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An *AtmaNirbhar* initiative by Indian entomologists for promoting Insect Science

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***Cover Page:**
***Ceratina* spp.**
Host: Cucumber
Place: Bathya Village, (13.192471,77.484772), Bengaluru Rural
As identified by Dr. U. Amala. ICAR-NBAIR
Photo by Dr. M. A. Rashmi

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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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Short popular insect notes, review essays, new records, profiles, tributes, and views are acceptable. There are no page charges; each article should preferably not exceed 500 words. Authors can refer to back volumes available on the website for writing style. Good photographs are encouraged. A special insect photo gallery "Insect Lens" is to encourage professional and amateur photographs of insects. These will be published in the quarterly *Insect Environment.* The blogs are for quick dissemination of insect "news". These will be uploaded within a month of submission and will be on the website. Blogs should be about a hundred words with one photograph, in simple English.

This journal is unique in that it encourages articles from students to amateurs to professionals! It is hosted in CABI (as full text) and ZooBank, Indian Abstracts, Research Gate, Google Scholar etc. ensuring global coverage. Scientific articles are assigned DOI.

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Editorial

My editorial invariably touches upon weather patterns, as climate change continues to be alarmingly predictable yet nearly unmanageable. The month of May has been declared the wettest across the Indian subcontinent, with the pre-monsoon bringing an overwhelming deluge. Interestingly, the typical summer pests, such as sucking insects, showed some respite washed off the plants by the relentless downpours.

During a recent visit to the coffee heartland of Chikkamagaluru, Karnataka, some growers reported a decline in stem borer infestations in Arabica coffee due to these unpredictable, frequent spells of rain. We used to incorporate an organic sealer swab for Arabica coffee here, and this weather shift seems to have naturally reduced pest pressure and coffee entomologists accede to this.

However, the rains also triggered an uptick in fruit fly infestations in mangoes and cucurbits. Fortunately, Rashvee liquid lures sold exceptionally well, and farmers expressed high satisfaction with their effectiveness.

Meanwhile, the *Insect Environment*-linked Rashvee Plant Health Clinic in Devanahalli is witnessing a significant rise in footfalls from an earlier range of 30-40 to a promising 60-80 farmers. *Insect Environment* through plant clinic and blogs is now more effectively addressing farmers' needs, bridging gaps in outreach as specialists with appropriate and adequate input support. This is where we truly excel; our blogs reach a wider audience, thanks to automatic mail distribution to subscribers every Monday. The response and feedback have been overwhelming, lifting our spirits.

Our super authors are the backbone of *Insect Environment*. They keep the journal vibrant and engaging, and we are immensely grateful for their contributions.

Previously, our guiding philosophy, *"By the entomologists, for the entomologists, to the entomologists,"* was quoted elsewhere by another publication so, we revised our philosophy during the last Editorial Meet to:

"By the entomologists, for the entomologists, to the students, naturalists and farmers."

This broader framework now encompasses a diverse audience of students, professionals, and amateurs alike. Our mandate remains steadfast: to promote and popularize the natural history of insects. A rich variety of articles and visuals continue to support this vision.

We deeply appreciate the unwavering dedication of our authors, supporters, team web managers, and AVIAN Trust, our publisher. A special acknowledgment goes to Dr. Rashmi M. A., Dr. Deepak S., and Ms. Salome Ruth for their excellent work in managing our digital editorial office.

Stay tuned for our next issue on **30 September 2025!**

Cheers!

Abraham Verghese
Chief-In-Editor
Insect Environment

Focus Articles

DOI: 10.55278/KQNP7699

Desert Locust (*Schistocerca gregaria* Forsskål): India's strategic management and success story (2018-2021)

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Abstract

Locusts, belonging to the order Orthoptera, are short-horned grasshoppers known for their migratory habits, marked polymorphism, and voracious feeding behavior. Among the various species, the Desert Locust (*Schistocerca gregaria* Forsskål) is particularly notorious for forming swarms of adults and hopper bands of nymphs, causing significant devastation to both natural and cultivated vegetation. These "sleeping giants" can flare up at any time, inflicting severe damage to crops and potentially leading to national emergencies concerning food and fodder supplies. This article aims to compile all relevant information about locusts to benefit students, teachers, researchers, policymakers, and others interested in this critical subject.

Introduction

Locusts, members of the order Orthoptera, are short-horned grasshoppers renowned for their highly migratory habits, marked polymorphism, and voracious feeding behavior. These insects can form swarms (adult congregations) and hopper bands (nymphal congregations), causing significant devastation to both natural and cultivated vegetation.

Historically, locust plagues have been recorded for centuries, with their impact leading to severe agricultural losses and food shortages. The Desert Locust (*Schistocerca gregaria* Forsskål) is particularly infamous for its ability to travel vast distances and consume large quantities of crops in a short period. Effective management and control of locust populations are crucial to prevent potential national emergencies related to food and fodder supplies. This article aims to provide comprehensive information on locust biology, behavior, and control strategies to benefit students, teachers, researchers, policymakers, and others interested in this critical subject.

Table 1. Important species of locusts in the world.

S. No.	English Name	Scientific Name
1.	The Desert Locust	*Schistocerca gregaria* (Forskål, 1775)
2.	The Bombay Locust	*Patanga succincta* (Johannson, 1763)
3.	The Migratory Locust	*Locusta migratoria manilensis* (Meyen,1835) *Locusta migratoria migratorioides* (Reiche & Fairmaire, 1849)
4.	The Italian Locust	*Calliptamus italicus* (Linnaeus, 1758)
5.	The Moroccan Locust	*Dociostaurus maroccanus* (Thunberg, 1815)
6.	The Red Locust	*Nomadacris septemfasciata* (Serville, 1838)
7.	The Brown Locust	*Locustana pardalina* (Walker, 1870)
8.	The South American Locust	*Schistocerca piceifrons* (Walker, 1870)
9.	The Australian Locust	*Chortoicetes terminifera* (Walker, 1870)
10.	The Tree Locust	*Anacridium* spp.

Off these, only four species *viz*. Desert locust, Migratory locust, Bombay Locust and Tree locust are found in India. The desert locust is the most important pestiferous species in India as well as in intercontinental context.

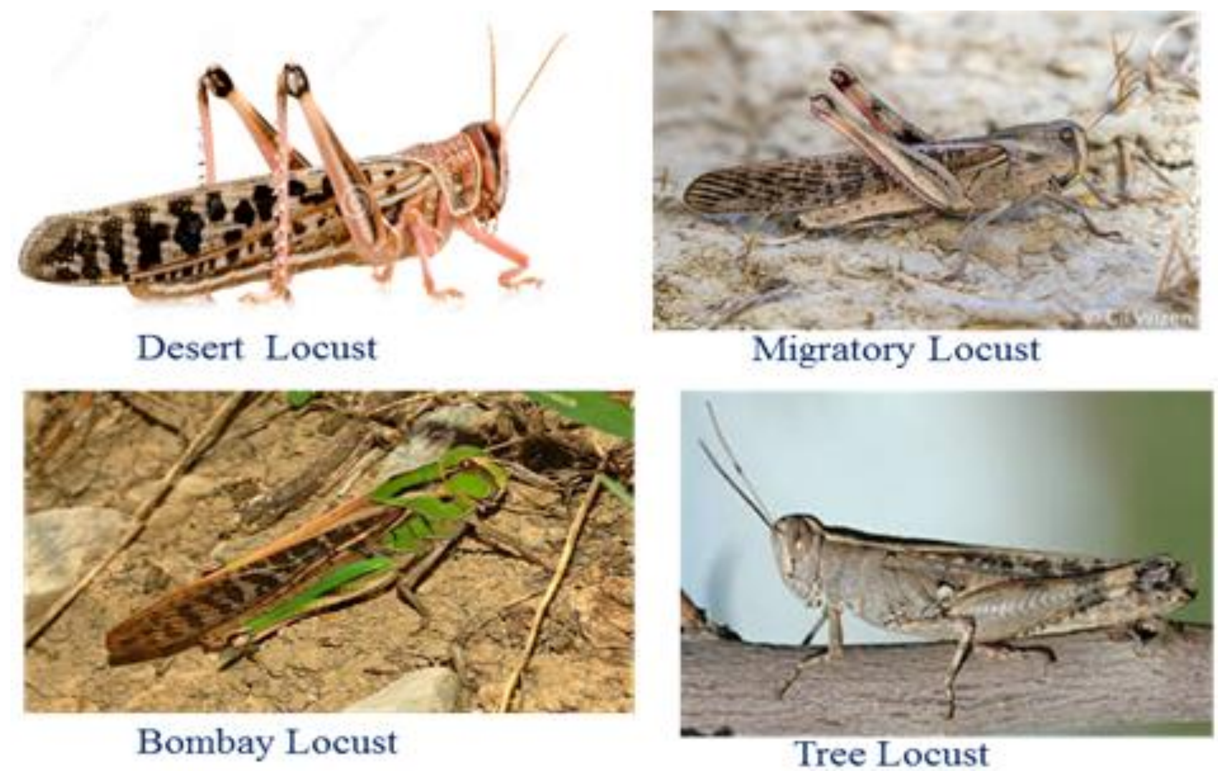


Fig. 1. Major locust species in India.

The desert locust, *Schistocerca gregaria* (Forskål, 1775):

Historically, the Desert Locust (DL) has posed a significant threat to human well-being. Ancient writings, such as the Old Testament and the Holy Quran, mention the Desert Locust as a curse to mankind. The magnitude of damage and loss caused by locusts is immense and often beyond imagination, leading to starvation due to their polyphagous feeding habits. On average, a small locust swarm can consume as much food in one day as about 10 elephants, 25 camels, or 2,500 people. Locusts cause damage by devouring leaves, flowers, fruits, seeds, bark, and growing points. When they settle in masses on trees, their weight can even cause the trees to break.

The Desert Locust has the remarkable ability to change its behaviour, physiology, and appearance in response to environmental conditions. This transformation from a harmless solitary individual to part of a collective mass of insects is known as "gregarization." The intermediate phase between solitary and gregarious, where locusts begin grouping, is referred to as "transiens." The gregarized cohesive swarm can cross continents and seas, quickly devouring any vegetation they settle on, particularly in farmers' fields. The DL is considered the most important and dangerous of all migratory pests in the world due to its inherent ability to destroy vegetation rapidly.

The invasion area of the Desert Locust covers about 30 million square kilometers, including whole or parts of nearly 64 countries. This area encompasses regions such as North West and East Africa, the Arabian Peninsula, the southern parts of the former USSR, Iran, Afghanistan, and the Indian subcontinent. During recession periods, when locusts occur in low densities, they inhabit a broad belt of arid and semi-arid land stretching from the Atlantic Ocean to North West India, covering over 16 million square kilometers in 30 countries.

Biology of the desert locust:

Like any other exopterygotan insect, locusts have three distinct life stages viz. egg, nymph/hopper and adult.

Egg: Eggs are laid in pods in moist sandy soil at a depth of about 10 cm. at an interval of 7 – 10 days. Gregarious female usually lays 2-3 egg pods each having 60-80 eggs on an average. Solitarious female mostly lay 3-4 times having 150-200 eggs on an average. The rate of development of eggs depends on soil moisture and temperature. The incubation period is 10-12 days at the optimum temperature of 32-35°C and no development takes place at temperature below 15°C.

Nymph/Hopper: Eggs hatch into nymphs after the incubation period. There are 5 instars in gregarious and 5-6 instars in solitarious population. In each instars there is change in characteristic coloration.

1st instar: Newly hatched are white but turns black in 1-2 hours.

2nd instar: Head is larger and pale colour pattern is conspicuous.

3rd instar: Two pairs of wing buds projects on each side of thorax

4th instar: Colour is conspicuously black and yellow.

5th instar: Colour is bright yellow with black pattern.

The rate of development in hopper depends on temperature. It takes about 22 days when the mean air temperature is hot about 37°C and may be delayed up to 70 days when the mean temperature is cold about 22°C.

Adult: The 5th instar nymph moults into adult, this process is called as 'fledging'. The young adult is called 'fledgling' or 'immature adult' meaning sexually immature. Young immature adults are pink in colour but old ones become dark red or brown in cold condition. On maturation the adults become bright yellow. The period of sexual maturity varies with suitable conditions. The adult may mature in 3 weeks in cool and /or dry conditions and the maturity may take as long as 8 months otherwise. During this stage the adults fly in search of favourable breeding condition and may cover thousands of kilometers. Males mature before females. Oviposition commences within two days of copulation.

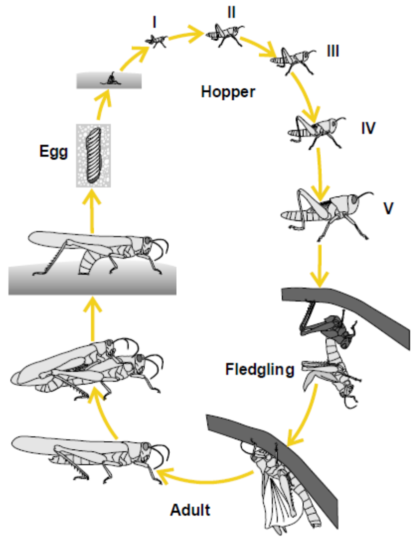
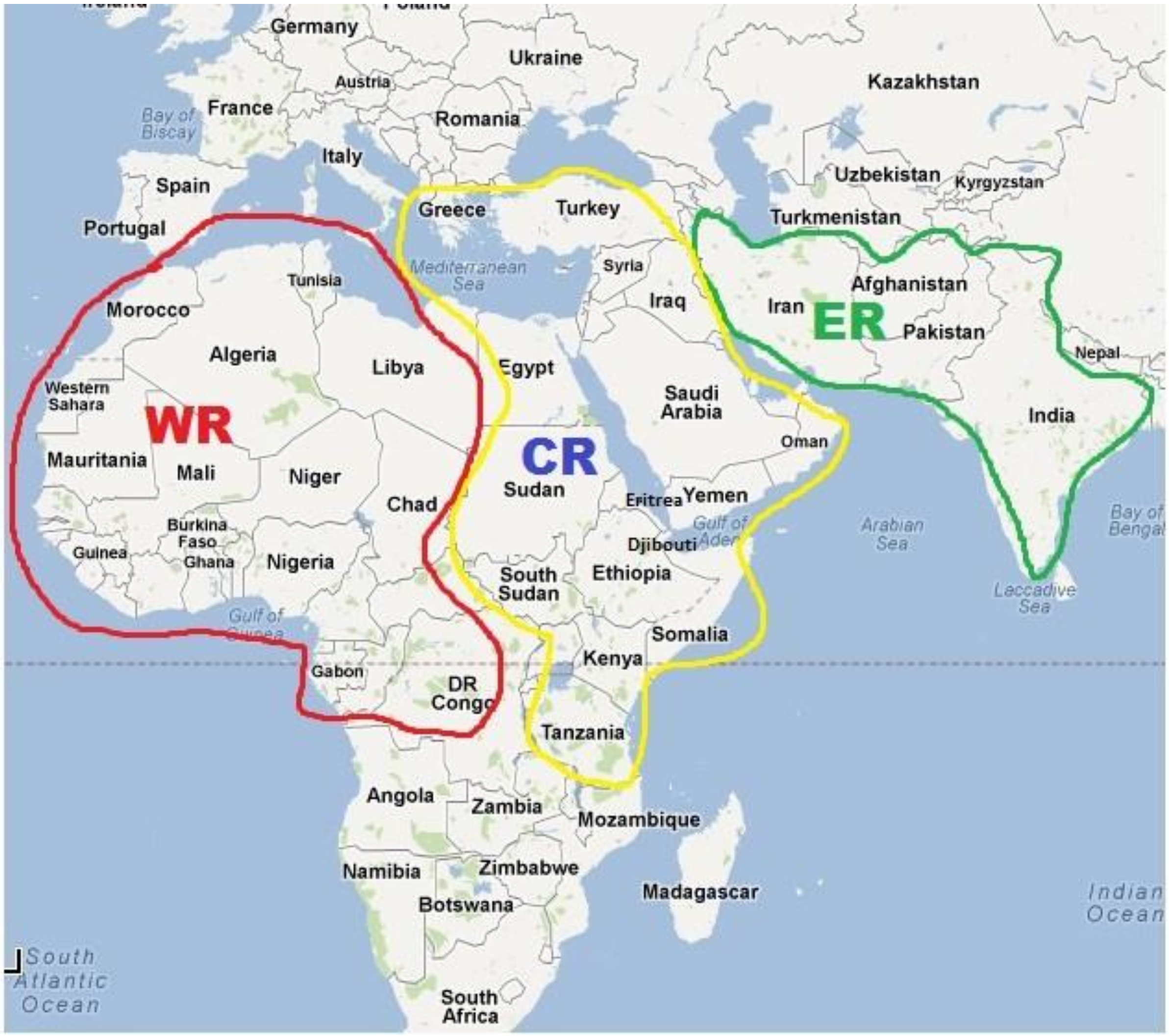


Fig. 2. Biology of the Desert Locust.

Phases of the desert locust:

The Desert Locust is typically present in small numbers across the deserts between Mauritania and India. However, their population can rapidly increase if the area receives substantial rainfall, leading to the emergence of green vegetation. Within a month or two, Desert Locusts can multiply, concentrate, and gregarize. If unchecked, this can result in the formation of small groups or bands of wingless hoppers, as well as small groups and swarms of winged adults. This phase is known as an “OUTBREAK” and usually occurs over an area of about 5,000 square kilometers (100 km by 50 km) in one part of a country.



(WR: Western Region, CR: Central Region and ER: Eastern Region)

Fig. 3. Regions of Desert Locust activity.

If an outbreak or simultaneous outbreaks are not controlled, and if adjacent areas have good vegetation due to rainfall, this can lead to several successive breeding cycles, causing further hopper band and adult swarm formation. This phase is called an "UPSURGE," which has the potential to affect an entire region.

If an upsurge is not controlled and ecological conditions remain favourable for breeding, locust populations will continue to increase in number and size. When the majority of infestations occur as bands and swarms, this can lead to the development of a "PLAGUE." A major plague exists when two or more regions are affected simultaneously. While outbreaks are common, only a few lead to upsurges, and similarly, only a few upsurges lead to plagues.

Historical events of upsurges and plagues of desert locust:

Major incursion of locust swarms was noticed during1926-31,1940-46,1949-55 and the last locust cycle in India was during 1959-62. No locust plague cycles were observed after 1962. During 1978 and 1993, large scale locust upsurges were reported.

Weather and Desert Locust biology

The life cycle of a locust requires ideal meteorological conditions to develop and cause widespread damage. Understanding and forecasting the movement of swarms and various developmental stages of locusts necessitates information on meteorological and ecological parameters such as rainfall, soil moisture, soil and air temperatures, surface and boundary winds, synoptic-scale patterns, and the convective state of the atmosphere. These developmental stages include egg-laying, egg development, hopper development, moulting, wing hardening, adult maturity, the movement rate of hopper bands and adult swarms, and the transition from the solitary phase to the gregarious phase.

Rainfall is crucial for identifying areas suitable for breeding, as it leads to the growth of green vegetation. Temperature data helps estimate the development rate of eggs and hoppers and indicates whether it is warm enough for adults to take off and fly. Wind and large-scale (synoptic) data are useful during periods when adults or swarms are likely to migrate and to assess the invasion threat from neighbouring countries.

Eggs require moist soil conditions to absorb moisture and complete their development. However, extreme rainfall after egg-laying can destroy eggs through flooding. Hopper development, from the first instar to fledging (the final moult from wingless fifth or sixth instar to winged adult), indirectly depends on rainy conditions, as hoppers need edible vegetation for survival. Adults begin to mature when they arrive in areas that have recently received significant rainfall. After fledging, the hardening of the locust's soft wings is stimulated by rainfall.

Wind is the primary transportation mechanism for locusts and also concentrates them through convergence. In certain parts of the locust-prone areas, winds are regular in speed and direction during specific seasons. These patterns can be identified using local climatological knowledge, which helps predict the spatial distribution of swarm movements. Air brought into strong frontal systems and cyclones from surrounding regions can collect locusts from scattered solitary populations and survivors from multiple swarming populations.

Both day-flying swarms and night-flying solitary individuals are displaced downwind. Seasonal changes in mean wind flow bring locusts into particular zones during specific seasons. For example, locusts move southwards from northwest Africa into the Sahel of West Africa at the beginning of summer. In autumn, they move northwards again, but low nighttime temperatures limit the movement of night-flying solitaries compared to day-flying swarms. Downwind displacement tends to bring locusts into areas during the season when rain is most likely, such as the Sahel of West Africa and Sudan in summer and the Red Sea coasts in winter.

Once rain falls, locusts mature and breed. By the time the new generation of adults is capable of sustained flight, the seasonal wind pattern may have changed, and breeding conditions may become poor. The locusts then migrate rapidly, often over great distances, to another area. This general pattern is not always consistent, as movements can occur during periods of particular winds rather than prevailing wind flow. Rare and unprecedented movements also continue to occur, which is why only part of the seasonal breeding area is infested in any given year. Another major reason for unsuccessful breeding is the failure of seasonal rains.

