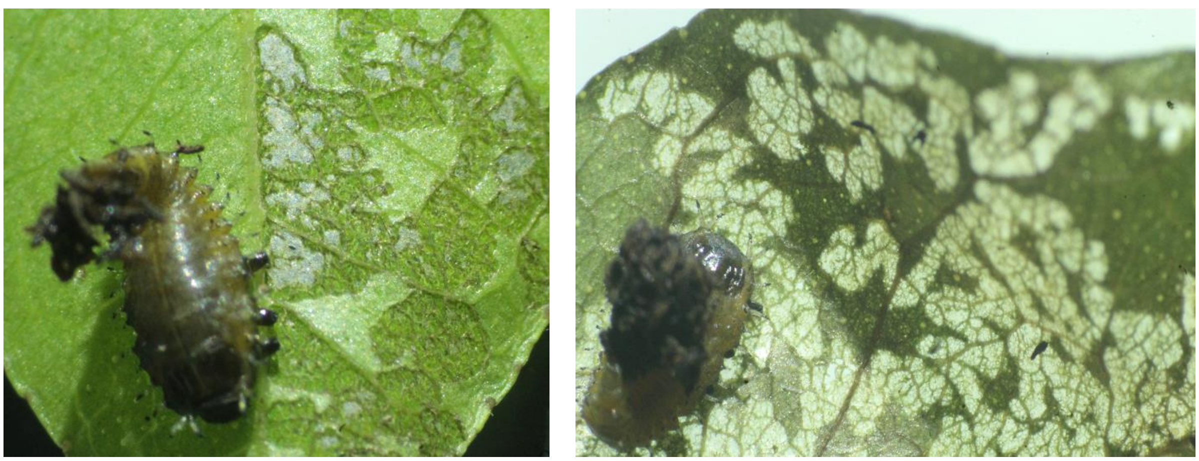

Fig 11: Feeding symptom by grubs

Fig 12: Feeding symptoms by adult

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A study on the public awareness and attitude towards weaver ant nests in and around St Joseph's University Campus, Bengaluru, Karnataka

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Ants are one of the most common insects belonging to the order Hymenoptera. Globally there are 12,571 species of ants. The Indian subcontinent has 828 species belonging to 100 different genera (Rajagopal *et al.*, 2018), among which the Asian weaver ant, *Oecophylla smaragdina* (Formicidae) well known for the unique layout of their nests. *O. smaragdina* weaves the leaves together with the help of the silk produced by their larvae to construct the nest. Weaver ants are part of the diet, medicine and tradition of the local people of many tribes found in Assam (Langthasa *et al.*, 2017). The weaver ants are found to be more active at the temperature of 20-25℃, and activity decreases with the increase of the temperature to 30℃ (Sangma *et al.*, 2021). *O. smaragdina* nests play a very important role as biological control in fruiting plants (Verghese *et al.*, 2013). Characteristics and features of the tree and the leaves might be taken into account for the nest site selection by the weaver ants (Devarajan, 2016). Weaver ants feed on nectar and honeydew produced by various homopterans (Blüthgen and Fiedler, 2002). And yet are viewed as pests particularly in urban areas where pesticides or herbal extracts are used to eradicate them. Red ants are also found to feed on mosquitoes and so act as biological controllers (Vanitha, 2021).

A study was conducted in and around the campus of St. Joseph's University, Bengaluru (12.96 N Latitude and 77.59 E Longitude) (Map 1 and 2). St. Joseph's University is located in the heart of Bengaluru, surrounded by the residential area, where the average temperature oscillates between 31℃-18℃. *O. smaragdina* nests were spotted in the study area. Perception study about the species was undertaken with the residents of the area and the number of nests per plant/tree was counted. A total of fifteen households were visited during the survey in and around the SJU campus (Map 2). During the survey, the following questions were asked of the residents: 1). Did they know what the nest was? 2). Were they aware of the presence of ant nests in their vicinity? 3). Did they know it belonged to the weaver ant? 4). What is their opinion on the nest? Is it a nuisance or beneficial? 5). Are they unbothered by the ants or do they take measures to eradicate them? 6). Any annoying experience with the ants? 7). Was it an adult, a child or a pet that got bitten and how often? The study was conducted in the months of February and March 2023. We used a RealmeC15 mobile phone and Samsung to which lenses of 12X and 24X were attached, to tag the location and to take the photographs of the nest and the ants.

Map 1: Location of the nests (1-9), 1 represents SJU CAMPUS

Map 2: Location of the nests (10-17)

Based on the responses to the questionnaires, the results were recorded as follows: 6 out of 15 knew what the nest was, 11 out of 15 were aware of its presence, 4 out of 15 knew it belonged to weaver ants, 10 out of 15 had no opinion about the ants. Only 2 of them considered them to be beneficial, 7 out of 15 cut the branches, whereas 5 of them used neem spray. 9 out of 15 had a painful experience with the ants, 10 out of 15 said the ants were found biting adults and 2 out of 15 said the ants annoyed the pets as well. The responses are represented in Fig 1-7.

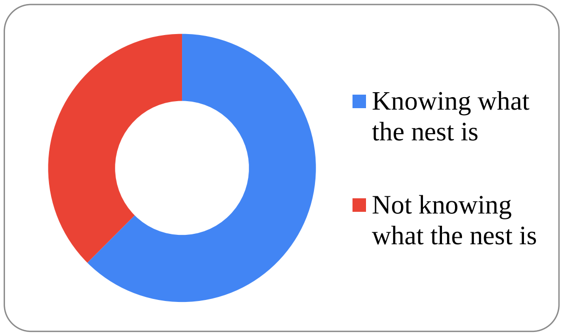

Fig. 1: Response to, Did they know what nest is?

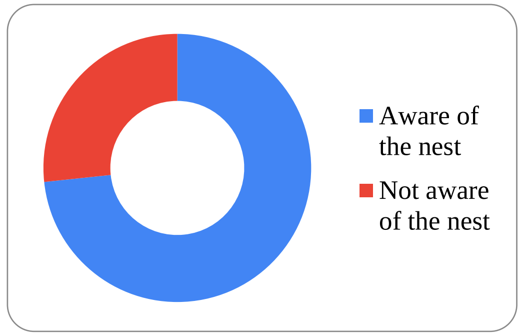

Fig. 2: Response to, Were they aware of the presence of ant nests in their vicinity?