Eggs can dry up if exposed to wind. Hopper band movement is usually downwind. Adult migration occurs at night when the air temperature is above 20°C–22°C and the wind speed is less than 7 m/s (13.6 knots). The direction of flight is downwind, and swarms typically take off when wind speeds are below 6 m/s (11.7 knots). Swarms land about an hour before sunset as convection dies away.

Swarms move under the influence of large-scale weather patterns on a synoptic scale. The structure of swarms depends on weather conditions, governed by convective winds and low-pressure systems. Cool, overcast weather favours stratiform swarms, while convective updrafts on hot afternoons promote cumuliform swarms. Thus, swarms are usually stratiform in the morning and become cumuliform in the heat of the day when convection occurs from the hot ground.

- Locust populations move downwind
- The hotter the wind, the greater the distance travelled per day
- Highly turbulent (and correspondingly hot) winds disperse populations (reduce their area density)
- Downwind movement eventually brings locusts into zones of wind convergence, where they accumulate
- As opposed to steady wind conditions, where turbulence disperses populations, convergent winds have been shown to concentrate populations at least to the order of 10000-fold
- Locust populations are trapped in zones of wind convergence and participate in the diurnal and daily cycle of movement of such zones. In some places and seasons, these movements are relatively small and

the locust population is correspondingly relatively stationary.

- Waiting for locusts to concentrate and form high-density populations is the most important strategy for efficient and economic control of locusts, so that the concentrating effect of zones of convergence must be utilized in control techniques.

Weather and desert locust plagues and upsurges

The majority of Desert Locust upsurges and plagues develop as a result of unusual meteorological conditions such as those associated with cyclones and other extreme weather events that lead to heavy rainfall, which, in turn, causes ecological conditions to become extremely favourable for locust breeding. Plague declines are often attributed to the combined effects of control operations and unfavourable environmental conditions.

Importance of weather information and conditions for desert locust control

The behaviour of the Desert Locust is directly influenced by meteorological parameters such as rainfall, temperature, and winds arising from convergence, monsoons, storms, depressions, and fluctuations in seasonal convergence zones like the Inter-Tropical Convergence Zone (ITCZ) and the Red Sea Convergence Zone.

Locust movements generally occur during temporary spells of warm winds ahead of cold fronts. These depressions bring the winds necessary for movement and the rain required for breeding. Locusts are blown from areas of divergence towards areas of convergence, often related to the position of the ITCZ.

While environmental conditions, especially rainfall, are crucial for locust development and breeding, wind and other atmospheric disturbances are most important for flying swarms. Locust swarm movements are influenced by large-scale weather patterns and smaller-scale wind motions. Swarms flying in a given area tend to accumulate along lines of convergence in the wind field, such as atmospheric fronts separating warm and cold air masses. These lines of convergence, like the ITCZ or the sea-breeze front, restrict swarm movement. The movement of these fronts is usually accompanied by heavy rains, with winds blowing in the direction of the fronts.

Temperature governs the speed of locust development and swarm movement. Increased temperatures associated with climate change can potentially shorten the long maturation and incubation periods during spring, allowing an extra generation of breeding in North-West Africa, the Arabian Peninsula, and South-West Asia. This could increase the number of locust generations per year in these regions and amplify the overall plague risk. Changes in El Niño and La Niña events due to climate change could affect breeding during winter in the Great Horn of Africa and summer in the West African Sahel.

The effects of climate change on winds are less certain. Changes in wind speed, direction, and circulation flows are expected to affect Desert Locust migration, potentially allowing adults and swarms to reach new areas at different times of the year. Whether they can establish, survive, and breed in these new areas will depend on ecological, habitat, and weather conditions.

Combining meteorology with knowledge of locust behaviour can determine the best times for locust surveys, as solitary locusts can be difficult to detect. These locusts are most active when soil temperatures range between 25°C and 30°C. Therefore, in summer, surveys are best conducted between 7 a.m. and 11 a.m. and between 4 p.m. and 6 p.m., while in winter, the optimal times are between 9 a.m. and 3 p.m.

Migration and seasonal distributions

Since both day-flying swarms and night-flying solitary individuals are displaced downwind, seasonal changes in mean wind flow bring locusts into specific zones during particular seasons. For example, locusts move southwards from northwest Africa into the Sahel of West Africa at the beginning of summer. In autumn, they move northwards again, but low nighttime temperatures limit the movement of night-flying solitaries compared to day-flying swarms.

Downwind displacement tends to bring locusts into areas during the season when rain is most likely, such as the Sahel of West Africa and Sudan in summer, and the Red Sea coasts in winter. Once the rain falls, locusts mature and breed. By the time the new generation of adults is capable of sustained flight, the seasonal wind pattern may have changed, and breeding conditions may become poor. The locusts then migrate rapidly, often over great distances, to another area.

This general pattern is not always consistent. Movements can occur during periods of specific winds rather than prevailing wind flow. Additionally, rare and unprecedented movements continue to happen. This is why, in any given year, only part of the seasonal breeding area is infested. Another major reason for unsuccessful breeding is the failure of seasonal rains.

Within the recession area, locusts move with the winds. These bring them into particular zones during the summer (the Sahel and the Indo-Pakistan desert) and during the winter/spring (northwest Africa, along the Red Sea and Baluchistan).

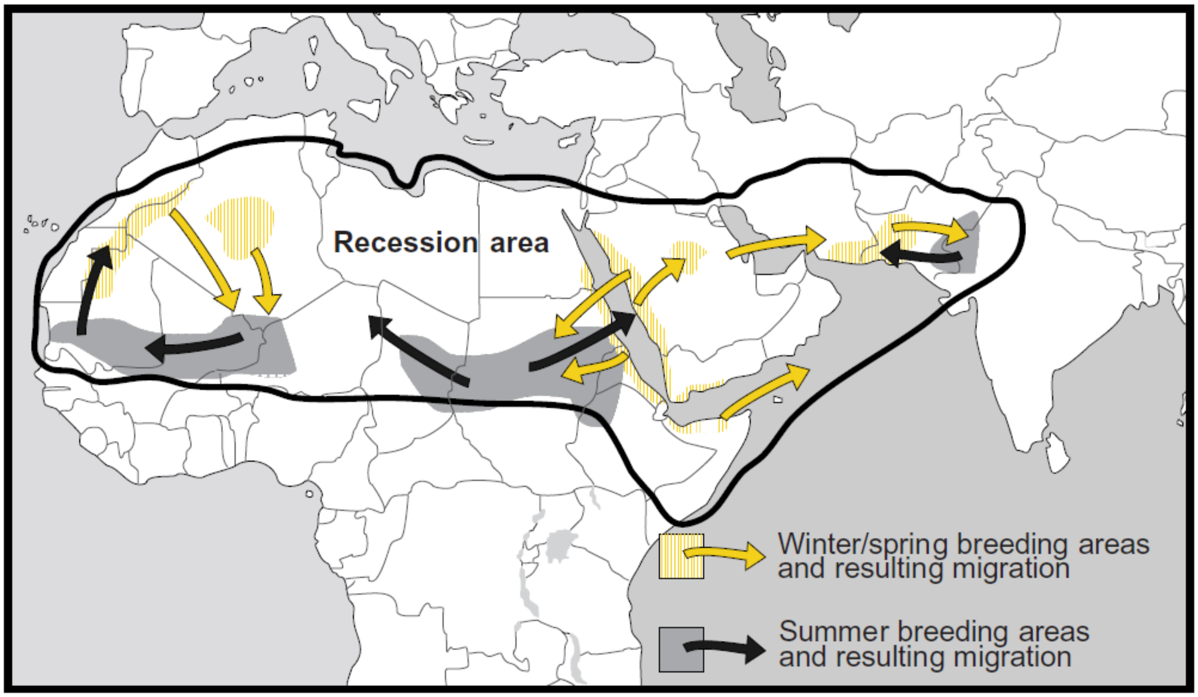


Fig. 4. Recession area and migration of locusts

Periodical development of desert locust during 2018-2021:

In the year 2018, cyclones "Mekunu" in the month of May and "Luban" in October brought heavy rains in the Empty Quarter of the southern Arabian Peninsula gave rise to favourable breeding conditions for at least nine months since June, 2020. As a result, three generations of breeding of DL occurred, which was undetected and invariably there were no control measures.

During January 2019, the first swarms of Desert Locust migrated from empty quarter of the southern Arabian Peninsula towards Yemen and Saudi Arabia, and reaching southwest Iran where heavy rains had been received. The favourable weather conditions during February to June, lead to widespread spring breeding in Yemen, Saudi Arabia and Iran which in turn resulted in large number of swarms. The intended control operations by Iran and Yemen were less successful. As a result during June to December, 2019, swarms invaded the Indo-Pakistan border from Iran, where longer than normal monsoon had occurred and DL could successfully complete three generations. This led to large number of swarms. Meantime, in Yemen, swarms formed and moved to Northern Somalia and Ethiopia where breeding occurred, and more swarms formed.

Fig. 5. Empty Quarter of the southern Arabian Peninsula.

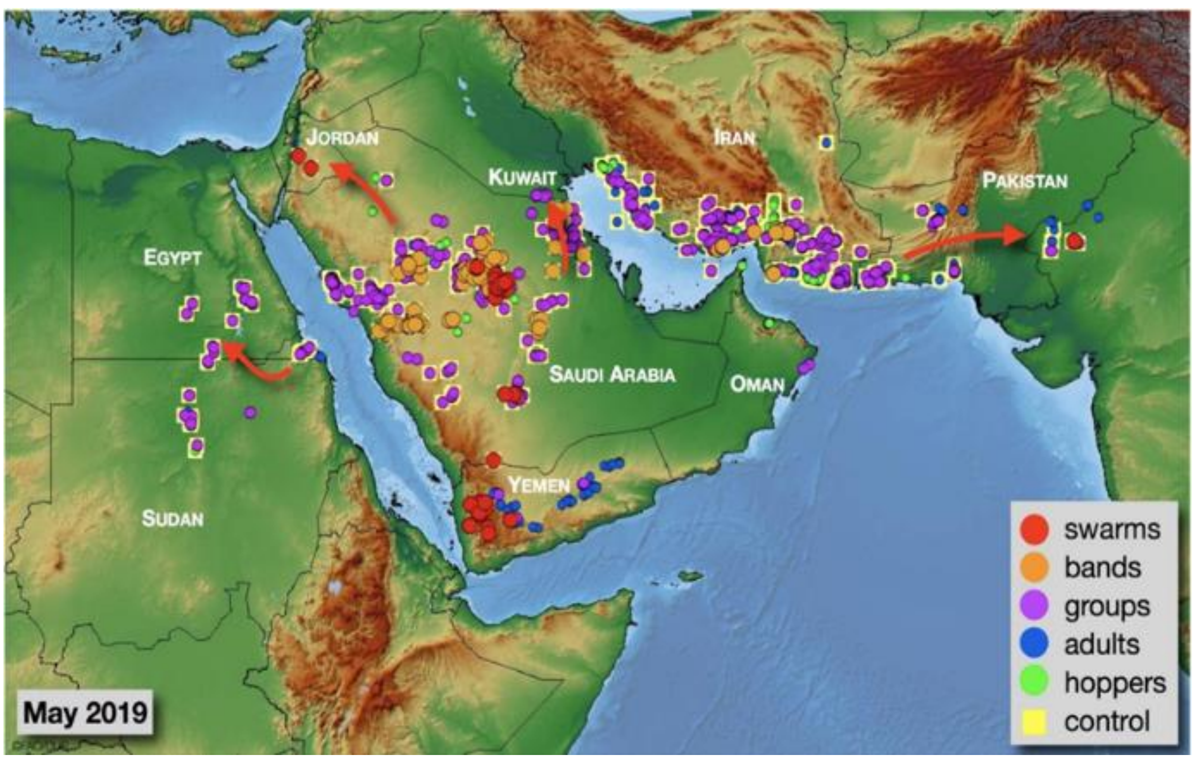


Fig. 6. Migration of swarms from empty quarter to Yemen and Saudi Arabia, reaching southwest Iran.

During October to December 2019 swarms migrated from Ethiopia and Northern Somalia to Eritrea, Djibouti, Eastern Ethiopia, the Ogaden, Central and Southern Somalia to reach North-Eastern Kenya. The hopper bands and swarms formed along parts of the Red Sea, coastal plains in Yemen, Saudi Arabia, Eritrea and Sudan.

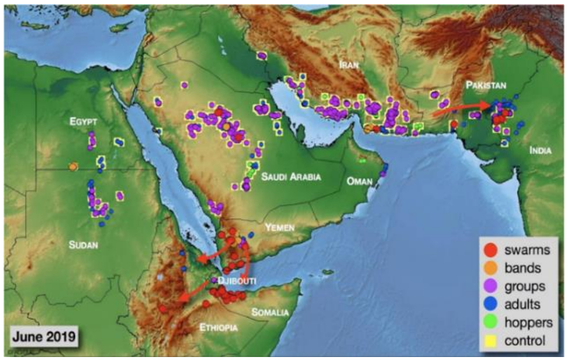
In January 2020, locust swarms continued to invade, spread, mature, and lay eggs in Ethiopia and Kenya, with hatching occurring in northeastern Somalia. Meanwhile, other swarms moved into the interior of Yemen and Saudi Arabia. During February, swarms persisted in Kenya, with some reaching Uganda, South Sudan, and Tanzania. Widespread hatching and hopper band formation occurred in Kenya, and other swarms reached both sides of the Persian Gulf.

In March, widespread hatching led to a new generation of swarms in Ethiopia and Kenya, which then invaded Uganda and South Sudan. Concurrently, swarms laid eggs and hatched in southern Iran. By April, more swarms had formed, matured, and started laying eggs in Ethiopia, Kenya, Somalia, and Yemen. Second-generation hopper bands emerged in Iran and Pakistan.

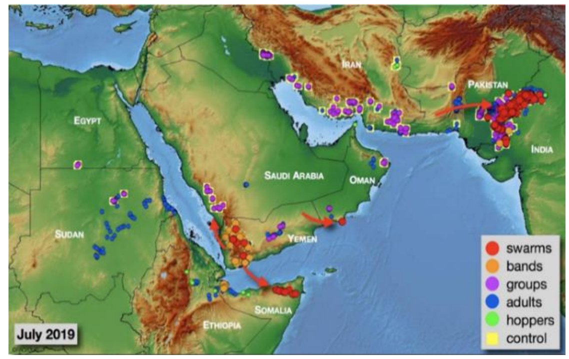
By May and June, the next generation of hatching and band formation began in Ethiopia, Kenya, Somalia, and Yemen. Second-generation swarms formed in Iran and Pakistan, migrating to the Indo-Pakistan border and continuing to other parts of northern India. Second-generation swarms also formed in northwestern Kenya, Ethiopia, Somalia, and Yemen. Spring-bred swarms then moved to Rajasthan and northern states of India.

In July, more swarms formed in northwestern Kenya, Ethiopia, Somalia, and Yemen. Some swarms moved within Ethiopia, while others travelled from Yemen to northeastern Ethiopia. First-generation laying, hatching, and band formation began along the Indo-Pakistan border. By August, swarms matured and laid eggs in northeastern Ethiopia, with some swarms invading Eritrea and breeding. Immature swarms persisted in northwestern Kenya and northern Somalia. Hopper bands and swarms continued in the interior of Yemen, with some swarms moving to southwestern Saudi Arabia.

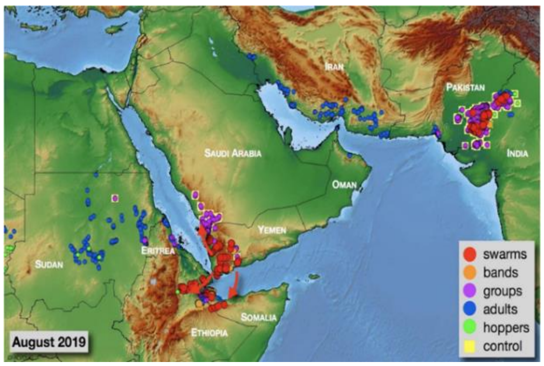
By September 2020, widespread hatching and band formation occurred in northeastern Ethiopia and Yemen, with immature swarms persisting in northern Somalia and northern Kenya. Swarms arrived in eastern Sudan and laid eggs.



2019 (Feb-Jun): Yemen, Saudi Arabia and Iran



2019 (Jun-Dec): Indo-Pakistan border



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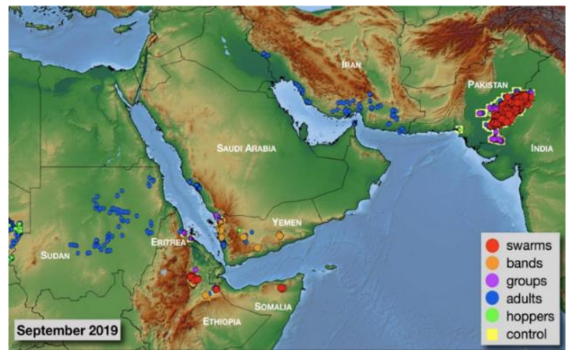
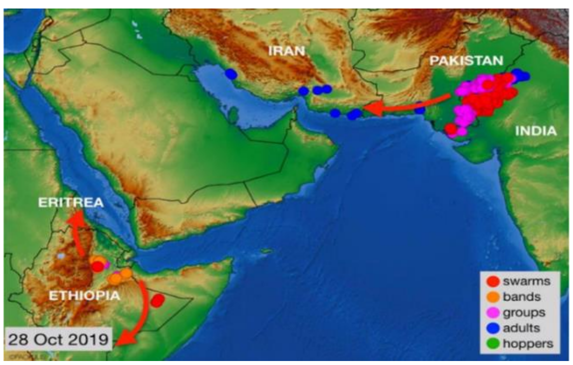
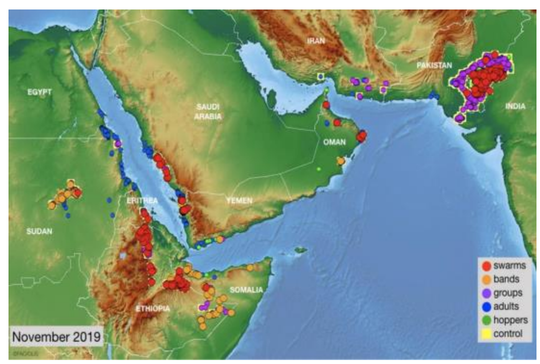


2019 (Oct-Dec): NE Kenya, Red Sea and coastal plains in Yemen, Saudi Arabia, Eritrea and Sudan.



2019 (Oct-Dec): NE Kenya, Red Sea and coastal plains in Yemen, Saudi Arabia, Eritrea and Sudan.



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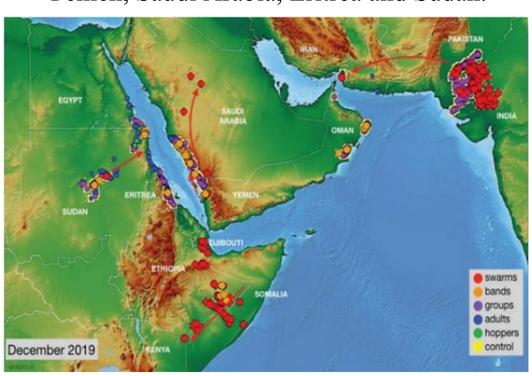
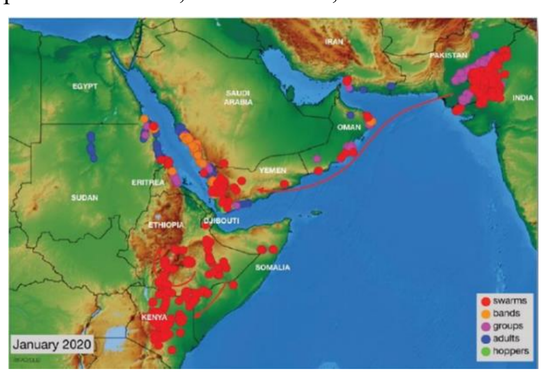
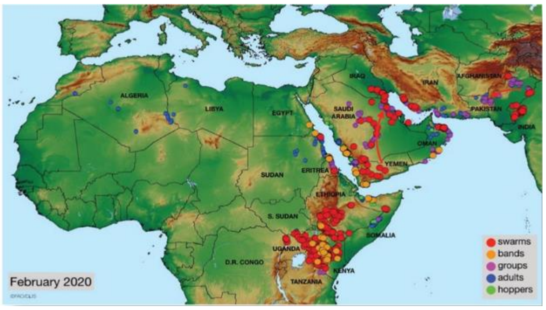


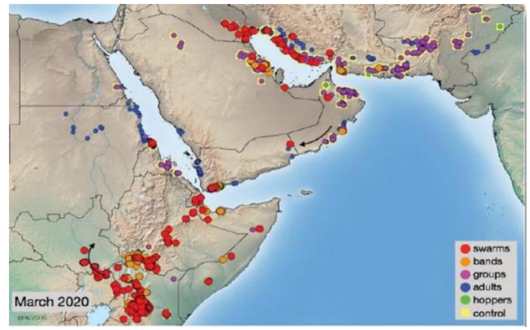
2019 (October-December): NE Kenya, Red Sea and coastal plains in Yemen, Saudi Arabia, Eritrea and Sudan.



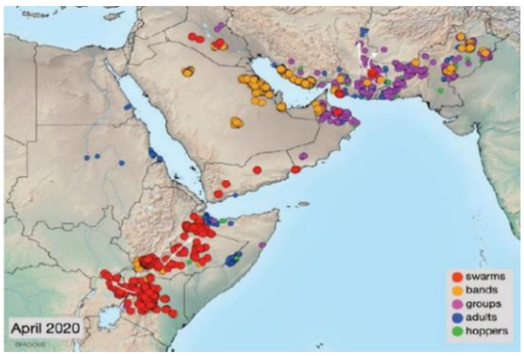
2020 (January): Ethiopia and Kenya, NE Somalia, Yemen and SaudiArabia.



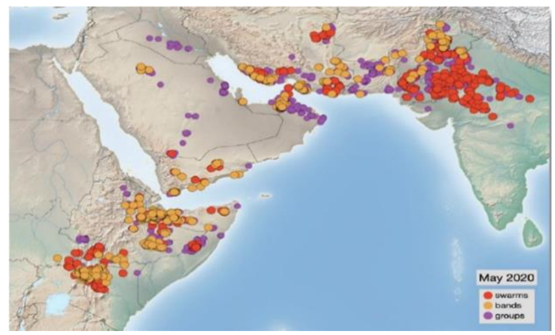
2020 (February): Kenya, Uganda and South Sudan, Tanzania, Persian Gulf.



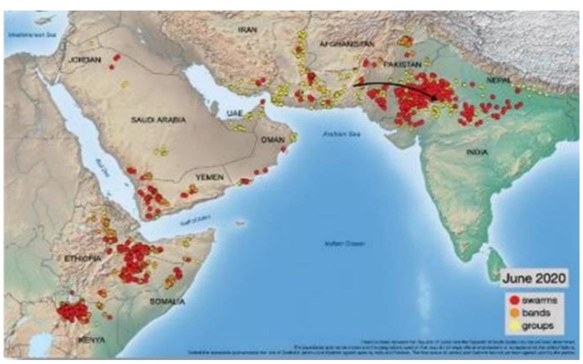
2020 (March): Ethiopia, Kenya, Uganda South Sudan and southern Iran.



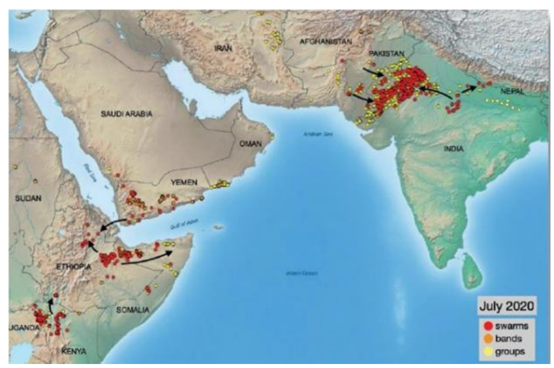
2020 (April): Ethiopia, Kenya,Somalia, and Yemen, Iran and Pakistan.



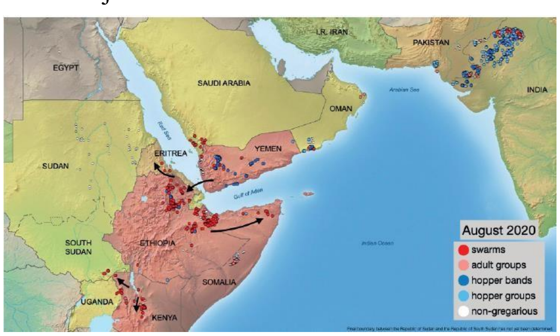
2020 (May): Ethiopia, Kenya,Somalia, Yemen Iran, Pakistan, Indo-Pakistan and northern India.



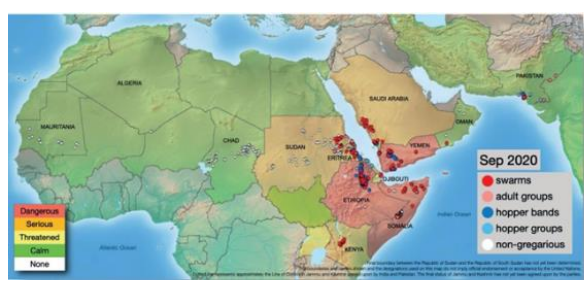
2020 (Jun): NW Kenya Ethiopia, Somalia, Yemen and Rajasthan and northern states of India.



2020 (Jul): NW Kenya, Ethiopia, Somalia, Yemen and Indo-Pakistan border.



2020 (Aug): NE Ethiopia, Eritrea, NW Kenya, Northern Somali, Yeme and SW Saudi Arabia.



2020 (Sept): SW Asia returns to calm.

Fig. 7. Periodical situation of the desert locust in different countries

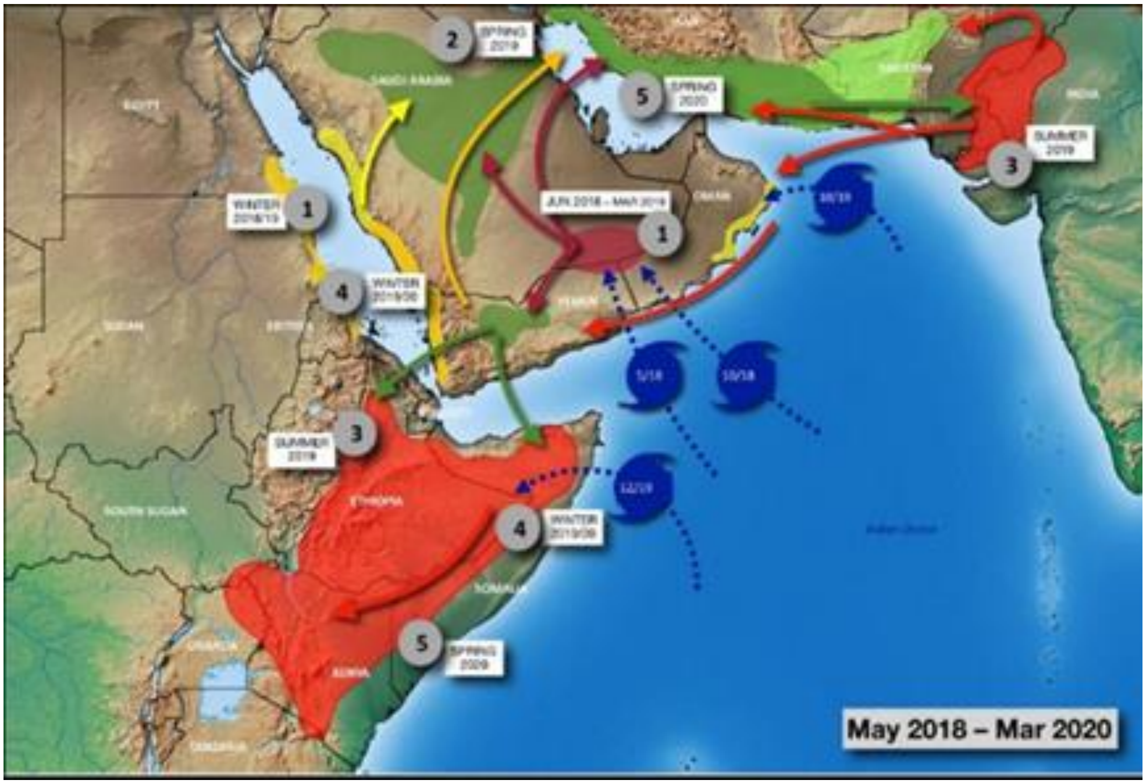


Fig. 8. Desert Locust situation from May 2018 to March 2020

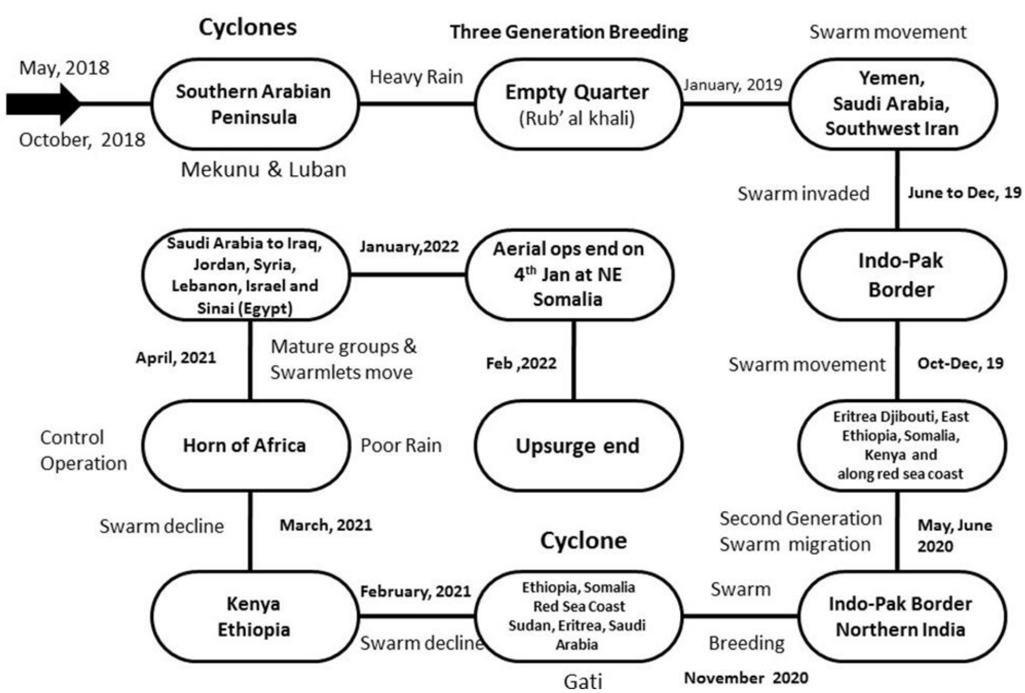


Fig. 9. Upsurge of the Desert Locust during 2019-2021

Locust monitoring and control in India:

In India, the Locust Warning Organisation (LWO) of the Directorate of Plant Protection Quarantine and Storage (DPPQ&S), under the Ministry of Agriculture & Farmers Welfare, is responsible for monitoring, surveying, and controlling Desert Locusts in Scheduled Desert Areas (SDA). These areas are primarily located in the states of Rajasthan, Gujarat, and parts of Haryana. The LWO organizes suitable control operations to prevent the incursion of exotic locust swarms into India.

The LWO stays updated on the locust situation at both national and international levels through monthly Desert Locust Bulletins issued by the Desert Locust Information Service (DLIS) of the FAO, based in Rome, Italy. Field functionaries regularly collect survey data, which is transmitted to LWO circle offices, the field headquarters in Jodhpur, and the central headquarters at DPPQ&S in Faridabad. This data is compiled and analyzed at the headquarters, and forewarnings on potential locust outbreaks and upsurges are issued to field functionaries and respective states.

Significant innovations have been made in locust survey and surveillance to enable quick data transmission, analysis, decision-making, and mapping of survey areas through computerization. New gadgets and software like eLocust3, eLocust3M, eLocust3G, and RAMSES are being used for these purposes. In 2020, an Android mobile application called "eLocust3m" was implemented for real-time reporting of desert locust infestations, resulting in effective monitoring and control.

To strengthen ground control efforts, new vehicle-operated ULV sprayers with advanced features were procured in 2020. Additionally, for the first time in India, drone technology was employed to control locusts in inaccessible areas, tree tops, and high sand dunes. Two helicopters were also used for large-scale spraying of insecticides on locust swarms and breeding sites in Rajasthan during 2020.

In India, 276 desert locust swarms were observed in 2019, and 103 swarms were reported up to August 2020, marking the first significant locust activity in over 26 years since 1993. The locust situation was communicated to the state governments of Rajasthan and Gujarat, advising them to mobilize their field functionaries to maintain constant vigilance and report any locust activity to the nearest LWO offices for prompt action.

In 2019, significant damage to agricultural crops in Rajasthan and Gujarat was reported, prompting the government to grant compensation to the affected farmers. However, in 2020, no crop losses were reported up to August, thanks to the combined efforts of the Locust Warning Organisation, regional and international organizations, and the overall coordination by the Food and Agriculture Organization.

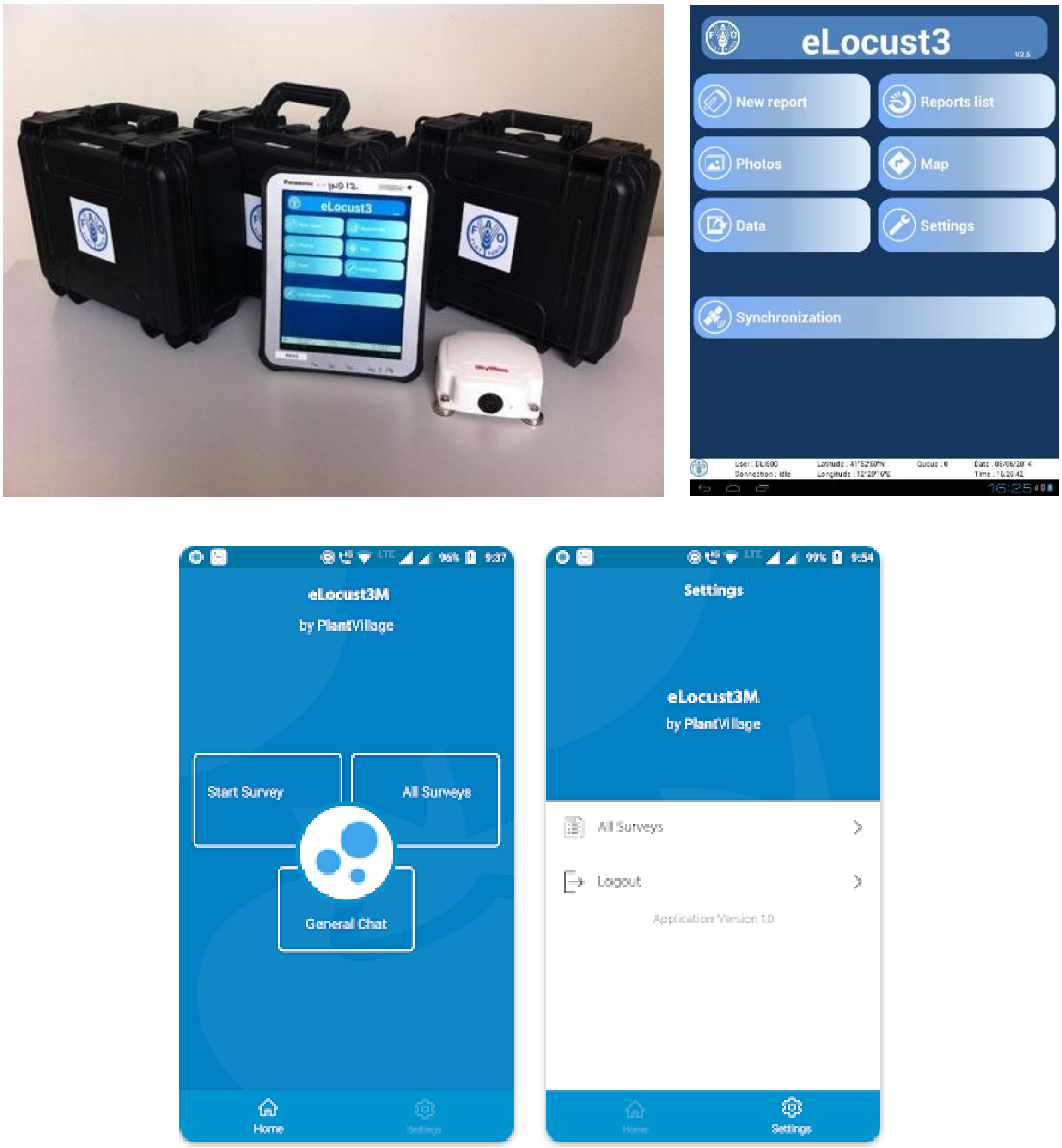


Fig. 10. eLocust used for survey of Desert Locust

Table 2. Scheduled desert Area in India

State/District	Tehsil, Taluka Area	# Villages	Area (sq km)
Rajasthan			
Alwar	Bansure, Behror	318	1380.30
Barmer	Barmer, Chohtan, Pachpadra, Sheo, Ramsar, Siwana	1636	27,755.64
Bikaner	Bikaner, Lunkaransar, Nokha, Sri, Kolayatji	673	22,611.13
Churu	Churu, Rajgarh, Ratangarh, Sardarshahar, Sri Dungargarh, Taranagar, Sujangarh	940	16,806.12
Jaisalmer	Jaisalmer, Pokaran	562	43,583.94
Jalore	Ahore, Bhinmal, Jalore, Sanchore	612	12,208.56
Jhunjhunu	Chirawa, Jhunjhunu, Khetri, Udaipur, Shekhawati	692	5,879.82
Jodhpur	Jodhpur, Osian, Phalodi, Shergarh	624	17,660.10
Nagaur	Nagaur, Jayal, Didwana, Ladnun, Nawa	878	11,132.70
Sikar	Sikar, Lachhmangarh, Neem ka Thana, Fatehgarh, Sawai Madhopur	1506	7,765.80
Sriganganagar	Sriganganagar, Anupgarh, Bhadra, Nohar, Suratgarh	2308	12,466.56
Total Rajasthan			**1,79,250.67**
Gujarat			
Amreli	Dwarka Taluka	42	711.17
Banaskantha	Deesa, Deodar, Dhanera, Palanpur (West of main Ahmedabad-Rly Line), Radhanpur, Tharad (Vav, Santalpur, Sihori, Talukas)	1086	9,843.09
Bhuj	Abdasa, Khadif, Khauvda, Lakhpat, Nakhtrana, Western-Half), Rapar	655	7,013.47
Halar Jamnagar)	Drol & Parts of Jdia, Kalyanpur, Khambalia, Jamnagar, Lalpura, Talukas lying along the gulf of Rann of Kutch.	221	2,374.50
Total Gujarat			**23,077.58**
Haryana			
Mohindergarh	Mohindergarh, Narnaul	378	3,457.20
Total Haryana			**3,457.20**
Grand total			**2,05,785.45**

Organizations of locust control campaign

With the onset of locust season an alert was issued to the agriculture authorities of Rajasthan, Gujarat, Haryana and Punjab States. Other stake holders like Ministry of Home Affairs, Defence, Science and Technology, Civil Aviation, Communication, Aircraft Companies and Pesticides Manufacturing Firms etc. were also sounded for providing needful assistance during locust emergency. The role of different Stake holders is given as under:

Fig. 11. Schedule Desert Area of India

Table 3. Role of different stake holders

Stake holder	Responsibilities
Locust Warning Organisation (LWO), Directorate of Plant Protection Quarantine and Storage, Ministry of Agriculture & Farmers Welfare.	• To monitor, forewarn and control locust in Scheduled Desert Area (SDA) being international obligation and commitment. • To conduct research on locust and grasshoppers. • Liaison and coordination with National and International Organizations. • Human resource development through training and demonstration for staff of Locust Warning Organization (LWO), State officials, BSF personnel and Farmers. • To maintain control potential to combat locust emergency by organizing locust control campaign.
Ministry of Home Affairs	• To advise BSF authorities to extend help and to provide facilities in border surveys. • To advise BSF authorities to extend help in arranging Indo-Pak border meetings. • To grant permission for establishing direct wireless linkage between Jodhpur and Karachi. • To extent help in reporting of locust population/swarm through BSF staff.
Ministry of Defence	• To provide wireless sets (HF and VHF), trained manpower for wireless and vehicles during locust emergency. Also request Defence Ministry to coordinate in using the HF frequency allotted for establishing direct wireless link between Jodhpur (India) and Karachi (Pak) for exchange of locust information's.
Ministry of Science and Technology:	• To provide meteorological data.
Ministry of Civil Aviation:	• To get permission from Air Traffic Control (ATC) for flying aircraft during locust control operation.
Ministry of Communication:	• To approach Ministry of Communication for timely renewal of wireless telegraph licence granted to operate the Locust Warning Organisation wireless communication network.
Government Departments:	• To report locust information to LWO. • To provide assistance in form of vehicles and manpower during locust campaign. • To conduct survey and surveillance of locust in cropped areas. • To control locust in cropped areas. • To create awareness among public and farmers about locust. • To provide facilities to LWO staff during locust survey and control campaign.
Aircraft Companies:	• To provide aircrafts/helicopters on hire basis for locust control.
Pesticide Manufacturing Firms:	• To supply the pesticides on short notice during locust emergency.