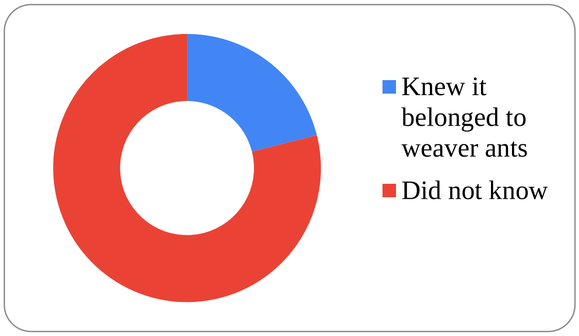

Fig. 3: Response to, Did they know it belongs to the weaver ant?

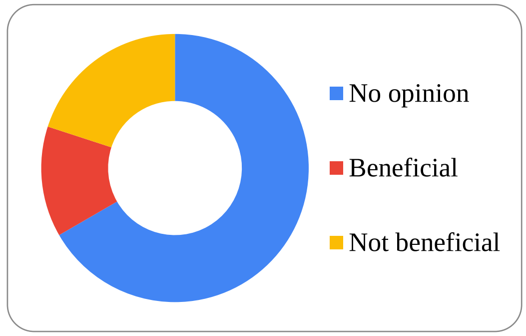

Fig. 4: Response to, What is their opinion on the nest? Is it a nuisance or beneficial?

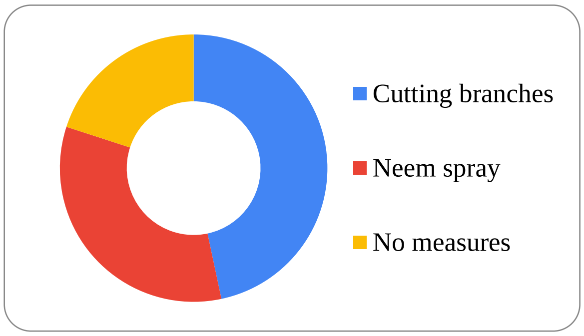

Fig. 5: Response to, Are they unbothered by ants or do they take measures to eradicate them?

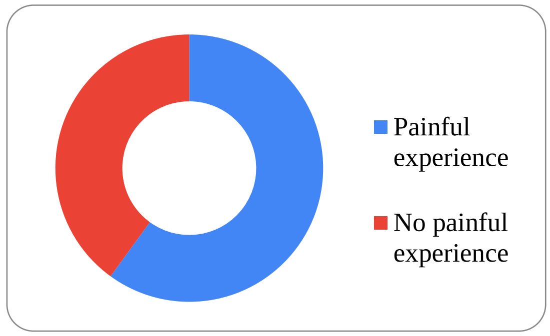

Fig. 6: Response to, Any annoying experience with the ants?

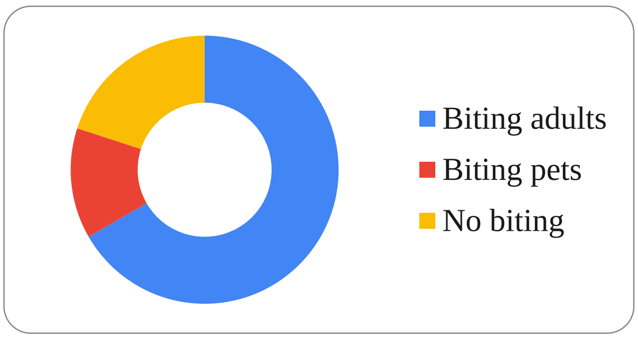

Fig. 7: Was it an adult, a child or a pet that got bitten and how often?

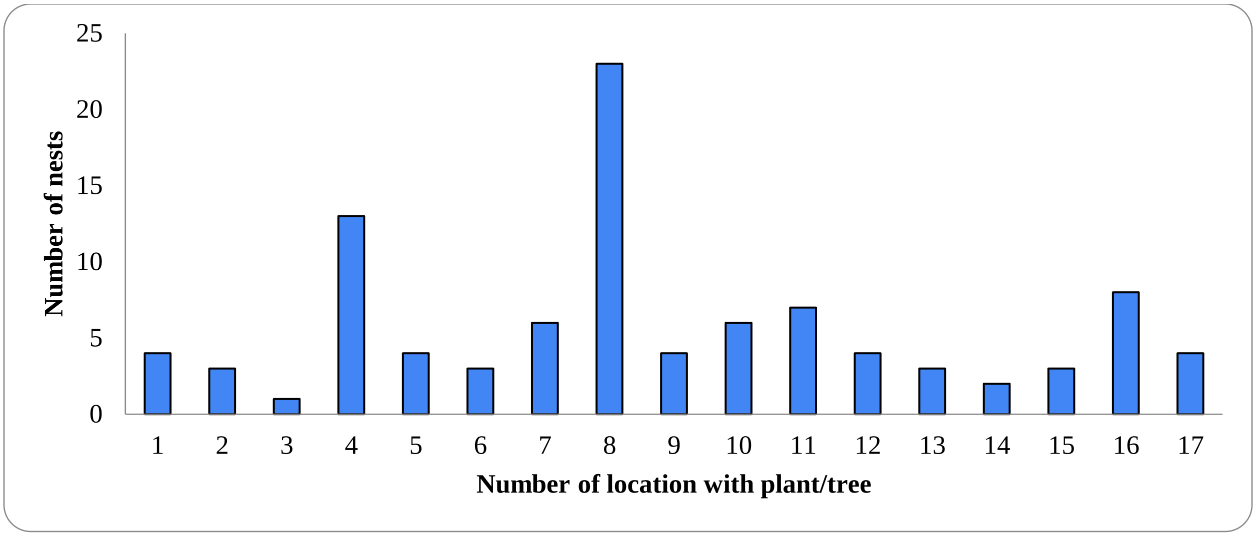

Fig. 8: Number of nests found in each location

Fig. 9: *Oecophylla* nest on *Mangifera indica*

Fig. 10: *Oecophylla* nest on *Ixora coccinea* (Inflorescence)

Fig.11: *Oecophylla* nest on *Ixora coccinea* (Leaves)

Fig.12: *Oecophylla* nest on *Hibiscus rosa sinensis*

Mangifera indica was the most common tree with nests (Fig. 9) on them *i.e.* 8 out of the 17 documented. *Ixora coccinea* had the most nests in one plant, 23 in one plant (Figs.10 and 11). The nests were also found on the *Hibiscus rosa sinensis* plant (Fig. 12). It is clear that the majority of people are aware of the nuisance caused by weaver ants. However, only a few of them knew about the nests that the weaver ants build. Neem spray and chopping off branches appear to be the most used methods to eradicate the nests. Two residents gave us insights on how chemical sprays do more harm than good and how chopping off the branches necessitates their burning to prevent further spread. Recently, Deva and Jayashankar (2023) have documented weaver nest occurrence around a water body in Bengaluru South. Notably, the present observation is a public awareness undertaken in an urban locality in Bengaluru.