Table 4. Management of upsurge by locust warning organization

Sl. No.	Particulars	2019-20	2020-21
01.	Survey (ha)	9,40,484	4,75,015
02.	Personnel (Regular) (No.)	200	300
03.	States affected	Rajasthan, Gujarat & Punjab (14 districts of three states)	Rajasthan, Gujarat, Madhya Pradesh, Uttar Pradesh, Punjab & Haryana, Maharashtra, Chhattisgarh, Bihar, Uttarakhand. (81 districts of 10 states)
04.	Control operations (ha)	4,03,488	2,87,986
05.	Pesticides used (l)	3,14,645	2,45,590







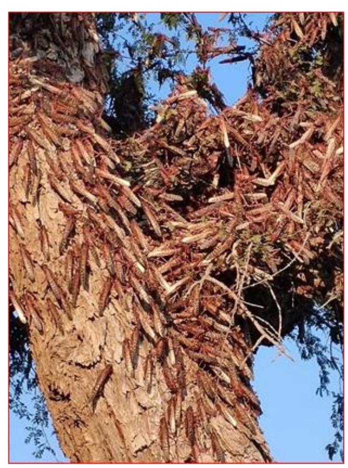


Fig. 12. Severity of DL infestation

Fig. 13. Hopper bands of Desert Locust

Fig. 14. Drones and helicopters used for control operations.

Fig. 15. Spray mounted vehicles

Table 5. Other expertise and resources used for the management of desert locust in India.

Sl. No.	Particular	Details
01.	Contractual staff	118 No. (Technical officers & Drivers)
02.	Helicopter	2 Nos. (1 Private & 1MI-17)
03.	Drones	15 No.
04.	Survey Vehicle	15
05.	Control Vehicle	104
06.	PP equipment (Vehicle mounted sprayers)	103
07.	Total teams	120
08.	SWAC TOC (Virtual meeting organised by FAO for member countries of SWAC)	28 Nos.
09.	Supply of pesticide	20,000 l (Malathion 96% ULV provided to Iran)

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Biological control and integrated pest management

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Introduction

Recent increase in trade and transportation around the world has enhanced the incidence of invasion of alien species. When an alien invasive species invades a country, indigenous and naturalized natural enemies provide frontline defense against the pest (Firake and Behere, 2020), establishing 'biotic resistance' (Heimpel and Mills, 2017). In a panic response to the establishment of an invasive pest, most governments – especially in developing countries – often subsidize and recommend use of synthetic chemical pesticides to combat it. This approach may provide a temporary relief but leads to a counterproductive situation by destroying local natural enemies. Invasive arthropod pests, in general, spread faster than that of invasive plants and cause direct damage to crops in invaded regions leading to farmers drawing attention of their governments. Invasive plants are more of a problem in forests, parks, pastures, and vacant lands, than in farm lands and gets less attention in developing countries.

Generally, there are more local natural enemies that attack an invasive arthropod than an invasive plant in the invaded regions. When the invasive fall armyworm (*Spodoptera frugiperda* J.E. Smith (Lepidoptera: Noctuidae)) invaded Africa and Asia in 2016 and 2018, respectively, Muniappan *et al*. (2024) reported 88 parasitoids and 44 predators from Asia and 57 parasitoids and 47 predators from Africa recruited locally attacking this pest. Very few local natural enemies were recorded on parthenium (*Parthenium hysterophorus* L. (Asteraceae)) and Siam weed (*Chromolaena odorata* (L.) King and Robinson (Asteraceae)) when they invaded India. Also, some of the arthropods recorded on them were pests of economic crops and the invaders were serving as alternate hosts (Shabbir, 2014). To tackle the invasive pests as well as the native ones, biological control gained momentum after such publications as the book 'Silent Spring' by Rachel Carlson in 1962, which highlighted the adverse impact of synthetic chemical pesticides on human and environmental health.

Biological control

According to DeBach and Rosen (1991), biological control is any reduction of plant or animal populations by natural enemies (understood to be predators, herbivores, parasitoids, or pathogens) occurring in natural or managed systems. Biological control has been classified based on its application as classical, augmentative (inoculative and inundative), and conservation.

Classical biological control

Classical biological control is defined as the deliberate introduction of an exotic natural enemy for suppression of the abundance or activity of an undesirable species (Heimpel and Mills, 2017). With the exception of eradication of an invasive species in its early stages of establishment and genetically modified crops, leading to suppression of invasive pests below the economic threshold level, classical biological control has produced silver bullets for pest management issues. For example, the invasive species, papaya mealybug (*Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Pseudococcidae)) (Sharma and Muniappan, 2021), cassava mealybug (*Phenacoccus manihoti* Matile-Ferrero (Hemiptera: Pseudococcidae)) (Neuenschwander, 2003), cassava green mite (*Mononychellus tanajoa* (Bondar) (Acari: Tetranychidae)) (Yaninek and Hanna, 2003), red coconut scale (*Furcaspis oceanica* Lindinger (Hemiptera: Diaspididae) (Muniappan *et al*., 2003), *C. odorata* (Muniappan *et al*., 2007), and giant salvinia (*Salvinia molesta* D.S. Mitchell (Salviniaceae)) (Joy *et al*., 1986) were suppressed by the classical biological control approach in the invaded regions. Similar results cannot be expected in all instances of classical biological control but it has led to partial suppressions as in the case of *P. hysterophorus*, Crofton weed (*Ageratina adenophora* (Sprengel) King and Robinson) (Asteraceae) lantana (*Lantana camara* Linn. (Verbenaceae) and fall armyworm. This partial control has given the opportunity for classical biological control to be integrated with other methods of control such as cultural and mechanical controls.

In some instances, classical biological control has taken place fortuitously as in the case of cotton mealybug (*Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae)), which invaded Pakistan and India in 2005 (Hodgson et al 2008), with its parasitoid *Aenasius arizonensis* (Girault) (Hymenoptera: Encyrtidae) (Hayat, 2009) accompanying it from the new world. Natural enemies introduced for classical biological control in one country have also moved to neighboring countries and contributed to suppression of the target pests. For example, *Zygogramma bicolorata* Pallister (Coleoptera: Chrysomelidae) introduced to India for control of *P. hysterophorus* fortuitously established in Bangladesh, Bhutan, Nepal, Pakistan, and Sri Lanka (Muniappan and Das, 2021). Similarly, the parasitoid *Acerophagus papayae* (Noyes and Schauff) (Hymenoptera: Encyrtidae) introduced to India for control of papaya mealybug fortuitously moved to Bangladesh, Nepal, and Pakistan (Muniappan, 2010; Muniappan, R. pers. obser.).

Classical biological control is mostly a government-initiated program requiring approval to start, support, operate, and implement. Additionally, it may also require collaboration with foreign governments to undertake as natural enemies involved in it need to be explored, host specificity-tested, and imported from outside. Little or no private industries, in general, are involved.

The economic impacts of most classical biological control activities have not been well documented, however, where evaluations were done, the results are impressive. Classical biological control of papaya mealybug in India resulted in a benefit of $524 million to $1.34 billion to the country over five years (Myrick *et al*., 2014), cassava mealybug in sub-Saharan Africa produced a benefit of $9 billion over 40 years in 27 countries (Zeddies *et al*., 2001), and cassava green mite in Nigeria produced a benefit of $1.688 billion over 17 years (Coulibaly *et al*., 2004). For additional information, refer to Norton *et al*. (2019).

Augmentative biological control:

Augmentative biological control is the release of large numbers of natural enemies with the goal of augmenting natural enemy populations or inundating pest populations with natural enemies (Collier and Van Steenwyk, 2004).

Augmentative biological control involves two aspects – inoculative and inundative. Inoculative release of natural enemies involves releasing them at critical times during the season or outbreak cycle (Heimpel and Mills, 2017) has been adopted in different biological control programs. It has been used in classical biological control programs once the introduced natural enemy is established in an area for its spread to other regions. While *Z. bicolorata* was established in Bengaluru, India in 1984, inoculative releases were made in several parts of the country in the succeeding years. After *A. papayae* was established in Bengaluru and Coimbatore in 2010, it was inoculatively released all over India (Shylesha *et al*., 2010; TNAU, 2016). Inoculative releases of parasitoids were also carried out for a native pest, pearl millet head miner, *Heliocheilus albipunctella* (de Joannis) (Lepidoptera: Noctuidae) in Niger. Pearl millet head miner has one generation in a year and the parasitoids are released when the moths emerge from diapause and start laying eggs on the ear head (Amadou *et al*., 2019). The beneficial fungus, *Trichoderma* sp. (Hypocreales: Hypocreaceae) is inoculatively treated seeds to provide protection to seedlings from pathogenic fungi (Nakkeeran, Renukadevi and Aiynathan, 2016). Inoculative seed or soil treatment with the bacterium, *Pseudomonas fluorescens* (Pseudomonadota: Pseudomonadaceae) is adopted for control of soil-borne Fusarium wilt on vegetable crops (Leeman *et al*., 1995) and a take-all disease caused by *Gaeumannomyces graminis* var. *tritici* (Sordariomycetes: Magnaporthaceae) of wheat (Kwak *et al*., 2012).

Inundative biological control flooding an area with large number of natural enemies for suppression of a pest. The process includes, for example, release of parasitoids such as *Trichogramma* spp. (Hymenoptera: Trichogrammatidae) for control of stem borers of sugarcane, rice, maize and sorghum, caterpillar pests of cotton, and vegetable and fruit crops, and it is widely adopted in India (Sithanantham *et al*., 2013). Repeated application of biopesticides such as *Beauveria* sp. (Hypocreales: Cordycipitaceae) and *Metarhizium* sp. (Hypocreales: Clavicipitaceae) nuclear polyhedrosis viruses and entomophathogenic nematodes also fall in this category. It is widely practiced all over the world, especially in protected cultivation. (Repeated application of synthetic chemical pesticides could also be considered as augmentative but not under biological control regime). The number and volume of agents used in augmentative biological control is steadily increasing in recent years (Varshney *et al*. 2024). It is amenable to be integrated with all pest control methods except where broad spectrum synthetic chemical pesticides are used.

Conservation Biological Control:

Biological control occurs everywhere in nature. Local natural enemies prevent native species from reaching pest status and also defend the ecosystem against invading pests. Human interventions involving manipulation of the environment of natural enemies so as to enhance their survival, physiological and behavioral performance, and enhancing efficacy is conservation biological control (Barbosa, 1998; Heimpel and Mills, 2017). It is achieved by manipulation of the environment in favour of natural enemies and reducing the adverse impact of synthetic chemical pesticides to natural enemies.

Some examples are ecologically engineered rice fields planted with sunflower, marigold, and cosmos to increase populations of parasitoids, spiders, and damsel fly; and also had higher incidence of parasitism of sentinel eggs of white backed planthopper, brown planthopper, rice hispa, and yellow stem borer kept in the field compared to control in Bangladesh (Ali *et al*., 2019). Similarly, Yele *et al*. (2012) also found planting flowering plants around rice fields increased the population of natural enemies and reduced pest incidence in India. Hatt and Döring (2025) found wildflower strips to enhance aphid predation in bean-wheat intercropping and further reduced aphid colonization in poppy-barley intercropping in Germany. Alfalfa perimeter strips reduced the incidence of *Lygus lineolaris* Palisot de Beauvois (Hemptera: Miridae), a primary pest of strawberry, by 36% in North America (Hetherington *et al*., 2025).

The use of broad spectrum synthetic chemical pesticides is a major impediment in conservation biological control and the adverse impacts of these pesticides have been well documented. However, selectively using pesticides that are less toxic to natural enemies could be incorporated in conservation biological control. For example, Naranjo and Ellsworth (2009) found that one application of a selective insect growth regulator replaced five applications of conventional broad-spectrum insecticides to control *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) in cotton fields in USA.

Integrated Pest Management

In a 1979 message to Congress, President Carter defined Integrated Pest Management (IPM) as "as a systems approach to reduce pest damage to tolerable levels through a variety of techniques, including predators and parasitoids, genetically resistant hosts, natural environmental modifications and, when necessary and appropriate, chemical pesticides." The concept of IPM evolved among the scientists in California who observed the adverse impact of synthetic chemical pesticides on natural enemies and the environment in the 1950s (Stern *et al*., 1959). IPM is site-, season-, and crop-specific and IPM tactics developed in developed countries require modification for introduction and adoption in developing countries, as their social, economic, and environmental conditions differ. Biological control is the foundation for any IPM program and all amenable techniques incorporated must safeguard it. Muniappan *et al*. (2021) of the IPM Innovation Lab has developed IPM packages for several crops, incorporating all locally available safe techniques, such as inoculative treating seeds with *Trichoderma* sp. and *P. fluorescens*, inundative release of *Trichogramma* sp. and avoiding the use of broad spectrum synthetic chemical pesticides for adoption of conservation biological control.

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Research Articles

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Emerging threats to litchi cultivation: managing *Tessarotoma javanica* infestation in orchards

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The genus *Tessaratoma* (Hemiptera: Tessaratomidae) comprises approximately 26 species, among which *Tessaratoma javanica* (Thunberg), *T. papillosa* (Dury), and *T. quadrata* (Distant) are known to infest litchi (*Litchi chinensis* Sonn.) across different regions of the world. These species are collectively referred to as litchi stink bugs (Srivastava & Choudhary, 2022). In India, *T. javanica* was reported as an economically important sucking pest of litchi (*Litchi chinensis* Sonn.) by Choudhary *et al*. (2013). This species of bug is also an important pest of Rambutan (*Nephelium lappaceum)*, Longan (*Dimocarpus longan*), Pomegranate, (*Punica granatum)*, Kusum (*Schleichera oleosa),* champak (*Michelia champaca)*, and many trees, including Eucalyptus and mulberry. Numerous outbreaks of *T. javanica* on litchi have been documented in India and its neighbouring countries, by various workers (Choudhary *et al.,* 2013; Mondal *et al.,* 2021; Srivastava and Choudhary, 2022).

Infestation typically begins with the onset of floral development phase in the last week of February and continues until fruits are ready for harvest. Throughout this duration, gregarious nymphs and adults penetrate and extract sap from floral buds, panicles, juvenile fruit peduncles, and delicate shoots. This feeding reduces the growth and development of flowers and fruits, leading to heavy crop loss in litchi (Choudhary *et al.,* 2013).

Stink bug nymphs and adults exhibit a voracious feeding behaviour, whereby they suck sap from delicate plant tissues, such as growing buds and tender shoots. As a consequence, desiccation occurs, resulting in the subsequent darkening of the fruits. Because of sucking of sap, flowers later detach from the peduncles. The phenomenon of adult swarming on the litchi tree commences during the initial week of February and persists until the end of the month. During the second week, egg masses become visible on the lower surface of developing leaves. Both adult individuals and neonates can release malodorous scents in response to disturbance. The stink bugs have a preference for warm and humid climatic conditions, which are now prevalent in the region of Bihar (Kumar et al., 2022) and in Jharkhand severe damage up to 80% were reported to the litchi crop (Choudhary et al., 2013).

Biology of litchi stink bug, *T. javanica*

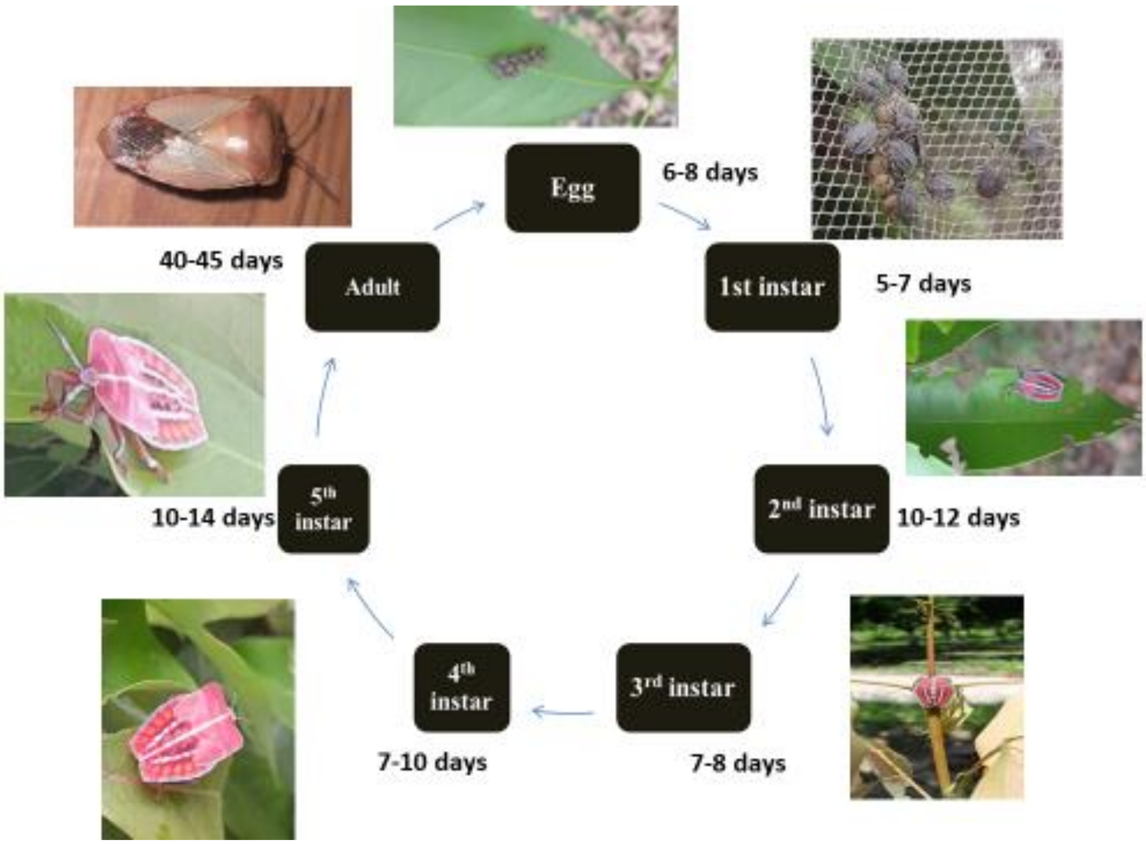

Fig. 1 Biology of litchi stink bug, *Tessarotoma javanica*

When inflorescences appear, the litchi stink bug population begins to increase. It peaks when flowers are fully bloomed, which corresponds with pollinator activity (Choudhary *et al.,* 2013). From August to February, when *T. javanica* bugs are less active on litchi, they deposit small number of globular, pink eggs, but it takes longer time (180 days) (Choudhary *et al.,* 2021). Nearly 10 to 13 days after mating, oviposition takes place, and eggs are typically placed in 3–4 rows in clusters of 14 (Srivastava and Choudhary, 2022) (Figure 1). Ideally, eggs are laid beneath the leaf surface, however they can sometimes be seen on fruits, inflorescences, and over previously laid eggs (Choudhary *et al.,* 2021). The immature phases are gregarious. With the exception of the first instar, which is almost sub-rectangular, the bugs undergo five instars, all of which are sub-rectangular and dark brick red (Wu *et al*., 2020). The newly born nymph is a soft-bodied, dirty white insect, but after a few days, its colour changes to yellow-red. According to

Parveen *et al.* (2015), the life duration of all stages is 13, 60, 60, and 75 days for the egg, nymph, male, and female adults, respectively. By sucking the sap from the flowers and fruits, the adult and nymphs directly harm them, causing them to wilt, die, and eventually fall to the ground. Removing adults by hand minimize the overwintering adult populations before egg laying begins (Figure 2). Litchi stink bugs, *T. javanica* like other stink bug species, exhibit a distinct pattern of colonization and dispersal within orchards. Initially, adults are concentrated on a few host plants, where females lay eggs, typically on the underside of leaves. After hatching, the newly emerged nymphs (first instar) tend to cluster around the egg mass and remain localized for a short period (Figure 3). As they progress through subsequent nymphal stages, they begin to migrate to more succulent and tender parts of the plant, such as young shoots, fruits, or developing leaves, in search of optimal feeding sites.

This movement is driven by the nymphs' need for high-nutrient plant tissues to support their rapid growth and development. As the nymphs mature, they disperse further from the original egg-laying site, gradually spreading throughout the orchard and infesting additional plants. This pattern of initial aggregation followed by dispersal facilitates rapid colonization of new host trees and can lead to widespread infestation if not managed promptly. The spread of stink bugs within an orchard is also influenced by chemical signals (pheromones) and plant-borne vibratory signals to locate mates and coordinate aggregation, which can further enhance their ability to concentrate on specific trees before dispersing. The quality and availability of host tree also play a significant role in their distribution, as stink bugs may shift to alternative plants if their preferred hosts become scarce.

Current management strategies mainly rely on insecticide sprays. Application of two sprays of any of the following insecticide combinations on appearance of the adults or congregated nymphs is recommended by National Research Centre on Litchi, Muzaffarpur:

- Thiacloprid 21.7% SC (0.5 ml/l) + Fipronil 5% SC (1.5 ml/l) per litre of water or
- Thiacloprid 21.7% SC (0.5 ml/l) + Profenophos 50% SC (1.5 ml/l) per litre of water
- Lambda Cyhalothrin 5% EC (1.5 ml/l) + Chlorfenapyr 10% EC (1.0 ml/l) per litre of water

Fig. 2 Egg laying and emergence of nymphs during flowering phase of litchi

Fig. 3 Congregation of different instars in the newly emerged shoots

Managing litchi stink bug, *T. javanica*

The nymphs during February–March (post-hatching) and adults in November–January (pre-oviposition) should be major targets for insecticidal spray. Further, during the vegetative phase, the first spray is advised from 7th to 10th August and the second spray from 17th to 20th August putting hurdles to insect life cycle in litchi orchard. Use sticker in insecticide solution at the rate of 0.4 ml/litre. Whenever an insecticide is sprayed, the insects that have fallen on the ground should be collected by broom and destroyed mechanically (manually) by placing them in a pit and covering them with soil. The practice of picking bugs after spraying insecticides is an effective strategy to prevent further infestation. Chemical sprays alone may not fully eliminate the pest population due to factors such as insecticide resistance or incomplete coverage. Additionally, manual removal of stink bugs ensures that any individuals that survive the spray do not continue to infest the crop or reproduce (Figure 4), thereby reducing the potential for resurgence of the pest population. Overall, combining insecticide application with manual removal of stink bugs enhance pest control efficacy and helps safeguard litchi yields. Further, release of *Anastatus bangalorensis* and *A. acherontiae* from the family Eupelmidae and *Ooencyrtus sp*. from family Encyrtidae of order Hymenoptera (Choudhary et al., 2015) can be included in the integrated pest management practices to manage the stink bug, *T. javanica*.

Fig. 4 Manual collection of stink bug adults and nymphs after insecticidal spray

Conclusions

Integrated pest management (IPM) strategies—encompassing cultural practices, biological control agents, and judicious insecticide application—are essential for mitigating the damage caused by *Tessaratoma javanica*. While insecticide use remains the primary immediate solution to suppress pest populations, long-term sustainable management requires a coordinated approach involving research institutions and state horticulture departments.

Given its potential to cause severe crop losses and its rapid spread under favorable climatic conditions, *T. javanica* represents a significant challenge for litchi cultivation in India. Immediate and sustained intervention, supported by predictive monitoring and farmer awareness programs, is imperative to safeguard litchi production and ensure the resilience of affected orchards

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Insect pest complex of bitter gourd (*Momordica charantia* L.) and their occurrence across different sowing dates in Tseminyu district, Nagaland

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Abstract

This study investigated the impact of insect pests on bitter gourd crops at various sowing dates. The major pests identified were the red pumpkin beetle (*Aulacophora foveicollis*), leafhopper (*Bothrogonia sclerotica*), and aphids (*Aphis gossypii*), while other pests such as grasshoppers, thrips, and fruit flies had a negligible impact. Pest infestations significantly affected the crop from early growth to harvest, with pest population dynamics influenced by sowing dates. The highest aphid population (7.15 aphids per plant) was recorded at 30 days after transplanting (DAT) on the first sowing date (D1, 23rd April), while the highest mean aphid population (5.39 aphids per plant) was observed during the fourth sowing date (D4, 7th June). The red pumpkin beetle population peaked at 4.25 beetles per plant at 30 and 45 DAT during the third sowing date (D3, 23rd May), with the highest mean population of 3.21 beetles per plant recorded at D3. Similarly, leafhopper populations peaked at 45 DAT in D1, with a maximum mean population of 3.21 hoppers per hill. These findings underscore the critical role of sowing dates in pest population dynamics and highlight the importance of implementing effective pest management strategies to minimize crop losses. The study provides valuable insights for the commercial cultivation of bitter gourd, reinforcing the need for integrated pest control measures throughout the growing season.

Keywords: Insect pests, Bitter gourd, Pest management, Planting dates

Introduction

Vegetables play a crucial role in human health by providing essential nutrients and energy. Among them, bitter gourd (*Momordica charantia* L.), a member of the Cucurbitaceae family, is extensively cultivated in tropical and subtropical regions, including India, China, and Southeast Asia (Palada & Chang, 2003; Behera *et al*., 2008; Win *et al*., 2014).

Renowned for its medicinal and culinary applications, bitter gourd is primarily grown for its fruit, which is incorporated into various dishes and beverages. Techniques such as blanching help reduce its characteristic bitterness, enhancing its palatability (Saeed *et* *al*., 2018). Beyond its culinary use, bitter gourd serves as a traditional remedy for diabetes, with studies indicating its insulin-like properties that aid in blood glucose regulation.

Additionally, bitter gourd exhibits multiple pharmacological benefits, including anti-cholesterol, anti-cancer, anti-inflammatory, and antibacterial activities. Notably, all parts of the plant contain over 60 phyto-medicinal compounds, contributing to its diverse therapeutic potential (Kole *et al.,* 2020).

However, like many crops, bitter gourd faces significant challenges from insect pests, which can cause substantial yield losses. Key pests include the fruit fly (*Bactrocera cucurbitae*), pumpkin beetles (*Aulacophora species*), leaf miners (*Liriomyza trifolii*), and aphids (*Aphis spp*.). These pests can reduce crop yields by up to 70%, severely affecting the economic viability of cultivation (Dhaliwal *et al*., 2007). Pesticide use is common for pest control, but excessive reliance on chemicals has led to resistance, environmental harm, and higher production costs.

The damage caused by insect pests not only decreases yield and quality but also increases the cost of production, posing a serious threat to farmers' income. The challenge of managing these pests effectively without harming the environment or increasing costs highlights the need for alternative pest management strategies.

To address the issue of indiscriminate pesticide use, eco-friendly techniques such as agronomic practices can be employed. One such practice involves altering sowing dates to avoid the peak activity of insect pests affecting crops. The timing of sowing significantly influences pest incidence, with variations in weather conditions playing a key role. Therefore, identifying optimal sowing times is crucial to minimizing pest damage while enhancing crop growth. This study aims to evaluate the impact of sowing time on insect pest incidence in bitter gourd cultivation in Tseminyu district of Nagaland, with the goal of advancing pest management strategies.

Material methods

An experiment was conducted at a farmer’s field in Sendenyu village, Tseminyu district, during the Kharif 2024 season to assess the impact of different sowing dates on the incidence of insect pests in bitter gourd cultivation. The hybrid variety Pariposa Tiny was selected for this study, and four sowing dates-23rd April, 8th May, 23rd May, and 7th June-were considered.

The seeds were initially sown in a high-tech polyhouse at New Terogvunyu. After 15–20 days, when the seedlings reached approximately 10–15 cm in height, they were transplanted into the main field. The experiment was replicated thrice following a Randomized Block Design (RBD). Standard agronomic practices were implemented, except for insecticidal sprays, to allow for an accurate assessment of pest incidence.

Observations on insect pest incidence were recorded on eight randomly selected plants, starting from 30 days after transplanting (DAT) until harvest. The population of sucking pests was assessed by counting individuals from three leaves per plant—one each from the top, middle, and bottom canopy.

The data obtained were subjected to Fisher's method of analysis of variance (ANOVA) using the 'F test' to determine statistical significance between treatments. If the F test indicated significance, the critical difference (CD) was calculated for further comparison.

Results and discussion

During the study, nine insect pest species were identified as prevalent on bitter gourd crops. Notably, the red pumpkin beetle (*Aulacophora foveicollis* Lucas) and the short-horned grasshopper (*Hieroglyphus banian* Fabricius) were observed from the seedling stage through to harvest, causing continuous damage throughout the growing season. Additionally, a variety of sucking pests, including thrips (*Thrips palmi* Karny), whitefly (*Bemisia tabaci* Gennadius), leafhopper (*Bothrogonia sclerotica* Young), and aphids (*Aphis gossypii* Glover), were present across the entire season, exhibiting varying levels of infestation intensity. The epilachna beetle (*Henosepilachna vigintioctopunctata* Fabricius) was primarily observed during the vegetative stage, while the blister beetle (*Mylabris phalerata* Pallas) and the fruit fly (*Bactrocera dorsalis* Hendel) were recorded during the flowering and fruiting stages of the crop.

Among these pests, the red pumpkin beetle, leafhopper, and aphids were considered the most significant, while the other pests had a negligible impact. These findings are consistent with those of Sunil *et al*. (2017), who reported that, like other cucurbits, bitter gourd is attacked by a variety of insect and non-insect pests, with the major culprits being the fruit fly, red pumpkin beetle, whitefly, aphids, and thrips. The infestation of these pests is a critical limiting factor in the commercial cultivation of bitter gourd. Pest attacks typically begin early in the crop's growth cycle and continue until harvest, with the intensity of infestation dependent on prevailing agronomic conditions. Jha (2008) identified *Bactrocera cucurbitae* and *Henosepilachna septima* as particularly serious insect pests of bitter gourd, noting that infestation by the fruit fly (*B. cucurbitae*) and epilachna beetle (*H. septima*) peaks during the Kharif season, with minimal or no infestation during the summer months. These findings are consistent with reports from Manandhar *et al*. (2009), Gameel (2013), and Sarwar (2013).

The data on the incidence of aphid, *A. gossypii* are tabulated in Table 1.1. It is evident from the data obtained that all the three different planting dates showed significant influence on the incidence of aphid population. The highest incidence of *A. gossypii* recorded was at 30 DAT (Days after transplanting) with 7.15 aphid/plant in D_1 followed by 7 aphid/plant at 30 DAT in D_2 whereas the lowest population with 3.16 aphid/plant was recorded at 30 DAT in D_1 followed by 3.35 aphid/plant in 60 DAT at D_2. The highest mean population of 5.39 aphid/plant was recorded at D_4 (i.e., sowing date: 7th June) while the lowest was observed in D_1 (i.e., sowing date 23rd April) with 4.74 aphid/plant. The finding also reveals that the aphid population persisted throughout the season in an increasing trend. The present findings get support from the observations of Meena *et al*. (2002) and Kumari and Yadav (2004) who reported that early sown crop are less infested by aphid and gave higher yield in comparison to late sown crop.

The data on the incidence of red pumpkin beetle (*Aulacophora foveicollis*) are presented in Table 1.2. The results indicate that planting date significantly influenced the beetle population, except at 120 and 135 days after transplanting (DAT). The highest incidence of *A. foveicollis* was recorded at 30 and 45 DAT in D3 (sowing date: 23rd May), with 4.25 beetles per plant, followed by 3.63 beetles per plant at 60 DAT in D3 and 45 DAT in D2. The lowest population, with 1.25 beetles per plant, was observed at 120 and 135 DAT in D1 (sowing date: 23rd April), and 1.50 beetles per plant at 105 DAT in D1. The highest mean population of 3.21 beetles per plant was observed in D3, while the lowest was in D1, with 1.74 beetles per plant. The findings also revealed that the red pumpkin beetle population persisted in the field throughout the growing season until harvest. These results are consistent with those of Johri and Johri (2003), who reported higher beetle incidence from March to September, and Ghule *et al*. (2015), who found the beetle most active in March, April, and May. Similarly, Saljoqi and Khan (2007) observed peak infestation between May 7 and June 18, with a gradual decline thereafter.

The data on the incidence of leafhoppers, *Bothrogonia sclerotica* are tabulated in Table 1.3. It is evident from the data obtained that all the three different planting dates showed significant influence on the incidence of the population except for 120 DAT and 135 DAT. The highest incidence *Bothrogonia sclerotica* recorded was at 45 DAT with 4.75 hopper/plant in D_1 followed by 4.38 hopper/plant at 30 DAT in D_1 whereas the lowest population with 1.00 hopper/plant was recorded at 120 and 135 DAT in D_4 followed by 1.13 hopper/plant in 135 DAT at D_1 and 105 DAT at D_4. The highest mean population of 3.21 hopper/plant was recorded at D_1 (i.e., sowing date: 23rd April) while the lowest was observed in D_4 (i.e., sowing date 7th June) with 1.63 hopper/plant. This finding is similar with the findings of Miah *et al.* (2021) with highest leaf hopper population recorded at the month of May with 4.67 hopper/plant.

Table 1.1. Effect of sowing dates of bitter gourd on the incidence of Aphids in Tseminyu

Treatment	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	105 DAT	120 DAT	135 DAT	Mean
D1	7.15	6.84	4.23	4.01	3.16	4.26	4.15	4.14	4.74
D2	7.00	5.10	3.35	3.70	3.91	5.08	5.83	6.25	5.03
D3	4.20	3.76	3.98	4.35	4.88	5.61	6.25	6.68	4.96
D4	3.78	4.26	4.93	5.25	5.73	6.01	6.50	6.64	5.39
SEm±	0.32	0.25	0.20	0.20	0.21	0.17	0.21	0.24	
CD(p≤0.05)	0.91	0.72	0.57	0.58	0.59	0.48	0.60	0.68	

Table 1.2. Effect of sowing dates of bitter gourd on the incidence of Red Pumpkin Beetle in Tseminyu

Treatment	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	105 DAT	120 DAT	135 DAT	Mean
D1	2.13	2.25	2.00	1.88	1.63	1.50	1.25	1.25	1.74
D2	3.38	3.63	3.13	2.38	2.00	1.88	1.75	1.38	2.44
D3	4.25	4.25	3.63	3.50	3.00	2.88	2.25	1.88	3.21
D4	2.88	3.00	2.50	2.50	2.25	2.00	2.00	1.63	2.35
SEm±	0.27	0.27	0.22	0.21	0.18	0.18	0.18	0.12	
CD(p≤0.05)	0.77	0.76	0.63	0.59	0.52	0.51	NS	NS	

Table 1.3. Effect of sowing dates of bitter gourd on the incidence of Leafhopper in Tseminyu

Treatment	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	105 DAT	120 DAT	135 DAT	Mean
D1	4.38	4.75	4.00	3.38	3.25	2.50	2.00	1.38	3.21
D2	3.63	3.25	2.75	2.38	2.13	1.88	1.63	1.38	2.38
D3	3.13	3.50	2.50	2.38	2.00	1.75	1.25	1.13	2.21
D4	2.25	2.50	2.25	1.50	1.38	1.13	1.00	1.00	1.63
SEm±	0.27	0.25	0.23	0.24	0.24	0.17	0.19	0.14	
CD(p≤0.05)	0.78	0.72	0.66	0.68	0.69	0.48	NS	NS	

Summary

The study underscores the significant impact of insect pests on bitter gourd cultivation, identifying red pumpkin beetle (*Aulacophora foveicollis*), leafhopper (*Bothrogonia sclerotica*), and aphids (*Aphis gossypii*) as the most prevalent pests. Pest infestations commenced early in the crop's growth cycle and persisted until harvest, with their severity influenced by sowing dates and agronomic conditions.

Notably, early-sown crops exhibited lower aphid populations, supporting previous research that highlights the crucial role of planting time in pest management. The red pumpkin beetle and leafhopper displayed distinct population peaks at specific growth stages, reinforcing the necessity for targeted pest control strategies. These findings emphasize the importance of strategic sowing dates and integrated pest management approaches to mitigate crop losses and enhance bitter gourd productivity.

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Report of *Rhopalosiphum nymphaeae* L. (Hem.: Aphididae) infesting lotus (*Nelumbo nucifera* Nelumbonaceae)

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Abstract

Rhopalosiphum nymphaeae L. (Hem.: Aphididae) was observed infesting on lotus flowers (*Nelumbo nucifera*) in the farm of Regional Agricultural Research Station, Kumarakom, Kottayam, Kerala. The feeding behaviour of the nymphs and adults caused upward curling, deformation and distortion of leaves, as well as drying of flower petals and flower buds. Additionally, the secretion of honeydew by aphids led to the proliferation of sooty mould, which reduced the photosynthetic efficiency of leaves, diminished the aesthetic value of the flowers, hindered plant growth, and ultimately resulted in plant desiccation

Keywords: Waterlily aphid, *Rhopalosiphum nymphaeae*, lotus, Kerala

Lotus (*Nelumbo nucifera*), the national flower of India and Vietnam (Sharan *et al*., 2021) is a multipurpose aquatic plant having religious significance, culinary, medicinal and aesthetic value. The flowers are mainly used for ornamental and religious purpose and it is also used as a source of perfume also. In India lotus is commercially grown mainly in the states, Chhattisgarh, Kerala, Kashmir, West Bengal, Jharkhand and Tamil Nadu (Shah *et al*., 2023).

It is a potential economic plant and the cultivation is comparatively easy relatively simpler (De L, 2020) and the cost of cultivation is lower, compared to other crops. The crop is commonly found in wetland habitats. Vo *et al*.,2021 reported that lotus cultivation can be a promising innovation for the wetland-based farming system where farmers can harness the flood conditions consequent to the changing climatic conditions for sustainable livelihoods. Moreover, it is highly compatible with aquaculture and is a potential player for ecotourism. So, there is huge opportunity in lotus farming in geographical locations like Kumarakom, an area below sea level where most of the area is wetland and is also a popular tourist destination.

Lotus has been cultivated in the various ponds and channels present in the Regional Agricultural Research Station, Kumarakom, Kottayam campus (9º 37’ 22” N 76º 25’ 45” E), with the intention of exploring and exploiting opportunities for commercial cultivation of the plant and its role in ecotourism. Infestation of the aphids, *Rhopalosiphum nymphaeae L.* (Hem.: Aphididae) was noticed on lotus flowers in the farm of RARS, Kumarakom, Kottayam during the first fortnight of March 2024. There was sudden change in the appearance of the plant in one of the ponds (3 acre) and upon examination, colonies of *Rhopalosiphum nymphaeae* L. (Hem.: Aphididae) were found congregating on petals (Fig. 1), flower buds, petioles and undersurface of leaves.

Aphids at various life stages were collected and preserved in 70% ethanol, and their damage characteristics were observed. Nymphs and adults were found on the lower surface of leaves, petioles, flower buds, and petals, where they fed by extracting cell sap from plant tissues. This feeding activity resulted in upward curling (Fig. 1), deformation, and distortion of leaves, as well as the drying of flower petals and buds. The secretion of honeydew by aphids facilitated the growth of sooty mold, which reduced photosynthetic efficiency, diminished the aesthetic value of flowers, slowed plant growth, and ultimately led to plant desiccation. The aphid colony consisted of oval-shaped apterous adults, alate adults, and olive-green nymphs.

Apterous adults were bigger when compared to alate adults and were reddish brown to dark brown in colour while alate adults were dark brown to shiny black in colour. *Rhopalosiphum nymphaeae* infestation was found to be very destructive since they reproduce very fast after colonizing, virtually blanketing the lotus plants and the infestation was spreading very fast within the pond from one area to another. The high fecundity of *R. nymphaeae* was documented by Storey (2007) which can give one offspring every six hours according to (Ballou et. al.,1986) can cover almost all plants in the water a few weeks after their first appearance.

In Kerala*, Rhopalosiphum nymphaeae* L. (Hem.: Aphididae) was first reported by Ganganalli et al., 2023 in *Nuphar lutea* and *Salvinia sp.* (Vellanikkara, Thrissur) and in *Nymphaea sp.* (Thiruvananthapuram). They also stated that aphids belonging to genera *Rhopalosiphum Koch.* were the second most diverse genus found in Kerala with two major species *R. nymphaeae* (L) and *R. maidis* (Fitch). The authors have described the nymphs and apterous adults of *Rhopalosiphum nymphaeae* as oval, reddish brown to dark brown with a whitish bloom on the ventral surface of the body and alate adults as dark brown to shiny black. Out of the six species of *Rhopalosiphum* reported in India, the water lily aphid, *R. nymphaeae* was reported for the first time in India in north Bihar on different aquatic plants *viz*., *Euryale ferox* (L.), *Ipomoea* (L.), *Nymphoides (Seg.), Marsilea* (L.), *Hydrilla (*Rich.), *Vallisneria* (L.), *Eichhornia (Kunth), Polygonum* (L.), *Pistia* (L.), *Ranunculus* (L.) *and Nymphaea* (L.) by Saraswati et al. (1990), and later on *Nymphaea lotus (L.)* and *Eleusine* *coracana* (L.) in Karnataka by (Joshi, 2008), on different aquatic plants in Varanasi, Uttar Pradesh by Halder et al. (2020), on *Azolla filiculoides* (Lam.) in Guilan Province, Iran by Farahpour *et al.* (2015).