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Review articles & Short notes

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Artificial Intelligence (AI) in entomology-Indian scenario

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The use of Artificial Intelligence (AI) in entomology has significantly impacted insect classification and pest management globally and in India as well. A brief note on Artificial Intelligence (AI) in different avenues of entomology in the Indian scenario is discussed.

Taxonomy: Through traditional morphological approaches, evolutionary approaches, and molecular tools, systematics has proven to be resilient over the centuries. AI techniques, such as machine learning and image recognition, have expedited the identification and classification of insects (Kasinathan *et al*., 2021). Entomologists are increasingly using deep learning models to classify insects as a result of advancements in AI including Convolution Neural Networks (CNNs) which show great potential in the automatic detection and classification of insects from videos and even time-lapse images. Advanced processors are used by microcomputers for real-time object-based monitoring, and radar sensors for the study of insects. The combination of picture and acoustic data may enable the identification of insects that are difficult to identify. Image-based models based on deep learning can be integrated with DNA barcoding methods to classify insects (Raibagi, 2021).

Conservation: The recent advancement in data science coupled with the revolution in digital and satellite technology has improved the potential for Artificial Intelligence (AI) applications in the forest sector and biodiversity conservation (Shivaprakash *et al*., 2022; Shreyas *et al*., 2022). By mapping the biodiversity of insects, image-based monitoring can pinpoint the species that are in danger of going extinct and develop plans to prevent them. While image recognition may be effective for certain species, it is not able to identify species that are not easily noticeable to the human eye. Acoustic recognition comes in quite handy in this situation. In addition to conventional and camera-based monitoring, auditory recognition will provide fresh perspectives that allow scientists to identify insect species that would otherwise go unnoticed, allowing them to keep an eye on and protect these important populations. First, a preliminary detection model identified candidate insects. Second, the candidate insects were manually screened by users of an online citizen science platform. Finally, all annotations were quality checked by experts (Bjerge *et al.*, 2022). For instance, automated detection of plant pests can be achieved through the utilization of image recognition technology that relies on deep learning algorithms. The researchers initially deployed an adhesive trap to ensnare six distinct types of airborne insects and gather photos in real-time. Subsequently, the detection and rough counting technique was established on You Only Look Once (YOLO) object detection, while the classification and precise counting relied on Support Vector Machines (SVM) utilizing global features. Ultimately, their computer vision model successfully detected bees, flies, mosquitoes, moths, chafers, and fruit flies with a precision of 90.18% and accurately counted them with a precision of 92.5%. V7 is an AI Data Platform that integrates automated annotation with dataset management, picture annotation, and video annotation (Khan, 2022).

Pest management: One such technique that is highly accurate in identifying the presence of pests is deep learning. An ML algorithm called CART can accurately predict when probable diseases and insect attacks will occur. Frequent human monitoring is not able to accurately estimate the extent of pest problems. Other techniques involved in agriculture and pest management include image processing algorithms, confusion matrices, and Neural Network Algorithms (Raja, 2022). Large agricultural fields may be scanned by drones with AI-powered image recognition systems, which can then quickly identify pests. There are several uses for AI in pest control *viz*., Simple way for field scouting, accurate field identification of the pest, and regular pest monitoring to undertake pest control intervention (Singh *et al*., 2022). Prabha *et al.*(2021) developed an automated Artificial Intelligence Powered Expert System (AIPES) for identifying fall armyworm infestation in maize. Computer vision can assist not only in the detection of agricultural diseases but also in their prevention. Pesticides can now be automatically sprayed evenly across large monoculture field patterns, like corn, thanks to Unmanned Aerial Vehicles (UAVs) outfitted with computer vision Artificial Intelligence. The ability to identify target spraying locations in real-time allows UAV sprayers to function with exceptional precision, both in terms of the area to be sprayed and the volume to be sprayed. This effectively lowers the chance of contaminating water supplies, land, people, and animals and aids in insect pest control (Khan, 2022). Drone operational characteristics such as flight speed, flight height, nozzle type, payload, and drone type are tailored for the particular situation in order to increase the efficacy of insecticidal application in crops. In cases where farmers are unable to use drones, a variety of mobile applications, based on artificial intelligence for the identification and warning of pests and diseases related to maize, have been released to identify insect pests on various crops. The National Agricultural Science Fund (NASF) provided funding for this investigation. Using a demonstrated deep learning algorithm, this app uses Artificial Intelligence to gather photos of several insect pests of maize, such as *Sesamia inferens*, *Chilo partellus,* and *Spodoptera frugiperda*, from farmer fields and provide advice to farmers. Plantix is a crop advisory app that can be used by gardeners, farmers, and extension agents on the go. PEAT GmbH, an AI startup with headquarters in Berlin, created Plantix. The app claims that it can identify crop-damaging pests, plant illnesses, and nutritional deficits and provides appropriate treatment options. Users can engage in discussions about plant health issues with scientists, farmers, and plant professionals in the online community. Farmers receive access to local weather information, valuable farming advice all season long, and disease alerts when a disease starts to spread in their area (Bhargavi and Jagadeesh, 2022).

Compared to the visual method of detecting plant disease, automatic detection with Artificial Intelligence (AI) takes less time and effort and is more accurate (Singh and Misra, 2016). The deep learning methods *viz*., Convolution Neural Network (CNN), Fast Region-based CNN (Fast R-CNN), Faster Region-based CNN (Faster R- CNN) and You Look Only Once v5 (YOLOv5) are used in in the field of entomology (Devi *et al*., 2022). The use of computer vision (CV) in agriculture allows for the early detection and prevention of disease/pest, CNN (VGG) model is used in identifying insect pest (Kumar *et al*., 2023; Gupta *et al*., 2023), accuracy rate of more than 80%, MobileNetV3 model faster and more accurate YOLO-based detection (Kumar *et al*., 2023).