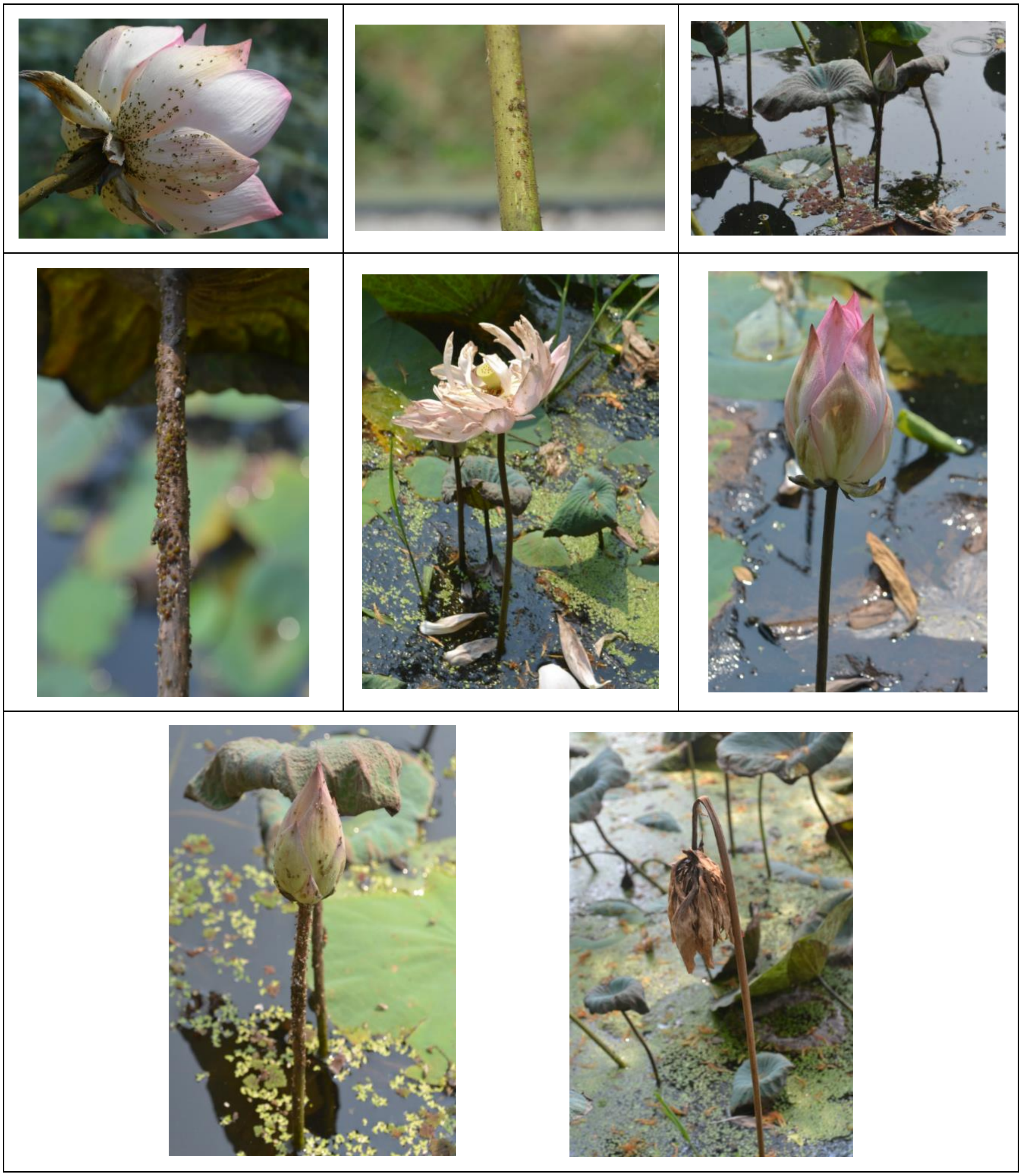

Fig. 1. Congregation and damage symptoms of *Rhopalosiphum nymphaeae* L. on different plant parts

Our observations revealed the presence of numerous parasitoid species, primarily Aphidiinae (Hymenoptera: Braconidae), along with coccinellid predators, including *Coccinella septempunctata* L. and *Menochilus sexmaculatus* Fabricius, closely associated with the aphid colonies.

Milankovic *et al.* (2022) reported that *R. nymphaeae* can survive in underwater conditions also with the help of specialized body hairs that traps air enabling it to feed on plant parts. In a host preference study conducted by Halder and coworkers (2020) it was found that *R. nymphaeae* has more preference towards lotus when compared to other aquatic plants. A single spray of Dimethoate 30 EC @ 2 ml/L on March 20, 2024 yielded satisfactory control. As the state is giving more thrust to ecotourism activities, the judicious use of existing resources like canals and ponds for lotus cultivation can generate additional income to farmers. However, the infestation of water lily aphid, *Rhopalosiphum nymphaeae* L. (Hem.: Aphididae) on lotus is highly destructive, hence there is an urgent need for the development of integrated management practices including biological, mechanical and chemical methods against water lily aphid *Rhopalosiphum nymphaeae* L. (Hem.: Aphididae).

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Butterfly diversity in central Bengaluru, Karnataka, India

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The Bengaluru Urban district has seen tremendous economic growth and urbanization over recent years. This has invariably led to changes in vegetation cover, quality of microhabitats, and abundance of native species. The diversity in the vegetation has been particularly shaped by social preferences (Sudhira and Harini, 2013). These changes can have long-term impacts on the diversity of fauna within the city. Butterflies are highly reliant on the diversity of fauna and react to disturbances and changes (Mac and Fleishman 2004). Consequently, they play a key role as an indicator species (Lewis and Yves, 2007) and may reflect the health and status of the microhabitats within the city. They also play a critical role as prey species to a variety of fauna and are crucial links in the food web (Aneesh *et al*., 2013). St Joseph's College (Autonomous), now St. Joseph's University (SJC/U), located in Bengaluru, has several plants and canopies providing a conducive habitat for butterflies. The college campus lies in proximity to Lalbagh, Cubbon Park, and several lakes that have an abundance of flowering plants and host species for butterflies that function as urban microhabitats with a diversity of microfauna.

The study was conducted on the campus (12.9620°N, 77.5962°E) and the adjoining areas, selected due to their proximity to multiple green spaces known for their rich butterfly diversity. The research spanned April 2017 to April 2018, during which butterfly species were surveyed using a visual sampling approach in randomly selected green patches.

Surveys were carried out twice a week, ad libitum, with observations recorded during three distinct time intervals: 8–9 AM, 1–2 PM, and 4–5 PM. Butterfly species were identified using field guides and online sources (Gaonkar, 1996; Kunte *et al*., 2014; Chaturved, 2016; Bhakare and Ogale, 2018).

A total of 43 species of butterflies belonging to five families were recorded from the study areas (Table 1). Of these, the family Nymphalidae was the largest represented by 16 species (37.20%), followed by Lycaenidae with 11 (25.58%), Papilionidae with 7 (16.28%), Pieridae with 5 (11.63%), and Hesperidae with 4 (9.30%) (Figure 1). Based on the updated list and the species level of identification, Common Pierrot (*Castalius rosimon*), Common Hedge Blue *Acytolepis puspa* are protected under Schedule I, while Crimson Rose (*Pachliopta hector*), Dakhan

Baron (*Euthalia aconthea*), Dark-Banded Bushbrown (*Mycalesis mineus*) are protected under Schedule II of the Wildlife Protection Act 1972 (Kunte, 2024).

The butterflies of the family Nymphalidae (37%) dominate the butterfly fauna of the study area within St Joseph's campus and the adjoining areas (Fig.1). The butterflies of this family feed on a variety of food and can hence survive in a range of varying habitats (Majumder *et al*., 2013). The dominance of the Nymphalidae family is consistent with data obtained through diversity studies in other parts of South India. Relatively lower numbers of other butterfly species may be due to their small size and difficulty in spotting and identification. Habitat selection in butterflies is highly specific and depends on the availability of resources for larvae and adults (Grossmueller and Lederhouse, 1987). The diversity observed within the study site may represent stability and equilibrium in the microhabitat (Alexander *et al*., 2016). Maintenance of the faunal cover and improving local plant species is of utmost importance to ensure improvements in butterfly diversity. This data provides the basis for long-term studies that may provide more insight into changes due to anthropogenic stressors.

Summary

The study recorded 43 butterfly species across five families, with Nymphalidae being the most dominant (37%), followed by Lycaenidae (25.58%), Papilionidae (16.28%), Pieridae (11.63%), and Hesperiidae (9.30%). The prevalence of Nymphalidae aligns with observations from other regions in South India, likely due to their diverse feeding habits and adaptability to various habitats (Majumder *et al*., 2013).

Several species identified in the study, such as *Castalius rosimon* (Common Pierrot) and *Acytolepis puspa* (Common Hedge Blue), are protected under Schedule I of the Wildlife Protection Act, 1972, while Pachliopta hector (Crimson Rose), *Euthalia aconthea* (Dakhan Baron), and *Mycalesis mineus* (Dark-Banded Bushbrown) fall under Schedule II (Kunte, 2024).

Butterfly habitat selection is highly resource-dependent, with species diversity indicating stability within the St. Joseph's campus and its adjoining areas (Grossmueller & Lederhouse, 1987). Conservation efforts—such as maintaining faunal cover and enhancing local plant diversity—are vital for sustaining butterfly populations.

Preserving faunal cover and enhancing local plant diversity are crucial for sustaining and improving butterfly populations. These efforts contribute to habitat stability, promoting species richness and ecological balance. Additionally, this dataset serves as a foundation for long-term studies, offering valuable insights into the impact of anthropogenic stressors on butterfly diversity and habitat dynamics.

Table 1: List of species observed during the study

Sl. No.	Family	Common name	Scientific name
1	**Hesperidae**	Common Banded Awl	*Hasora chromus*
2		Indian Bush Hopper	*Ampittia dioscorides*
3		Giant Redeye	*Gangara thyrsis*
4		Grass Demon	*Udaspes folus*
5	**Lycaenidae**	Common Hedge Blue	*Acytolepis puspa*
6		Indian Angled Pierrot	*Caleta decidia*
7		Common Cerulean	*Jamides celeno*
8		Asian Zebra Blue	*Tarucus plinius*
9		Common Pierrot	*Castalius rosimon*
10		Lime Blue	*Chilades laius*
11		Plains Cupid	*Chilades pandava*
12		Pale Grass Blue	*Pseudozizeeria maha*
13		Indian Red Pierrot	*Talicada nyseus*
14		Indian Common Silverline	*Spindasis vulcanus*
15		Small Cupid	*Chilades parrhasius*
16	**Nymphalidae**	Common Castor	*Ariadne merione*
17		Oriental Plain Tiger	*Danaus chrysippus*
18		Oriental Striped Tiger	*Danaus genutia*
19		Indian Common Crow	*Euploea core*
20		Oriental Blue Tiger	*Tirumala limniace*
21		Tawny Coster	*Acraea terpsicore*
22		Baronet	*Symphaedra nais*
23		Dakhan Baron	*Euthalia aconthea*
24		Indian Common Sailer	*Neptis hylas*
25		Oriental Great Eggfly	*Hypolimnas bolina*
26		Lemon Pansy	*Junonia lemonias*
27		Chocolate Pansy	*Junonia iphita*
28		Tailed Palmfly	*Elymnias caudate*
29		Common Evening Brown	*Melanitis leda*
30		Dark-Banded Bushbrown	*Mycalesis mineus*
31		Common Four-ring	*Ypthima huebneri*
32	**Papilionidae**	Dakhan Tailed Jay	*Graphium Agamemnon*
33		Common Jay	*Graphium doson*
34		Common Mormon	*Papilio polytes*
35		Common Rose	*Pachliopta aristolochiae*
36		Crimson Rose	*Pachliopta hector*
37		Blue Mormon	*Papilio polymnestor*
38		Lime Swallowtail	*Papilio demoleus*
39	**Pieridae**	Mottled Emigrant	*Catopsilia pyranthe*
40		Three Spot Grass Yellow	*Eurema blanda*
41		Common Grass Yellow	*Eurema hecabe*
42		Great Orange Tip	*Hebomoia glaucippe*
43		Common Albatross	*Appias albino*

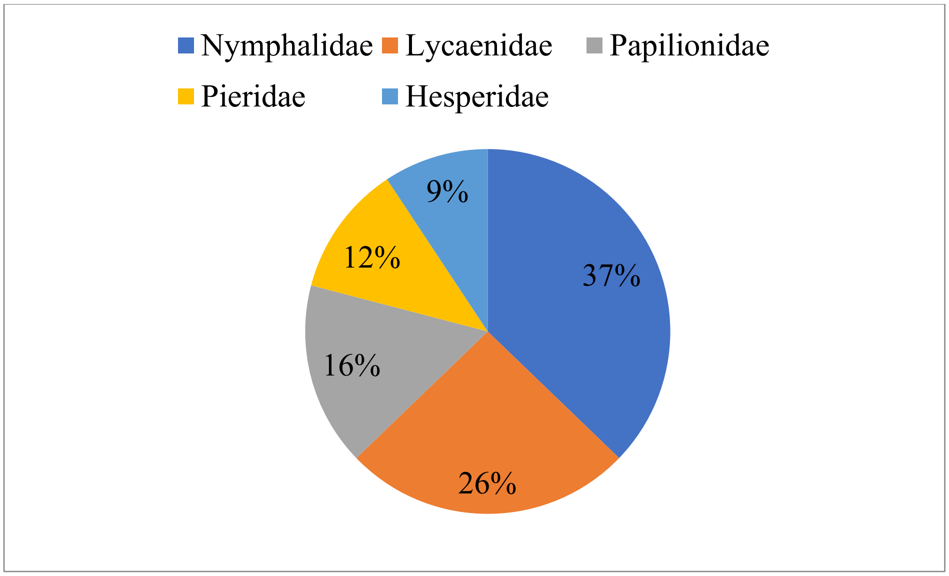

Fig. 1: Family-wise distribution of species observed

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Bioprospecting botanicals with mosquitocidal properties for the ecofriendly management of *Aedes albopictus* (Skuse)

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Mosquitoes are significant vectors responsible for transmitting deadly diseases such as malaria, dengue, chikungunya, Zika, and yellow fever, leading to numerous fatalities each year. *Aedes* (Stegomyia) *albopictus* (Skuse), or the Asian tiger mosquito, is an anthropophilic day- biting species (Fouad *et al.*, 2017) a competent arboviral vector capable of transmitting approximately 22 different arboviruses. It is considered as a dengue maintenance vector as it displaces *Aedes aegypti* in certain places (Gratz *et al*., 2004). Several botanical extracts have demonstrated mosquitocidal properties, making them viable alternatives to chemical insecticides (Nath *et al*., 2006).

This study was conducted at the Division of Entomology, Regional Agricultural Research Station, Pattambi. The experiment was done to evaluate the potential of different botanicals against the larvae and pupae of *Ae. albopictus*. Larvae and pupae of *Ae. albopictus* were maintained in the net house during the period of experimentation. Based on the initial screening studies done at the lab, the botanicals selected were *Anamirta cocculus*, *Gliricidia sepium*, *Calotropis gigantea*, *Cassia fistula* and *Azadirachta indica*. Shade dried and powdered seeds of *A. cocculus* and leaves of other botanicals were subjected to aqueous extraction. Experimental design adopted was completely randomised design and three replications were maintained for each treatment. For each treatment, ten larvae and five pupae were introduced into solutions containing a 5% concentration of the respective botanicals. Larval mortality was recorded at 30-minute intervals—specifically at ½ hour, 1 hour, 1 ½ hours, 2 hours, 2 ½ hours, and 3 hours—until 100% mortality was observed in at least one replication. Pupal mortality was recorded after 24 and 48 hours. Mortality percentages were calculated and analysed using WASP 1.0.

$$\text{Percentage mortality of larvae/pupae} = \frac{\text{Number of dead larvae/pupae}}{\text{Number of larvae/pupae introduced}} \times 100$$

The best two plants from this experiment were evaluated in different combinations for their synergistic effect.

In the first experiment, after 3 hours of treatment *A. cocculus* and *C. gigantea* showed statistically on par larval mortality with mean mortality of 89.09 per cent and 83.25 per cent, respectively. Regarding pupal mortality rate at 24 HAT, *A. cocculus* treated pots had 38.88 per cent mortality and at 48 HAT, *A. cocculus C. gigantea* and *G.sepium* demonstrated statistically similar pupal mortality rates of 89.09%, 89.09%, and 77.41%, respectively **(Table 1).** In combination trials of *A. cocculus 2.5%* and *C. gigantea 5%*, the highest larval mortality of 89.09% and highest pupal mortality of 89.09 per cent was recorded in 1:2 combination of *A. cocculus* and *C. gigantea,* respectively **(Table 2).**

The potential of *A. cocculus* and *C. gigantea*, is to be further explored for ecofriendly management of *Ae. albopictus*.

Table 1: Efficacy of botanicals against larvae and pupae of *Ae. albopictus*

Treatments	Mortality of larvae		Mortality of pupae	
	2.5 HAT	3 HAT	24 HAT	48 HAT
Anamirta cocculus-5%	68.85 a	89.09a	38.85a	89.09 a
Gliricidia sepium-5%	0.90 c	6.74 b	0.90b	77.40a
Calotropis gigantea-5%	56.99 b	83.25a	0.90 b	89.09 a
Azadirachta indica-5%	0.90 c	0.90b	0.90 b	28.29 b
Cassia fistula	0.90 c	0.90 b	0.90 b	0.90 c
Control	0.90 c	0.90 b	0.90 b	0.90c
CD (0.05)	5.727	10.396	8.793	19.787

The present study evaluated the efficacy of botanical extracts in controlling *Aedes albopictus* larvae and pupae, focusing on *Anamirta cocculus* and *Calotropis gigantea*, which exhibited promising mosquitocidal potential.

These results align with previous findings on botanical insecticides as viable alternatives to synthetic chemical insecticides (Nath *et al*., 2006). Bioactive compounds in A. cocculus, such as picrotoxin, and latex-derived phytochemicals in C. gigantea are known to possess mosquitocidal properties (Rajkumar & Jebanesan, 2007). Govindarajan *et al.,* 2011 reported mosquito larvicidal, ovicidal, and repellent activities of *E. coronaria* and *Caesalpinia pulcherrima* plants.

The effectiveness of these botanicals underscores their potential for integrated vector management (IVM) strategies aimed at reducing mosquito populations while minimizing environmental hazards associated with chemical insecticides (Ghosh *et al*., 2012). Govindarajan *et al.,* 2011 reported mosquito larvicidal, ovicidal, and repellent activities of *E. coronaria* and *Caesalpinia pulcherrima* plants.

The synergistic evaluation of *A. cocculus* and *C. gigantea* in combination trials further emphasized their efficacy. The highest larval and pupal mortality rates (both 89.09%) were recorded in the 1:2 combination of *A. cocculus* (2.5%) and *C. gigantea* (5%). Synergistic interactions between phytochemicals often enhance insecticidal properties, suggesting that combinations of botanical extracts could serve as a more potent and eco-friendly approach to mosquito control (Govindarajan *et al*., 2011).

Given the increasing global concern over mosquito-borne diseases and the resistance developed by mosquitoes against synthetic insecticides (Benelli, 2015), botanicals such as *A. cocculus* and *C. gigantea* warrant further exploration. Future studies should focus on identifying specific bioactive compounds responsible for mosquitocidal activity and assessing their long-term environmental impact.

Table 2: Efficacy of *A. cocuulus: C. gignatea* (1:2) against larvae and pupae of *Ae. albopictus*

Treatments	Mortality of larvae		Mortality of pupae	
	2.5 HAT	3 HAT	24 HAT	48 HAT
A. cocculus 5%	61.22 [a]	68.855 [b]	38.855a	89.094 a
C. gigantea 5%	41.154 [b]	56.998 [cd]	0.906b	89.094 a
A. cocculus 2.5 % + *C. gigantea 2.5%-*	61.714 [a]	63.93 [bc]	61.705 a	74.698 ab
A. cocculus 2.5% + *C. gigantea* 5%-	72.483 [a]	89.094 [a]	67.766 a	89.094 a
A. cocculus 5%+ *C. gigantea* 2.5%-	39.232 [b]	50.768 [d]	61.705 a	67.766 b
Control	0.906 [c]	0.906 [e]	0.906 b	0.906 c
CD (0.05)	13.784	7.855	30.877	17.084

Summary

This study assessed the mosquitocidal efficacy of *Anamirta cocculus* and *Calotropis gigantea* against *Aedes albopictus* larvae and pupae. Both botanicals demonstrated significant mortality rates, with the combination trials revealing enhanced efficacy in a 1:2 ratio of *A. cocculus* (2.5%) and *C. gigantea* (5%). These findings highlight the potential of botanical insecticides as eco-

friendly alternatives for mosquito control, aligning with sustainable pest management strategies. Further research is needed to optimize formulation, understand synergistic mechanisms, and evaluate the ecological safety of these extracts for large-scale applications.

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Biology of variegated ladybird beetle, *Hippodamia variegate* (Goeze) on cowpea aphid, *Aphis craccivora* Koch

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Abstract

The variegated ladybird beetle, *Hippodamia variegata* (Goeze) is one of the most important predator of cowpea aphid. In this study, the biological aspects of ladybird beetle, *H. variegata* feeding on cowpea aphid, *Aphis craccivora* Koch were investigated under laboratory condition. The average incubation period of *H. variegata* was 2.33±0.47 days and the duration of total larval period was 12.80±0.96 days. The pre-pupal and pupal periods were 1.06±0.25 and 3.43±0.50 days, respectively. The mean pre-oviposition period was 4.80±0.63 days and the oviposition period was 24.40±3.09 days. The female beetles laid on an average 374.70±22.41 eggs with the hatching per cent of 87.64±4.32. The mean longevity of the male and the female beetles were 27.96±1.21 and 30.93±0.98 days, respectively.

Keywords: Variegated ladybird beetle, development, biology, life cycle, *Hippodamia variegate*, cowpea aphid, *Aphis craccivora*

Ladybird beetles are globally recognized as predators of various insect pests and are among the most well-known beneficial insects (William, 2002). Coccinellid beetles are of great economic importance in agro-ecosystems due to their effective role in the biological control of numerous harmful insect species (Agarwala & Dixon, 1992). Their adaptation and efficiency in controlling aphid populations vary depending on species and environmental conditions (Dixon, 2000).

These beetles serve as crucial predators in both their larval and adult stages, targeting key agricultural pests such as aphids, coccids, and other soft-bodied insects (Hippa et al., 1978; Kring et al., 1985). Among the various ladybird species, *Hippodamia variegata* is particularly significant, as it preys on numerous insect pests, including aphids, psyllids, whiteflies, lepidopteran larvae, and mealybugs (Franzman, 2002).

Species within the genus *Hippodamia* have been widely reported as aphid predators in nearly all agro-ecosystems. Several of these species have been identified as potential biological control agents for various aphid species across different agricultural crops (Fan & Zhao, 1988). *Hippodamia* spp. are voracious feeders of harmful aphids and help keep their populations below damaging levels (Kontodimas & Stathas, 2005).

The ability of winged predators like *H. variegata* to efficiently locate and identify aphid colonies in both outdoor and indoor environments surpasses that of many other natural aphid enemies. As one of the most effective biocontrol agents of aphids in agricultural systems, studying the biology of *H. variegata* could provide valuable insights for future biological control programs.

Materials and Methods

The study on the biology of the ladybird beetle, *Hippodamia variegata*, feeding on the cowpea aphid, *Aphis craccivora*, was conducted in the P.G. Laboratory, Department of Entomology, N. M. College of Agriculture, Navsari Agricultural University, Navsari, from October 2022 to March 2023. The experiment was carried out under controlled conditions at 25 ± 1.0°C and 55 ± 5% relative humidity.

The initial culture of *A. craccivora* was collected and maintained on cowpea plants grown in micro-plots (2m × 3m). To establish the initial culture of *H. variegata*, adult beetles were obtained from the field and paired based on morphological features. Fresh aphid-infested leaves were provided daily as food. Eggs laid by the females were carefully transferred to Petri dishes using a soft camel hairbrush.

The grubs of *H. variegata* were individually reared on aphids, with the number of aphids provided increasing as the larvae matured. This method was followed until pupation. Upon adult emergence, aphids were continuously supplied as food until the beetles' natural death. The number of eggs laid by each female over a 24-hour period was recorded, and eggs were kept in separate Petri dishes to determine total egg production, hatching time, and hatching success rate.

After hatching, young larvae were transferred individually into **6.0 × 1.0 cm** Petri dishes containing blotting paper at the bottom. Fresh cowpea shoots infested with aphids were provided as food every morning. Larvae were observed twice daily at 12-hour intervals until pupation. The number of instars and the duration of each stage were recorded.

Pre-pupae and pupae were kept undisturbed until adult emergence, with their development periods carefully documented. The newly emerged adults were examined for color, shape, and size, and sex determination was conducted using a binocular micrometer.

Further observations included pre-oviposition, oviposition, and post-oviposition periods, as well as the longevity of male and female beetles. The total life cycle duration and sex ratio were recorded, along with the morphological characteristics of all developmental stages.

Results and Discussion

Incubation period: The incubation period was 2 to 3 days with an average of 2.33±0.47 days (Table 1). Elhabi *et al.* (2000) observed that the incubation period of *H. variegate* was 3 days. However, Lanzoni *et al.* (2004) and Grigorov (1977) reported that it was 3 and 3 days, respectively using bean aphid as host. These results seem to be close with the present observation. The hatching per cent was 76.92 to 96.66 per cent with an average of 87.64±4.32 per cent. Jafari (2011) reported 82.86±3.12 per cent egg hatching of *H. variegate* eggs when reared on *A. fabae* as food. These results seems to close with the present observation.

Larval stage: The mean of total larval period (1st instar to 4th instar) was 11 to 15 days with an average 12.80±0.96 days (Table 1). Kontadimas and Stathas (2005) observed that the period of *H. variegate* was 15 days using *Dyaphis crataegi* as food, which is similar to the present finding. Grigorov (1977) observed that the total larval period of *H. variegate* varied from 17 to 19 days on bean aphid. This result was higher than the present study. However, Wang *et al.* (2004) reported that the quality of food and environmental factors like temperature, humidity also play an important role on different aspects of biology of coccinellid beetles. So, this variation may be due to the quality of food and environmental factors like temperature and humidity.

The newly hatched larvae was silvery shine pale black in colour with shining dark head capsule and legs, later on it turns black in colour and having spiny structure over body. The development of first instar larva of *H. variegata* was completed in 2 to 3 days with an average 2.33±0.47 days when reared on *A. craccivora* (Table 1). Lanzoni *et al*. (2004) reported that this period of *H. variegata* was2 to 3 days using bean aphid as host. This result supported to the present observations. The length of the first instar larvae ranged from 1.23 to 1.89 mm with an average of 1.55±0.166 mm, while width varied from 0.3 to 0.6 mm with an average 0.47±0.073 (Table 4.2). The second instar larva that had just shed its shell was slender and spherical, shiny black with a pale-yellow head capsule and black legs.

Orange-coloured transverse patches started to appear on the fourth and sixth abdominal segments in addition to the mesothorax. The larval body has a spiny structure. The length of second instar larva ranged from 2.05 to 4.02 mm (Av. 3.11±0.63 mm) while width varied from 0.59 to 1.10 mm (Av. 0.91±0.15mm) (Table 2). The second instar larvae lasted for 2 to 3 days with an average 2.60 ± 0.49 days when reared on *A. craccivora,* respectively (Table 1). Jafari (2011) reported that the duration of the second instar varied from 2 to 4 days and the mean duration was 3.05±0.20 days when reared on *A.*

fabae. Lanzoni *et al*. (2004) found that the duration of the 2nd instar larvae of *H. variegate* was 2.5 to 4 days on aphids, which is comparatively similar to the results of the present findings. Elhabi *et al.* (2000) founded that the duration of 2nd instar of *H. variegate* varied from 2.5 to 3.5 days using bean aphid as a host. The duration of third instar was in the range of 2 to 4 days with an average of 3.40±0.56 days when reared on aphid, *A. craccivora* (Table 1).

The third instar larvae was similar in general appearance to second instar larvae, except larger in size. In third instar larvae, the spiny structure was little larger than in second instar. Freshly moulted third instar larvae was dark black in colour. The colour pattern was more intensified with additional development of orange transverse patches on mid-dorsal line of other segments except prothorax. The length of third instar larvae ranged from 4.80 to 5.30 mm with an average 5.03±0.13 mm, while the width varied from 1.22 to 1.83 mm with an average 1.50±0.15mm (Table 2). Kontadimas and Stathas (2005) founded that the duration of third instar larvae of *H. variegate* varied from 2.5 to 4 days on cotton aphid. This result supported to the present observation.

The duration of fourth instar larvae varied from 4 to 5 days with an average 4.46±0.50 days when reared on aphid, *A. craccivora* (Table 1). The fourth instar larvae were deep black in colour, when freshly moulted but changed to black in colour before pre-pupation. It developed additional rectangular dark orange spots in a continuous series mid-dorsally on abdominal segments, whereas the spots on fourth abdominal segment were orange. The length of fourth instar larvae varied from 5.15 to 6.98 mm with an average 5.93±0.41mm, while the width varied from 1.57 to 1.88 mm with an average 1.72±0.08 mm (Table 2). Lanzoni *et al.* (2004) reported that the duration of final instar larvae of *H. variegate* was 3 days. Kontadimas and Stathas (2005) found that the duration of final instar larvae of *H. variegate* varied from 2.8 to 3.6 days on cotton aphid. This duration was within the range of present findings.

Pre-pupal and pupal stage: The duration of pre-pupal stage varied from 1 to 2 days with an average 1.06±0.25 days when reared on *A. craccivora* (Table 1). The fully formed larvae in its fourth instar stopped feeding and stayed lethargic, its bloated body looking for a good spot to pupate. The larvae connected its posterior abdominal segment to the surface of leaves or the walls of plastic vials, converting into a pupa. With white spots visible on the larval body, the pre-pupa resembled the fourth instar. Pre-pupa formed by larvae was more or less rectangular in shape. The colour of pre-pupa was similar to the last larval instar. It undergoes a very short pre-pupal period. The length of pre-pupa varied from 4.45 to 5.34 mm with a mean of 4.84±0.26 mm, while width ranged from 1.96 to 2.78 mm with an average 2.28±0.17 mm (Table 2). The duration of pupal stage varied from 3 to 4 days with an average 3.43±0.50 days when reared on aphid *A. craccivora* (Table 1). Wang *et al.* (2004) recorded that the mean pupal duration of *H. variegate* was 4.15±0.11 days when larvae reared on *D. noxia*. Different finding revealed that the pupal period of coccinellid beetles varied with the differences of food and it was correlated with the temperature (Wang *et al* 2004). The colour of pupa was bright yellow when it was first formed, the pupa gradually changed to pale orange-yellow colour. When the pupa reached adulthood, its colour was yellowish orange and it had two vertical lines of symmetrical triangular dots on the dorsal side. The pupae measured about 4.43 to 5.50 mm in length with an average 4.94±0.28 mm and 2.61 to 3.71 mm in width with an average 3.05±0.26 mm (Table 2). Jafari (2011) in a study also reported similar colour and size of pre-pupae and pupae of *H. variegate* when reared on *A. fabae.*

Adult stage: The per cent adult emergence from pupae varied from 60.0 to 100 per cent with an average 84.62±9.59 per cent (Table 1). The longevity of male varied from 25 to 30 days when reared on *A. craccivora* with an average 27.96±1.21 days. The female longevity varied from 29 to 33 days with an average 30.93±0.98 days (Table 1). It showed that the longevity of the male beetle was shorter than the female. Jafari (2011) observed the mean longevity of adult male and female beetles of *H. variegate* as 50±3.2 and 55.5±3.37 days, respectively when fed on *A. fabae*. Further, Elhagh and Zaiton (1996) reported that the adult of *H. variegate* lived for 32 to 60 days. This result was near similar to the present study. Elhabi *et al.* (2000) found that the longevity of male and female were 44±2 and 61±9.89 days. These results are also close to the present observations.

Pre-oviposition: The time between the date of adult emergence and the first egg deposition was considered as pre-oviposition period. The pre-oviposition period of *H. variegata* was 4 to 6 days with an average of 4.80±0.63 days (Table 1)). Elhagh and Zaiton (1996) studied that the pre-oviposition period was 6 to 7 days, which is partially similar to the present findings.

Oviposition: Oviposition period was the duration between first and last egg laying. The oviposition period in the present study was 20 to 30 days (Table 1) and the mean oviposition period was 24.40±3.09 days. Elhagh and Zaiton (1996) reported that the period of *H. variegate* lasted from 35 to 48 days using *A. fabae* as food, which is more or less partially in accordance with the present findings. However, difference is due to change in prey and climatic conditions.

Post-oviposition: The time between ceasing of egg laying to death of female was considered as post-oviposition period. The post-oviposition period of *H. variegata* was 4 to 7 days with an average of 5.60±0.84 days (Table 1)). Elhagh and Zaiton (1996) also recorded similar periods, which is more or less similar to the present findings.

Fecundity: The egg laying capacity of laboratory reared female beetle varied from 320 to 402 eggs when reared on *A. craccivora* with an average 374.7±22.41 eggs. (Table 1). Kontodimas and Stathas (2005) revealed that the total fecundity of *H. variegata* ranged between 789 and 1256 eggs with the average total fecundity as 959.6±134.7 eggs per female when reared on *Dysaphis crataegi.* Jafari (2011) in a study reported that a single female of *H. variegate* laid 587 to 1247 eggs with an average 943.90±53.53 eggs in her life span. Moreover, Lanzoni *et al.* (2004) reported that the number of eggs deposited per female of *H. variegate* was 900±80.23 and 70 per cent eggs were hatched. Elhabi *et al*. (2000) observed that the fecundity of female varied from 800 to 900 eggs with mean 870.5 and with average 79 per cent eggs were hatched. These results seem to be close with the present findings.

Total life cycle: The total life cycle of male varied from 44 to 50 days when reared on *A. craccivora* with an average 47.73±1.50 days. In case of female, it varied from 47 to 54 days with an average 50.70±1.44 days, respectively (Table 1). Jafari (2011) observed that the life cycle of male and female *H. variegate* were ranging between 40 to 60 days when reared on *A. fabae* under laboratory condition. These results seem to be close with the present observation.

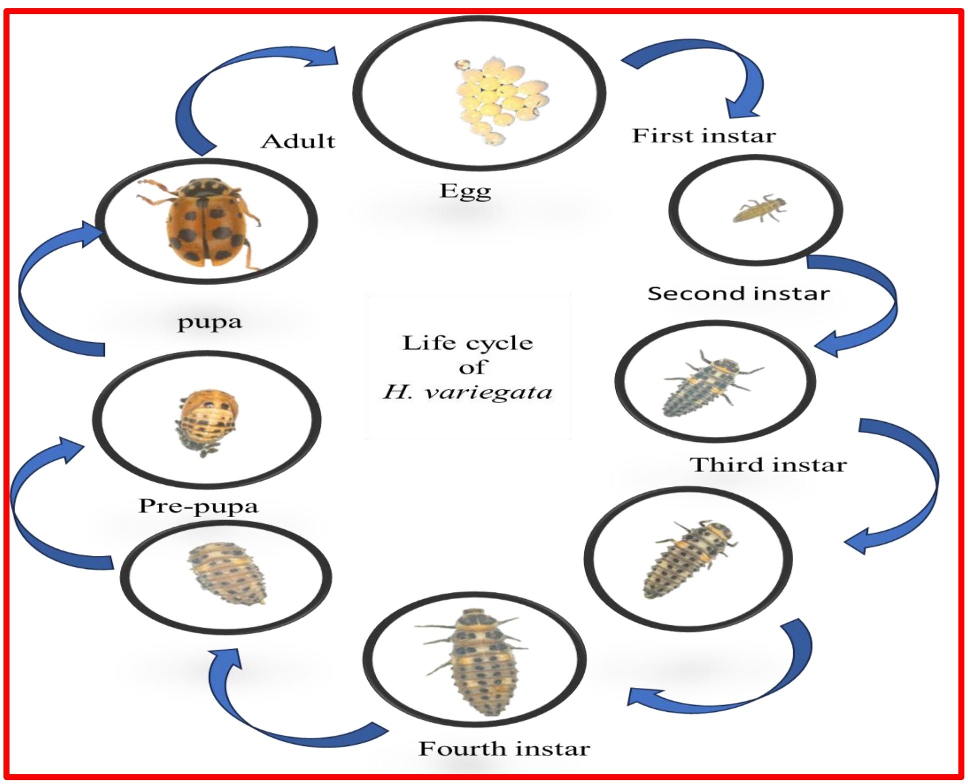

Plate 1: Life cycle of variegated ladybird beetle, *H. variegata*

Table 1: Biology of variegated ladybird beetle, *H. variegata* on cowpea aphid, *A. craccivora*

Sl. No.	Particular	Range	Mean±S.D.
1.	Incubation period	2-3	2.33±0.47
2.	Hatching per cent	76.92-96.66	87.64±4.32
3.	Larval period (Days)		
	I instar	2-3	2.33±0.47
	II instar	2-3	2.60±0.49
	III instar	2-4	3.40±0.56
	IV instar	4-5	4.46±0.50
	Total larval period	11-15	12.80±0.96
4.	Pre-pupal period (Days)	1-2	1.06±0.25
5.	Pupal period (Days)	3-4	3.43±0.50
6.	Adult emergence (%)	60-100	84.62±9.59
7.	Sex ratio (Male: female)	1:1.0-1:1.43	1:1.29
8.	Adult longevity (Days)		
	Male	25-30	27.96±1.21
	Female	29-33	30.93±0.98
9.	Total life cycle (Days)		
	Male	44-50	47.73±1.50
	Female	47-54	50.70±1.44
10.	Pre-oviposition period (Days)	4-6	4.80±0.63
11.	Oviposition period (Days)	20-30	24.40±3.09
12.	Post-oviposition period (Days)	4-7	5.60±0.84
13.	Fecundity (No. of eggs /female)	320-402	374.70±22.41

Table 2: Measurements of various stages of ladybird beetle, *H. variegata* (mm)

Stage	Length		Width	
	Range	Mean± S.D.	Range	Mean± S.D.
Eggs	0.94-1.02	0.97±0.023	0.39-0.48	0.42±0.024
Larva				
I Instar	1.23-1.89	1.55±0.166	0.30-0.60	0.47±0.073
II Instar	2.05-4.02	3.11±0.633	0.59-1.10	0.91±0.152
III Instar	4.80-5.30	5.03± 0.135	1.22-1.83	1.50±0.157
IV Instar	5.15-6.98	5.93±0.414	1.57-1.88	1.72±0.087
Pre-pupa	4.45-5.34	4.84±0.265	1.96-2.78	2.28±0.170
Pupa	4.43-5.50	4.94±0.284	2.61-3.71	3.05±0.262
Adult				
Male	4.27-5.96	4.97±0.343	3.37-4.81	3.78±0.387
Female	4.29-6.23	5.35±0.586	3.21-4.90	4.28±0.486

Summary

The study examines the life cycle of *Hippodamia variegata* when reared on *Aphis craccivora*, highlighting developmental durations and variations influenced by environmental factors. Incubation lasted 2 to 3 days, while the total larval period spanned 11 to 15 days, followed by a 1 to 2-day pre-pupal stage and 3 to 4 days of pupation. Adult longevity varied, with males living 27.96 days and females 30.93 days. The fecundity ranged from 320 to 402 eggs, and the total life cycle duration was 44 to 50 days for males and 47 to 54 days for females, aligning with previous studies but showing differences due to prey and climatic conditions.

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Review Articles

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Insect frass: A sustainable organic fertilizer for enhancing soil health and crop productivity

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Abstract

This review explores the emerging role of insect frass as a primary organic fertilizer in sustainable agricultural systems. With the global population rising and insect farming expanding as an alternative protein source, insect frass - the excreta produced during insect rearing has gained significant attention as a valuable agricultural by product. This paper synthesizes current research on insect frass composition, its effects on soil health and plant growth, practical applications in agricultural contexts, and future research directions. Evidence suggests that insect frass is a promising component of circular economy models, offering a sustainable solution to multiple challenges in modern agriculture.

Keywords: Insect farming, Insect frass, Agricultural byproduct, Sustainable agriculture, Circular economy

Introduction

World population has increased very rapidly with a consequent increase in the demand for resources such as water, food and energy. Post-green revolution intensification of agriculture has resulted in soil degradation in the form of compaction, erosion, loss of organic matter, pesticide contamination, low biodiversity, increased soil salinization and water logging, etc. (Turpin *et al*., 2017). In response to these challenges, the large-scale breeding of insects for feed and food has emerged as an efficient and sustainable alternative for animal protein production Insects exhibit rapid growth and reproduction, possess high feed conversion efficiency, and can be reared on biowaste streams, making them an environmentally viable protein source. An integral aspect of the mass rearing process is the generation of frass (insect excreta), a valuable byproduct with potential applications in agriculture and soil health. The name “frass” is derived from a German word meaning “Devour” (Ortiz *et al*., 2016). Frass can be used as organic fertilizer to replace the use of agrochemicals and is considered a viable alternative in the development of sustainable agriculture and a circular economy (Poveda, 2021).

During insect production, frass is generated in significant amounts estimated to be 30 to 40 times the insect biomass harvested (Bruun *et al*., 2022). Rather than being discarded, this byproduct can be repurposed as a nutrient-rich fertilizer, aligning with circular economy principles and creating an additional revenue stream for insect farmers (Lombardi *et al*., 2019).

Insect frass contains essential plant nutrients, including nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) Nutrient content varies by insect species and their diet. For example, black soldier fly (*Hermetia illucens*) frass typically contains between 2-5% N, 1-3% P, and 1-2% K on a dry weight basis (Houben *et al*., 2020), while cricket (*Acheta domesticus*) frass may contain N, P and K, 3 to 4, 1 to 2 and 1 to 3%, respectively (Poveda *et al*., 2019).

Beyond nutrients, insect frass fosters beneficial microbial activity, housing plant-friendly bacteria and fungi that enhance soil fertility (Watson *et al*., 2022). These microorganisms can persist in soil after application, influencing plant root zones and boosting plant health (Menino *et al*., 2021). Additionally, bioactive compounds like chitin, antimicrobial peptides, and enzymes present in frass may strengthen plant defences and improve stress resistance (Wantulla *et al*., 2023).