India's agricultural industry is being revolutionized by AI, which is improving cultivating techniques and necessitating a substantial investment in training. AI algorithms are reducing insect pests, hence enhancing food security (Taneja *et al.*, 2023). Mobile apps have been created by research organizations to effectively manage insect pests in a variety of crops. The Digital Agriculture team of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad launched the iHub (innovation hub) that plays a critical role in strengthening connections between researchers and the private sector. Outcomes include Digital tools like Plantix and Kalgudi that create two-way information flows between researchers and farmers. Plantix, developed by German startup Progressive Environmental and Agricultural Technologies (PEAT), uses deep learning to detect more than 300 diseases, from images of crops uploaded by farmers, while Kalgudi provides an opportunity for ICRISAT to rapidly deliver pest alerts to more farmers (https://knowledge4food.net/icrisat-innovation-broker-working-with-private-sector-an-interview-with-ram-dhulipala/)

Farmers are adopting new technologies to meet global food demands by managing insect pests using artificial intelligence approaches contributing to increased food security. The adoption of cognitive solutions will play a significant role in farming's future.

Glossary

Acronym	Full Form
YOLO	You Only Look Once
SVM	Support Vector Machines
ML	Machine Learning
CART	Classification and Regression Trees
UAVs	Unmanned Aerial Vehicles
NASF	The National Agricultural Science Fund
AIPES	Artificial Intelligence Powered Expert System
CNN	Convolution Neural Network
R-CNN	Region-Based Convolution Neural Network
CV	Computer Vision
PEAT	Progressive Environmental and Agricultural Technologies

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Climate variables affecting insect pests

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Climate change is the most significant global change that has attracted the attention of the scientific community all over the globe. Climate parameters such as elevated temperatures, elevated CO_2 levels and erratic precipitation patterns have significant impacts on agricultural insect pests. Climate change can affect insect pests in several ways. According to a survey, about 940 out of 1600 insect species showed the effects of climate change (Deka *et al.,* 2011). It resulted in accelerated insect-pest reproduction, expansion of geographic ranges, disruption of interactions with host plants, changes in diapauses duration and led to increased insect-transmitted diseases (Shrestha, 2019).

Abiotic variables affecting insect pests:

(a) Elevated temperature

Increased temperatures, particularly in an early season have been reported to increase the incidence of viral diseases in potatoes due to early colonization of virus-bearing aphids (Robert *et al.,* 2000). Every 1°C increase in temperature caused additional migration of 14-16 lepidopteron species to England from southwest Europe (Sparks *et al.,* 2007). A significant increase in the activity of enzymatic markers in apple aphids was displayed with an increase in temperature (Dampc *et al.*, 2020). The number of generations of *Helicoverpa armigera* was predicted to increase with a decrease in their generation time under elevated temperatures (Srinivasa Rao *et al.*, 2023). The adult longevity of *Citrostichus phyllocnistoides* and *Cirrospilus ingenuus*, when reared on citrus leaf miner, exhibited a significant decrease in response to elevated temperatures (Ullah *et al.*, 2023).

(b) Elevated CO_2 (eCO_2)

Larval weights of *Achaea Janata* and *Spodoptera litura* on the foliage of castor plants were significantly increased with an increase in CO_2 concentrations (Srinivasa Rao *et al.*, 2009). Chewing insects suffer from reduced plant quality due to lower foliar nitrogen under eCO_2 while phloem-sucking insects like aphids show species-specific responses often increasing because eCO_2 leads to more sugar levels of leaf, impacting leaf structures, amino acids and secondary metabolites (Sun *et al.*, 2011).Asian ladybird beetle increased their predation on aphids under elevated CO_2 concentration compared to ambient CO_2 concentration (Chen *et al.*, 2007). Chewing insects decreased under eCO_2 while sucking insects like aphids increased under CO_2 (Sun *et al.*, 2011).

(c) Erratic precipitation

In the sub-saharan desert area of Africa, changes in rainfall patterns have led to changes in migratory patterns of the desert locust (Cheke and Tratalos, 2007) whereas, small-bodied pests like aphids, mites, jassids and whiteflies can be washed away during heavy rainfall (Pathak *et al.*, 2012). Tomato russet mite, *Aculops lycopersici* numbers significantly increased under drought conditions (Ximenez-Embun *et al.*, 2017). The fecundity of fall armyworm, *Spodoptera frugiperda* was significantly decreased with an increase in relative humidity (Zhao *et al.*, 2021). Moreover, erratic precipitation also affects the tri-trophic interaction of insect pests (Kumar *et al*., 2021).

(d) Interaction of abiotic variables

Sorghum crop resistance to sorghum midge was broken under high humidity and moderate temperatures which was observed in India (Sharma *et al*., 1992). Plants become susceptible to insect pests like Japanese beetle and western corn root worm due to reduced production of defensive cysteine proteinase inhibitors (CystPIs) under higher temperatures and CO_2 (Gouinguene and Turling, 2002). Climate change-induced alterations in atmospheric gas composition can disrupt insect communications and elevated CO_2 and ozone levels affect herbivore-induced plant volatiles, potentially altering prey detection by insect predators (Boullis *et al.*, 2015). Recently, *Thrips parvispinus* invaded the chilli ecosystem causing 40 to 80 percent of the damage in Andhra Pradesh and Telangana which was presumed to be due to the change in weather and climatic conditions (Sridhar *et al.*,2021).

Conclusion

It is widely accepted that climate change greatly affects insect pests associated with agriculture. Insect pests' responses to climate change vary globally due to species diversity. There are various uncertainties related to this impact including elevated temperature, elevated CO_2 level, and erratic precipitation patterns. These variables profoundly impact insect pest distribution, abundance, developmental rate and consumption of insect pests. Additionally, it increases pest survival allows for more generations, promotes invasive species and leads to an increase in insect-transmitted diseases. Overall, climate change is expected to increase the frequency and diversity of pest outbreaks creating complex challenges for pest management and collectively contributing to challenges in agriculture, including reduced crop yields and compromised food quality. For these situations, we need to develop weather-responsive pest forecasting models to predict and prepare for changing pest dynamics, advocate for pest-resistant crop varieties and sustainable practices for resilient agriculture andscreen novel pesticides suitable for climate-resilient pest management.

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First record of leaf-twisting weevil *Apoderus tranquebaricus* Fab. (Curculionidae: Coleoptera) on Ixora, *Ixora coccinea* Linn. (Rubiacea) from Tamil Nadu, India

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The leaf-twisting weevil *Apoderus tranquebaricus* Fab. (Curculionidae: Coleoptera) primarily infests various tree crops such as mango, amaranthus, jamun, jackfruit, teak, guava, cashew, neem, etc. Mango trees experience significant infestation levels, particularly from July to October (Manikandan *et al*., 2021). The leaf-twisting weevil can also infest the Indian butter tree (Manikandan and Rengalakshmi, 2023). The leaf-twisting weevil is recognized as a significant pest, affecting mango trees, and impacting both nursery and main field environments. The life cycle of *A. tranquebaricus* includes eggs, five larval instars, pupae and adult stage (Manjunath and Umamaheshwari, 2018).

For the first time, the infestation of leaf-twisting weevil *A. tranquebaricus* on the leaves of *Ixora coccinea* is reported at Anbil Dharmalingam Agricultural College and Research Institute (Latitude 10^0 45ʾN and Longitude 78^0 36ʾE), Navalurkuttapattu, Manikandam block, Tiruchirapalli district of Tamil Nadu. The ixora leaves rolled (Fig.4,5,6) by leaf-twisting weevils. Other insect species that were reported in ixora earlier were *Aphis spiraecola* and *A. gossypi* (Verghese and Rashmi, 2023)

The adult weevils exhibit a behavior where they cut and twist the leaves, forming well-shaped thimble-like rolls that remain connected to the branches. The eggs were deposited individually (Fig.1) in the outer region of the twisted leaf. In the initial stage, the larvae are diminutive, exhibiting slow movements and a pale-yellow hue (Fig.2), devoid of legs (Manjunath and Umamaheshwari, 2018).

The pupal stage takes place inside the rolled leaves. The adult weevils are medium-sized, characterized by a reddish-brown coloration and possess a long snout (Fig.3). The adult weevil scrapes the chlorophyll from the leaf surface. Consequently, the affected leaves display injury symptoms characterized by dark reddish-brown dried areas, indicative of the damage caused by the weevil. While weevils roll a single leaf for each egg, the process of leaf rolling can have a broader impact, affecting multiple leaves during the attempt.

Fig 1. Egg of leaf twisting weevil

Fig 2. Grub of leaf twisting weevil

Fig 3. Adult leaf-twisting weevil

Fig 4, 5, 6. Ixora leaves rolled by leaf-twisting weevil

Ixora coccinea cultivars are differentiated by colour variations in flowers (yellow, pink, and orange) and plant size. Furthermore, fully ripened fruits (Fig.7) are consumed as a dietary source (Anisha and Gnanavel, 2020).

Fig 7. Fruit of Ixora

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First report of brown wheat mite, *Petrobia* sp. on wheat in Gujarat

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Wheat [*Triticum aestivam* (L.)] is popularly known as "Gehoon" and belongs to the family of Poaceae. Wheat is a grass widely cultivated for its seed, a cereal grain that is a worldwide staple food. The many species of wheat together make up the genus *Triticum*; the most widely grown is common wheat (*T. aestivum*). In 2020, world production of wheat was 761 million tonnes, making it the second most-produced cereal after maize (Anonymous, 2020).

A study on the seasonal activity of pest infesting wheat was carried out at an entomology farm, B. A. College of Agriculture (22.5349° N, 72.9817° E), Anand Agricultural University, Anand Gujarat (India). During the field visit in May 2021, wheat crop was found infested with new seasonal pests (Fig. 1). So, the adults were collected and brought to the Entomology laboratory for identification and further study. The findings of morphological studies confirmed the *Petrobia* sp. (Acari: Tetranychidae) and this is the first confirmed report of seasonal pests in wheat fields of Gujarat State, India. It is a highly polyphagous and seasonal pest. It has a reddish-brown cuticle, dark body contents and long legs. Claws pad-like, empodium hooked and with more than one pair of tenet hairs.

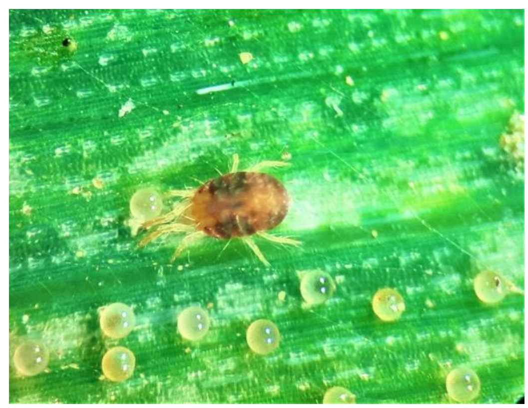

Fig. 1. Adult of *Petrobia* sp.

Genus *Petrobia* Murray, 1877 belongs to the family Tetranychidae, subfamily *Bryobiinae Berlese* and tribe *Petrobiini* Reck, 1952. *Petrobia* comprises three subgenera: *Mesotetranychus* Reck, 1948, *Petrobia* Murray, 1877 and *Tetranychina* Wainstein, 1960 (Mahdavi *et al*. 2018). This pest is more prevalent in Rajasthan, Delhi, Madhya Pradesh, Uttar Pradesh and Punjab. In India, since its first appearance in 1957, *Petrobia* *latens* has spread widely in major growing areas of wheat in different states. This is a serious pest in dryland agriculture, reaching usually higher densities on wheat than on barley. Coriander was also found infested by this species. Population levels were highest in March. It is most common under rainfed cultivation. Sharma & Srinivasa (2004) published a comprehensive report about this species. Although, the pest is recorded on pearl millet crops, it may feed on other crops *viz.*, sorghum, wheat, cotton, vegetables etc. therefore it may be an emerging threat to other agricultural crops as well.

Acknowledgement

We are thankful to Dr. A. B. Shukla, Senior Acarologist, Professor and Head, Department of Agricultural Entomology, N. M. College of Agriculture, NAU, Navsari (Gujarat) for the help in identification.

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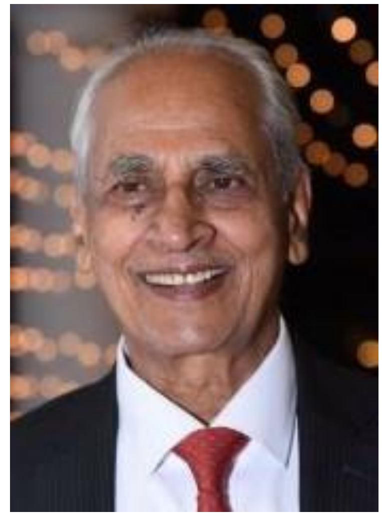
Obituary



DR. G. K. VEERESH
FORMER VC OF UAS-B AND AN EMINENT ENTOMOLOGIST IS NO MORE
(04.04.1934 – 06.02.2024)

Dr. G. K. Veeresh, an agricultural entomologist of international reputation and former Vice Chancellor of University of Agricultural Sciences, Bangalore, (UAS-B), breathed his last on Tuesday, 06 Feb 2024, at 11.45 A.M. owing to ill health related to old age at his residence in Ganganagar, Bengaluru. He was nearing 90 years. He left behind his wife, two daughters and a son, all married, and their families.

Prof. Veeresh had earned the following academic qualifications: B.Sc. (Agri.), Mysore University, 1957; M.Sc. (Agri.), IARI, New Delhi, 1960; and Ph.D., University of Agricultural Sciences, Bangalore, 1973. He was a Postgraduate Fellow at Rothamsted Experimental Station, U.K and Oregon State University, Corvallis, USA, during 1975.

Dr. Veeresh had started his professional career in 1961 and served as a lecturer at the Agricultural College, Hebbal, Bangalore, during 1961-1967. He then served at UAS-B as Asst. Professor of Entomology, 1967-1975; Prof. of Entomology, 1975-1982; Sr. Professor of Entomology, 1982-1986; Head, Division of Plant and Soil Sciences, 1986-1994; Director of Instruction (Agri.), 1988-1993; Dean, 1993-1994; ICAR Emeritus Scientist at UAS-B, 1994-95 and Vice Chancellor, UAS-B, 1995-1998.

While in active service and also after retirement, Dr. Veeresh had served in a number of expert committees at the Central and State Govts as also in other organizations. He served as President, International Union for Study of Social Insects, Indian Chapter, 1990. He was appointed as Chairman of a High Power Committee (2001-2002) set up by Mr. S. M. Krishna, then Chief Minister of Karnataka, to look into the causes responsible for a slew of farmers' suicide that occurred during three consecutive years. Dr. Veeresh was passionate about organic farming and was one of the first few, way back in 1996, to champion its cause and popularise it among the farmers. He had established the Association for Promotion of Organic Farming and served as its Founder President from 2000. Govt. of Karnataka had appointed him as the Chairman of Mini-mission on Organic Farming (2004). Dr. Veeresh was the Founding President of the Alumni Association of the UAS-B at Hebbal. He strived hard to mobilize funds to construct the majestic building of the Alumni Association. An auditorium has been named after him as "Prof. G.K. Veeresh Auditorium" while he was still alive. He had donated Rupees Fifteen Lakhs to the Alumni Association to be kept in Fixed Deposit in a bank and the interest utilized to award three farmers annually who practiced Integrated Farm System (IFS). He also served as President of the Academy of Music, Chowdiah Memorial Hall, Vyalikaval, Bengaluru, for six years up to 2017.

As an entomologist, Dr. Veeresh had distinguished himself in the area of root grubs and soil fauna and their management. He also had special interest in the study of social insects. He believed in extensive field work and also in research that can lead to solve farmers' problems. He was one of those responsible for developing the Dept. of Entomology as a strong unit at UAS-B. He had received a number of prestigious awards at the state, national and international levels. The Karnataka Govt. had bestowed upon him the Rajyotsava Award in 2016.

I had known Dr. Veeresh since around 1965 when he used to visit the erstwhile Commonwealth Institute of Biological Control at Hebbal along with students where I was working there. We became friends as entomologists and then, when I joined the Dept. of Entomology at UAS-B as a staff, we became colleagues. Later, he was my guide for Ph.D. degree. We had always maintained close contacts and remained lifelong friends. Dr. Veeresh was simple, smart, soft-spoken, pleasant and very considerate. He had the knack of identifying the right people, building teams and getting the work done. He was an outstanding organiser and an institution-builder. We had worked together on many occasions including organising several seminars, Centenary Year Celebration of Agriculture School, raising funds for the alumni association building, Global Alumni Meet (Dec. 2015), etc. His students and friends are spread across the globe. In his demise, we lost a gentle soul, a dynamic leader, a great motivator and an achiever. Om Shanthi.

T. M. Manjunath
Bengaluru
07 February 2024

INSECT LENS

Carpenter ant, Camponotus sp. (Formicidae: Hymenoptera)

Carpenter ants farm aphids and protect the aphids from predators (usually other insects) while they feed on the sugary fluid excreta called honeydew from the aphids, which the ants get by stroking the aphids with their antennae.

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Egg mass of Fall Army Worm, Spodoptera frugiperda (Noctuidae: Lepidoptera)

Cluster of fall armyworm eggs meticulously laid in mass on a leaf surface. The tightly packed arrangement of the egg mass showcases the efficiency of the Fall armyworm's reproductive strategy, as each egg has potential to hatch into a voracious caterpillar, posing threat to agricultural crops.

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The carpenter bee, Xylocopa sp. (Apidae: Hymenoptera) on flower Thunbergia

The carpenter bee, Xylocopa sp., is known to suck nectar from the flowers of Thunbergia grandiflora. Many carpenter bees "rob" nectar by slitting the sides of flowers with deep corollae. With their short labia the bees cannot reach the nectar without piercing the long-tubed flowers, and sometimes they miss contact with the anthers and perform no pollination.

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Green lacewings, Chrysopa perla (Chrysopidae: Neuroptera)

Some green lacewings can predate about 150 preys in their entire lives and in other cases 100 aphids will be eaten in a single week. Hence, in many countries, millions of such voracious Chrysopidae are reared for sale as biological control agents of insect and mite pests in agriculture and gardens. They are distributed as eggs, since they are highly aggressive and cannibalistic in confinement. Their performance is variable; thus, there is scope of further research to improve the use of green lacewings as biological pest control. Chrysopids can be attracted and conserved in the farm by growing Asteraceae viz., calliopsis (Coreopsis), cosmos (Cosmos), sunflowers (Helianthus) and dandelion (Taraxacum) and Apiaceae such as dill (Anethum) or angelica (Angelica).

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Litchi stink-bug, Tessaratoma sp. (Tessaratomidae: Hemiptera)

They are usually metallic in colour, have large bodies and small heads. Most species spend their lives on tree leaves and stems, and are phytophagus. They can secrete a foul-smelling liquid and are generally slow moving, but can fly.

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Brown-veined white, Belenois aurota (Pieridae: Lepidoptera)

Brown-veined whites roosting for the night until early morning as it migrated in Kenya from West to East. Belenois aurota is a small to medium-sized butterfly found in South Asia and Africa. In Africa, it is well known during summer and autumn when large numbers migrate north-east over the interior.

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Multitrophic interaction playing out at best

Trophic level 1: *Associated Plant: Sunflower, Helianthus annuus (Asteraceae) - that provides nectar and pollen for the honey bee, Apis mellifera (Apidae)* ***(Trophic level 2)****. Flower crab spider, Thomisus sp. (Thomisidae)* ***(Trophic level 3)*** *perfectly camouflaged with the sunflower to maximise its successful ambush of visitors to the flower. Once the successful predation of the honey bee by the flower crab spider has happened and the prey and the predator are locked, the Jackal flies (Milichiidae)* ***(Trophic level 4****), true to its common name, tries to steal the hunt. The Jackal flies consumes the exuding body fluids of the prey (honey bee) which is being extra-orally digested (the liquefaction of the solid tissues of the prey by enzymes secreted and injected by the predator into the prey).*

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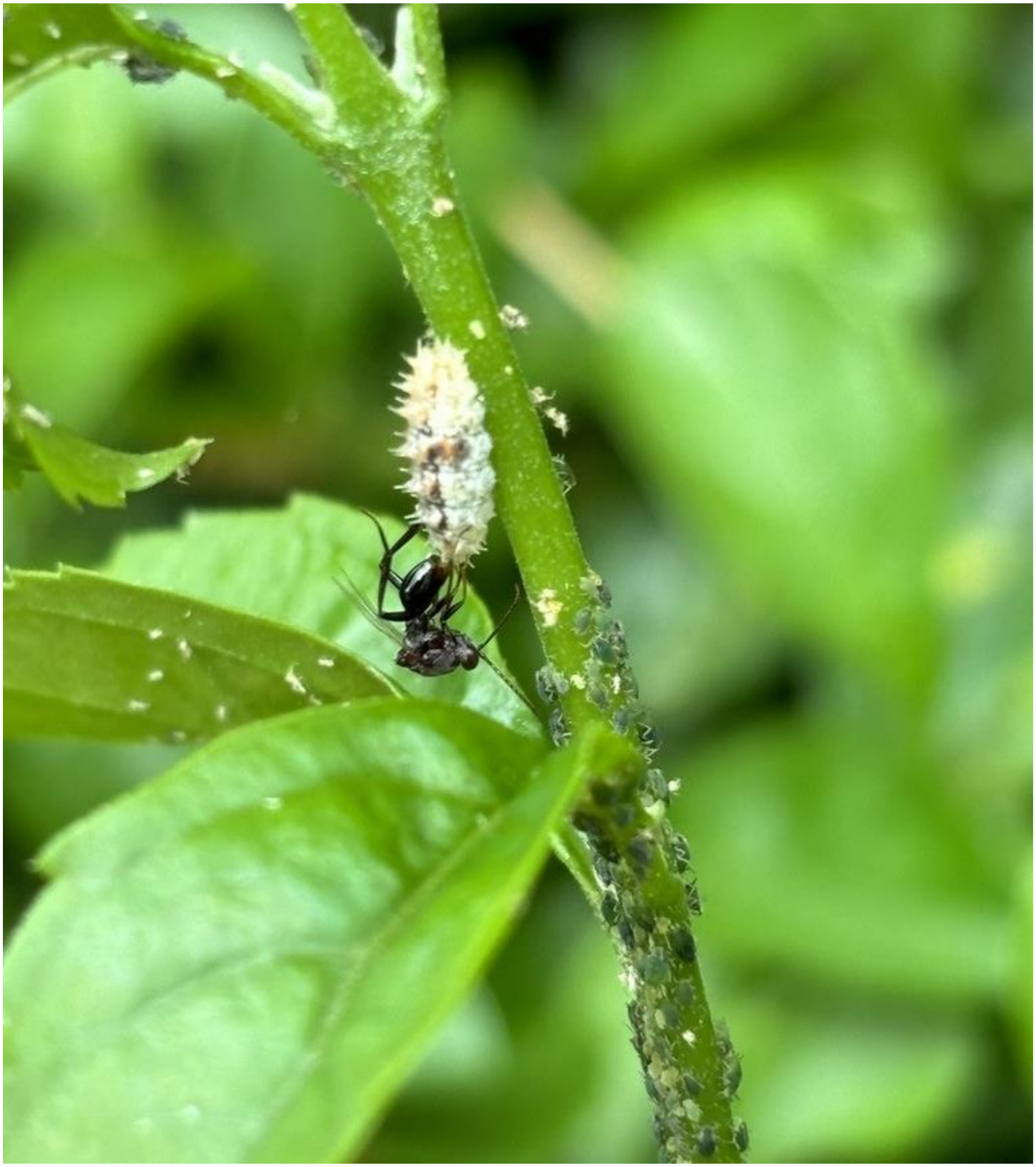

Ichneumonid parasitoid parasitising, Syrphid predating on Aphids infesting Duranta hedge plant

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Nymphs of Painted/Bagrada Bug, Bagrada hilaris (Pentatomidae: Hemiptera)

Bagrada bugs have five nymphal stages. Newly emerged first instars are bright red and have a slightly darkened to black coloration on the pronotum, head, legs, and antennae; the abdomen remains reddish and develops some black bands and white dots as the early nymphal stages advance. They attack various vegetable crops, weedy mustards and several ornamental plants of Brassicaceae such as sweet alyssum, stock, and candytuft.

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Indian Tawny Coaster Larva, Archea Terpsicore L. (Nymphalidae: Lepidoptera)

Acraea terpsicore can be seen in abundance wherever its larval food plant (Passiflora species) is found. The caterpillars of a batch tend to feed gregariously and devour all soft tissue of the host plant and becomes major menace to the passion flower plant. Like the adults, the caterpillar is protected by the toxins, processed from the Passiflora species.

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Mottled emigrant, Catopsilia pyranthe pyranthe (Pieridae: Lepidoptera)

The Mottled Emigrant is more often found in the fringes of the nature reserves where its host plant, Seven Golden Candlesticks (Cassia alata) is found. Catopsilia is an energetic and has rapid 'jumping' flight and males have a tendency to puddle.

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Eggs of Coccinellid Beetle, Coccinella septumpunctata (Coccinellidae: Coleoptera)

Eggs are tiny, elongated structures typically laid in clusters on the underside of leaves. These are often yellow or white in colour and may have distinct ridges or patterns. Ladybug eggs are laid near aphid colonies, as the larva emerges feed on these pests, making them beneficial for natural pest control in gardens and agricultural settings.

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Eggs of Pulse Pod Bug, Riptortus pedestris (Alydidae: Hemiptera)

Riptortus pedestris is a polyphagous agricultural pest and most damaging pests of soybean in East Asia. They are also responsible for stay green syndrome in Chinese soybean.

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Owl Moth, Erebus* sp. *(Erebidae: Lepidoptera)

Owl moth's are distributed in large areas of Asia and Africa. They are exceptionally large with a wingspan of about 12 cm. As their name suggests, the spots on their wings mimic the eyes of an Owl as a behavioural adaptation to keep predators away.

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Camouflaged grasshopper (unidentified)

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IE EXTENSION

Pomegranate Management 2024 - Free Training Programme at Vijayapura, Karnataka by Dr BT Gore, Leading Pomegranate Expert. Dalimb Ratna Mr. B. T. Gore, Founder of Farm DSS Agritech, trained over 700 pomegranate farmers from Karnataka and Andhra at Vijayapura, Karnataka, on 16 February. In this Pomegranate Training (lasting 6 hours) he taught the Good Agricultural Practices of Integrated Nutrient, Disease, Pest and Irrigation Management techniques. Organized by the Insect Environment Team. Supported by Rashvee IPRS, Shreenidhi Agrochemicals Plant Clinic and ICL Pvt Ltd.

Dr BT Gore was awarded 'Pomegranate Plant Health Award-2024' by Insect Environment Team for his passion for empowering farmers, coupled with his deep-rooted knowledge which has enabled farmers to be enriched in the entire gamut of pomegranate farming technologies.

Dr Abraham Verghese, Fruit Fly Man of India, Former Director, ICAR-NBAIR, Former Head and Principal Scientist, Division of Entomology, ICAR-IIHR and Dr G S Prakash, the grape expert and Former Head and Principal Scientist, The Division of Fruit Crops, ICAR-IIHR, and Dr M. A Rashmi, CEO Rashvee-International Phytosanitary Research and Services, Bengaluru were also present and interacted usefully in the discussions.

Dr G S Prakash, the grape expert and Former Head and Principal Scientist, The Division of Fruit Crops, ICAR-IIHR was awarded Grapes Plant Health Award- 2024 by Insect Environment Team

For exceptional contributions to the field of agriculture IE Team was also felicitated by ICL India PVT LTD on 16th Feb 2024 at Vijayapura, Devanahalli, Bengaluru Rural

Dr Abraham Verghese, Former Director ICAR-NBAIR, Former Head Division of Entomology, ICAR-IIHR, known as the fruit fly man of India was conferred with the Lifetime Achievements Award for his committed and dedicated work towards the farming community for more than 4 decades and still continuing. He was awarded the Lifetime Achievements Award in Research & Development in Horticultural Sciences 2022-2023 by The Society for Horticultural Research and Development, India on 1st Feb 2024 at Jaipur

Plant health interventions require a new paradigm shift breaking away from the conventional package of practices interfacing at the convergence of crops-insects-diseases. Apart from viruses more than 50% of fungal and bacterial diseases are passively/ actively transmitted by plant-visiting insects. Glimpses of the lecture on "Plant Health Intervention at the Plant-Insect-Pathogen Interface" -A Startup Story, by DST-funded lecture series at the Division of Crop Protection, ICAR-IIHR, Bangalore on 26th Feb 2024

Insect Environment Editors Dr Abraham Verghese and Dr M A Rashmi participated at the International Women's Day ceremony at Nexus Mall, White Field, Bangalore on 10th March 2024 organized by Greenotsav Forum, Sparsha Foundation, and Nexus Mall as panelists on the theme "Clean environment and healthy residue-free food through terrace gardening."

Dr. M A Rashmi, Co-Editor-In-Chief Insect Environment was awarded the "Women Excellence Award 2024" in the Agri-entrepreneur category on 10th March 2024 organized by Greenotsav Forum, Sparsha Foundation, and Nexus Mall

Dr M. A Rashmi of Shreenidhi Plant health clinic with rural women hortipreneurs

Insect Environment participated in three-day Entomology students' conclave organized by the Entomological Society of India in association with UAS Bengaluru, ICAR-NBAIR, hosted at the University of Agricultural Sciences, GKVK, Bengaluru (Thanks to Dr. S.V Suresha, Vice Chancellor, Dr. Shivanna, Dr. Jemla Naik D and staff of Entomology division, UASB). Picture with R.G Agarwal (Chairman, Dhanuka Group) and Dhanuka team

Insect Environment team with International Editorial Advisor, Dr. Jose Romeno Faleiro, Former FAO Expert, IPM Specialist (Red Palm Weevil), Middle East and South Asia

Pomegranate field visit with Dr. B T Gore

Dr. B.T Gore visits Shreenidhi Agrochemicals Plant Health Clinic, Vijayapura Devanahalli

IE team with Dr Brinda, General Manager, NABARD, Bangalore

Dr Abraham Verghese with Dr. Tolety Janakiram, Vice Chancellor of Dr. Y.S.R. Horticultural University, Andhra Pradesh. Dr. Som Dutt (Managing Editor, Current Horticulture) Formerly Editor (Indian Journal of Agricultural Sciences and Indian Horticulture) ICAR- DKMA, New Delhi.

Dr Abraham Verghese, honouring Padma Shri and Arjuna awardee Malathi Krishnamurthy Holla International athlete