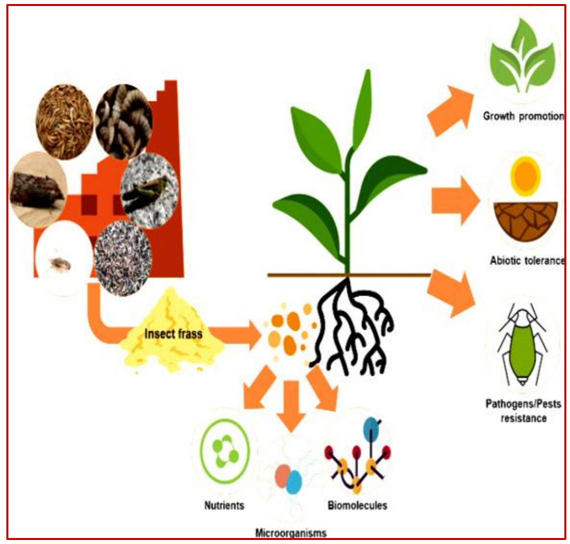

Fig. 1: Benefits from insect frass (Poveda, 2021)

Effects on Soil Health and Plant Growth

Incorporating insect frass into soil significantly enhances its structural properties by improving aggregate stability, increasing porosity, and reducing bulk density. These improvements help retain moisture, prevent erosion, and create an optimal environment for plant root development (Quilliam *et al*., 2020). Additionally, the organic matter in frass supports carbon sequestration, playing a crucial role in climate change mitigation (Poveda, 2021). From a chemical perspective, insect frass enriches soil organic matter, enhances cation exchange capacity, and stabilizes pH levels, leading to better nutrient availability, reduced leaching, and improved long-term soil fertility (Houben *et al*., 2020). Biologically, frass promotes microbial activity, enhances soil biodiversity, and increases enzyme functions that facilitate nutrient breakdown. It has also been linked to higher earthworm populations and a greater diversity of soil arthropods, further improving soil health (Barragán-Fonseca *et al*., 2022). Studies in both field and greenhouse settings show that insect frass boosts plant growth by increasing biomass, leaf area, and root development, often leading to 10-30% yield improvements, making it comparable to synthetic fertilizers (Beesigamukama *et al*., 2022). Additionally, frass can enhance crop quality by improving nutritional content, flavor, and shelf life while potentially strengthening plant defences against pathogens through systemic resistance activation (Jasso *et al.,* 2024).

Insect Frass as a Generator of Tolerance to Abiotic Stress Resistance to Biotic Stresses

Insect frass has been shown to help plants withstand various environmental stresses. For example, applying mealworm frass to bean plants improved their tolerance to drought, flooding, and salinity. Interestingly, sterilizing the frass did not reduce its effectiveness, suggesting that beneficial microorganisms within the frass play a key role. Researchers have identified several bacteria and fungi in frass that help plants by fixing nitrogen, making phosphorus and potassium more available, and producing plant-friendly compounds like auxins and ACC deaminase (Poveda, 2019).

In addition to aiding plant growth, insect frass may also help plants defend themselves against pests and diseases. When plant roots detect certain microbes and biomolecules in frass, they can trigger their natural defence systems using pathways like salicylic acid (SA) or jasmonic acid/ethylene (JA/ET) (Poveda, 2019). Some compounds in frass can also directly affect pest behavior. For instance, studies on potato plants found that black cutworm frass contains phenols and flavonoids, which discourage the potato tuber moth from laying eggs on the plant (Ahmed *et al*., 2013).

Practical Applications in Agricultural Systems

Insect frass can be applied using conventional fertilizer spreaders, mixed into soil during tillage, used as a top dressing, or processed into liquid formulations for foliar spraying, with recommended rates varying between 2-10 tons per hectare depending on crop and soil conditions (Lomonaco *et al*., 2022). It is beneficial in various farming systems, serving as an eco-friendly alternative to animal manure in organic farming and reducing synthetic fertilizer dependence in conventional agriculture, while also being suitable for greenhouses and urban farms due to its high nutrient content and low odor (Elissen *et al*., 2023). Combining insect frass with organic amendments like biochar, compost, and microbial inoculants can further enhance soil health and nutrient retention (Kenchanna *et al*., 2024). As production scales up, its economic feasibility improves, attracting interest from organic producers and sustainability-conscious consumers (Van Huis, 2013). Regulations vary globally, with Europe approving frass for organic farming under specific conditions, while industry standards and certifications continue to develop to ensure quality and compliance (IPIFF, 2023).

Table 1: Uses of frass from different insects as fertilizer in field

Sl. No.	Insects: Order	Species	Crops	Benefits	Mechanisms
1.	**Diptera**	*Hermetia illucens*	Cowpea	Decreased *Fusarium wilt* disease	Activation of plant defensive responses by chitin presence
2.	**Lepidoptera**	*Agrotis ipsilon*	Potato	Reduction of oviposition of the insect pest *Phthorimaea operculella*	Presence of phenols and flavonoids
		Lymantria dispar	Trembling aspen	Increased nitrogen content in plant tissues	Nitrogen supply to soil
		Mamestra brassicae	Cabbage	Increased nitrogen content in plant tissues	Plant growth promotion Nitrogen supply to soil
		Ostrinia nubilalis	Maize	Activation of plant defences against pathogens and pests	Presence of eliciting molecules
3.	**Coleoptera**	*Anoplophora glabripennis*	Salix babylonica	Insect attack reduction	Parasitoid attraction for VOCs
		Paropsis atomaria	Eucalyptus	Plant growth promotion	Nitrogen supply to soil
		Chlorophorus annularis	Lettuce	Increased germination and plant growth	Sugars, alkaloids and phenols supply
		Tenebrio molitor	Bean	Increased tolerance to abiotic stresses	Presence of microorganisms promoting plant tolerance
		Zophobas morio	Dragon fruit cacti	Plant growth promotion	Amides supply to soil
4.	**Orthoptera**	*Chorthippus curtipennis*	Beans	Nitrogen supply to soil	-
		Melanoplus borealis	Maize	Nitrogen supply to soil	-

Conclusion

Insect frass is emerging as a sustainable and effective organic fertilizer that enhances soil health, improves plant growth, and supports eco-friendly agricultural practices. Rich in essential nutrients, beneficial microbes, and bioactive compounds, it offers a viable alternative to synthetic fertilizers and animal manure. Its application improves soil structure, increases crop yields, and strengthens plant resistance to abiotic and biotic stresses. With the expansion of insect farming, the economic feasibility of frass is improving, attracting growing interest from organic and sustainability-conscious producers. However, regulatory frameworks are still evolving globally. As research continues to refine its benefits and application methods, insect frass holds great promise for fostering circular economy principles and advancing sustainable agriculture.

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Tribolium castaneum: A versatile model for genetic, developmental, and pest management research

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Abstract

Tribolium castaneum (Herbst), widely recognized as the red flour beetle, has emerged as a powerful and versatile model organism in both fundamental biological studies and applied entomological research. As a globally distributed pest of stored grain products, it not only poses significant economic threats but also offers unique advantages as an experimental system. Its relatively small and fully sequenced genome, short generation time, ease of laboratory rearing and availability of advanced genetic tools-including RNA interference (RNAi), CRISPR-Cas9 and transgenic techniques-have positioned it at the forefront of insect molecular research. This beetle has played a pivotal role in elucidating key processes in genetics, developmental biology, evolutionary biology, neurobiology, chemical ecology and behaviour. Furthermore, it serves as an essential model for studying mechanisms of insecticide resistance, pest management strategies and host–microbe interactions. The capacity to integrate classical experimental approaches with cutting-edge biotechnological methods has expanded its utility in both academic and industrial settings. This review explores the broad spectrum of research areas where *T. castaneum* contributes valuable insights, emphasizing its role in bridging basic and applied sciences.

Keywords: *Tribolium castaneum*, genetic model, RNAi, CRISPR-Cas9

Introduction

Tribolium castaneum, the red flour beetle, is a cosmopolitan pest that infests stored grains and their derivatives, yet it has also gained prominence as a powerful genetic model in scientific research. Its short generation time, ease of laboratory maintenance, high reproductive rate and robust physiology make it particularly suitable for experimental studies. Unlike traditional model insects like *Drosophila melanogaster*, *T. castaneum* shares several physiological and ecological characteristics with many pest species, making it both ecologically and economically relevant. A major milestone in its research utility was the complete sequencing of its genome in 2008 (Richards *et al*., 2008), which laid the foundation for advanced functional studies. Since then, the species has become a leading model for genetic manipulation through tools such as RNA interference (RNAi), which functions efficiently across developmental stages and CRISPR-Cas9, which allows for precise genome editing (Rylee *et al*., 2022). These innovations have enabled detailed investigations into developmental biology, gene regulation, immune function and behavior. Consequently, *T. castaneum* serves as a valuable system in both fundamental biological research and applied studies related to pest management, insecticide resistance and agricultural biosecurity.

Fundamental Research Applications

i) Genetic Research

Genetics is one of the most extensively explored fields in which *Tribolium castaneum* has been utilized. It has proven valuable in classical Mendelian genetics; population studies the investigation of epigenetic mechanisms. Researchers have exploited its genetic tractability for mapping traits, analyzing gene expression and determining the function of developmental genes. Linz and Tomoyasu (2015) examined the role of the odd-skipped family gene, specifically the drm gene, in thoracic exoskeletal development. Their RNAi-based experiments demonstrated that this gene is critical for the formation of pleural plates—chitinous structures essential for maintaining the beetle's body integrity and muscle attachment for leg movements. Disruption in this gene led to malformed or absent pleural plates, highlighting its role in thoracic segmentation and locomotion. The ability to silence genes through RNAi has allowed for large-scale screening to understand gene networks regulating metamorphosis and organogenesis. This approach has revealed functional redundancies and the interplay between transcription factors and signalling pathways during beetle development.

ii) Genomic Studies

The genome of *T. castaneum* (NCBI Tcas3.0) is approximately 160 Mb in size and comprises around 16,500 protein-coding genes, which is notably larger than that of Drosophila melanogaster. This rich genomic content includes many conserved and insect-specific genes, offering an expansive platform for studying gene function, regulatory elements and comparative genomics. In developmental studies, genes such as E-cadherin have attracted attention. E-cadherin is vital for dorsal closure during embryogenesis—a process wherein the lateral epidermis folds and fuses over the dorsal midline, forming a protective external layer. Gilles *et al.* (2015) demonstrated through CRISPR-mediated knockout and RNAi phenotyping that disruption of E-cadherin led to incomplete dorsal closure, thus underscoring its indispensable role in maintaining epithelial integrity during morphogenesis. The genome also provides resources for exploring immunity, stress response, detoxification and behaviour, all of which have practical applications in pest management.

iii) Olfactory Mechanisms

Olfaction is central to insect behaviour, particularly in host recognition, mate finding and predator avoidance. *T. castaneum* possesses a complex olfactory system comprising 50 odorant-binding proteins (OBPs), 20 chemosensory proteins (CSPs) and over 300 odorant receptors (ORs), making it one of the most chemically attuned beetles (Dippel *et al.*, 2016). This repertoire allows the beetle to detect a wide range of volatiles associated with grains and their decomposition products. Tomoyasu and Denell (2004) revealed the broad function of the Tc-ASH gene, which influences the formation of sensory organs and cuticle development. Disruption of this gene impaired antennal and maxillary palp formation, suggesting a fundamental role in developing olfactory appendages. The capacity to manipulate sensory genes aids in unravelling how *T. castaneum* interprets its environment and adapts to stored product habitats.

iv) Landscape Behaviour and Ecology

Understanding how beetles interact with their environment is critical in designing better pest control strategies. *T. castaneum* offers a model to explore landscape ecology and behavioral responses to spatial heterogeneity. Gerken and Campbell (2020) studied its oviposition preferences across 18 types of flour, revealing significant variation. For example, the beetles laid the most eggs in teff, wheat and rice flours, indicating a strong preference potentially driven by odor, texture and nutrient availability. These behavioural studies also revealed that the beetles altered their movement patterns depending on the texture and granularity of the landscape. In fine-grained substrates, they exhibited slower, more tortuous movements and extended residence times. These findings can inform trap placement and resource allocation in stored product facilities, especially under heterogeneous storage conditions.

Applied Research Applications

i) Insecticide Efficacy

In pest management programs, *T. castaneum* serves as both a target and a bioassay organism for testing insecticidal efficacy. One of the most studied compounds is Methoprene, an insect growth regulator (IGR) that disrupts development and reproduction. Liu *et al.* (2016) assessed Methoprene application in stored wheat under different treatment strategies. Their findings indicated that Methoprene combined with aeration was significantly more effective than individual treatments in reducing beetle populations over a 40-week period. The integrated treatment led to nearly complete suppression of adult emergence, showcasing the potential of IGRs when combined with physical control methods. These findings validate the utility of *T. castaneum* as a standard indicator species for testing novel compounds and delivery systems in real-world storage environments.

ii) Insecticide Resistance

Another compelling application of this beetle is in the study of resistance evolution. The PH-SR1 strain is an extensively studied resistant population of *T. castaneum* that demonstrates extreme resistance to phosphine—a widely used fumigant for stored grain insects. Jagadeesan *et al.* (2015) reported that this strain has a resistance ratio exceeding 93 times that of the susceptible Lab-S strain. Molecular analyses identified mutations in the dihydrolipoamide dehydrogenase (dld) gene and other components of the mitochondrial respiratory chain as the underlying causes. These mutations impair the normal electron transport process, reducing phosphine sensitivity. Such insights not only help in resistance monitoring but also enable the development of molecular diagnostics and resistance management programs that prevent resistance buildup and preserve chemical efficacy.

Conclusion

Tribolium castaneum is a versatile model organism that bridges the gap between basic and applied entomological research. Its compact genome, ease of laboratory handling and responsiveness to genetic tools such as RNAi and CRISPR-Cas9 make it a cornerstone of developmental biology, genomics and evolutionary studies. Moreover, its ecological relevance and role in stored product environments lend it immense value in evaluating insecticide efficacy, resistance mechanisms and behavioural ecology. The contributions of *T. castaneum* extend well beyond pest control, influencing biomedical research, environmental toxicology and evolutionary genetics. As new molecular tools continue to emerge, this beetle remains at the forefront of functional insect genomics, solidifying its status as an indispensable model organism.

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Short Notes

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Preliminary assessment of wood ash as a physical control agent against *Aulacophora foveicollis* (Coleoptera: Chrysomelidae) in cucurbits

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Abstract: A preliminary observational study conducted at the Palar Agricultural College Farm, Ambur, India, examined the potential of locally sourced wood ash (*Prosopis juliflora*) in controlling adult red pumpkin beetles (*Aulacophora foveicollis*), a major pest of cucurbits. Manual application of wood ash to infested plants resulted in a, noticeable reduction in foliar feeding damage suggesting its possible role as a physical deterrent or irritant to the beetles. While these initial findings indicate promising pest suppression effects, further controlled, quantitative research is essential to determine optimal application strategies, efficacy levels, and the broader ecological impact for sustainable pest management in cucurbit agroecosystems.

Keywords: Adult Red pumpkin beetle, *Aulacophora foveicollis,* Wood ash, Cucurbits, Physical pest control

Aulacophora foveicollis, a chrysomelid beetle pest prevalent in South Asia (including near Ambur), causes significant yield loss in cucurbit crops through foliar feeding and skeletonization. Given concerns surrounding the environmental and health impacts of synthetic insecticides, this study explores the potential of locally sourced wood ash (*Prosopis juliflora*) as a physical and deterrent control strategy against adult *A. foveicollis* in cucurbits.

This observational study was conducted in 0.25 acre cucurbit cultivation area at the Palar Agricultural College Farm, Ambur, Tamil Nadu, India. The study included several cucurbit species -bitter gourd (*Momordica charantia*), snake gourd (*Trichosanthes cucumerina*), ribbed gourd (*Luffa acutangula*), sponge gourd (*Luffa cylindrica*), ash gourd (*Benincasa hispida*), watermelon (*Citrullus lanatus*), cucumber (*Cucumis sativus*), pumpkin (*Cucurbita moschata*), and ridge gourd (*Luffa acutangula*). Plants showing active infestation by adult red pumpkin beetles (*Aulacophora foveicollis*), with visible symptoms such as foliar laceration and fenestration, were selected for observation.

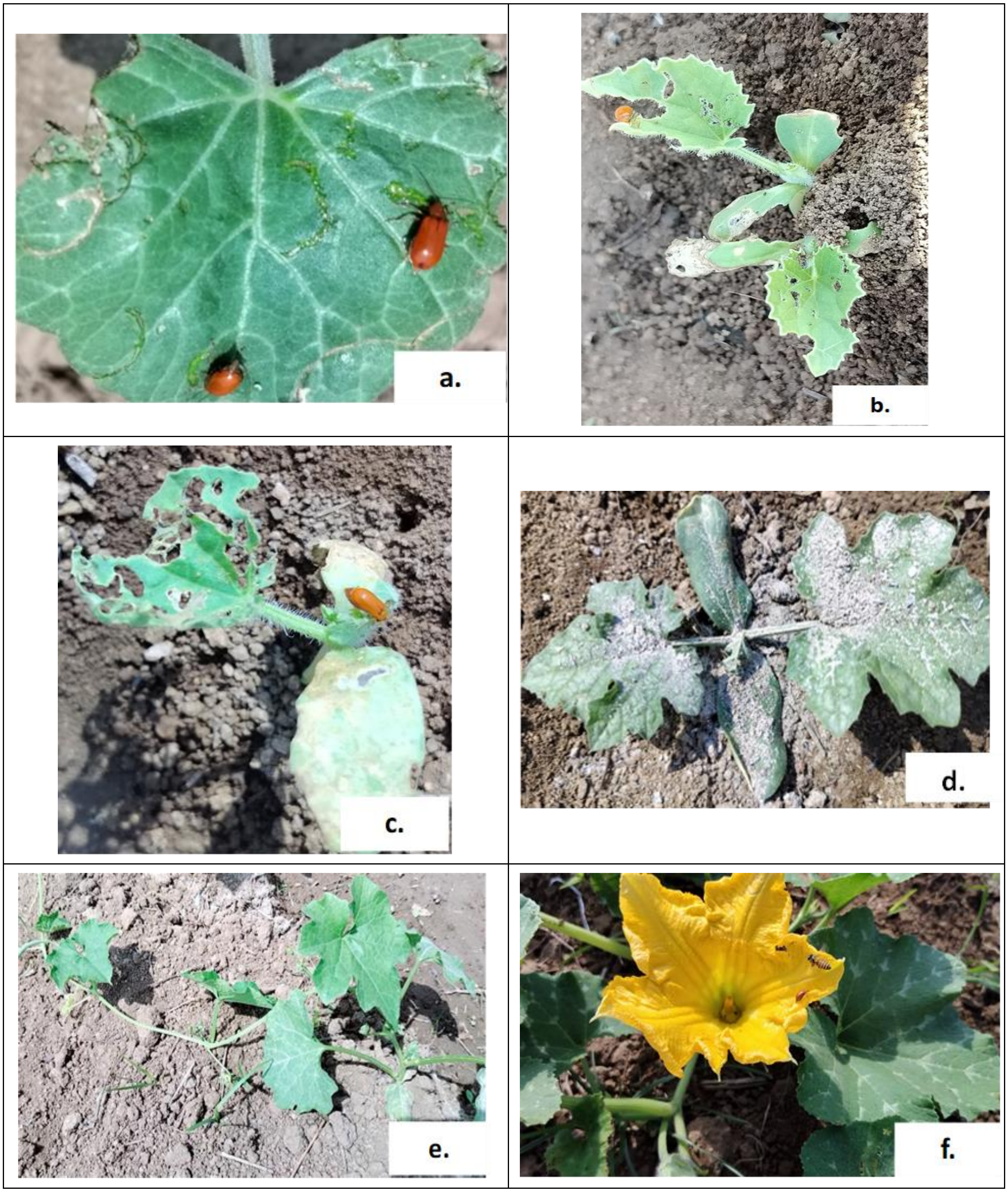

Figure. a–c. Defoliation observed before the application of ash powder
d–f. Recovery of leaf structures after the application of ash powder

Locally sourced wood ash from *Prosopis juliflora* was manually applied to infested plants at a rate of 1 kg per cent (approximately 40 m^2) of cultivated area, ensuring even coverage on both upper (adaxial) and lower (abaxial) leaf surfaces. Applications began 10 days after germination (2-leaf stage) and continued weekly until flowering, with no additional pest control measures used during the study period.

Baseline qualitative assessments of adult *A. foveicollis* infestation (number of beetles per plant) and foliar damage severity (percentage leaf area damaged) were conducted. Post-ash application, subsequent visual assessments were performed at [daily for the first week, then every other day] to monitor: the number of adult beetles on treated plants; the progression or cessation of foliar feeding damage (new laciniation or fenestration); behavioral effects on beetles (reduced mobility, feeding deterrence); and any phytotoxic effects on plants (leaf discoloration, wilting). Photographic documentation recorded plant condition and beetle infestation pre- and post-treatment.

Manual application of wood ash to *Aulacophora foveicollis*-infested cucurbits at the PAC Farm, Ambur, resulted in reduced active beetle feeding. Visual assessments before and after ash application revealed a qualitative decrease in adult beetle presence on treated foliage. Reduced progression of foliar damage—particularly laciniation and fenestration—suggested wood ash functioned as a physical barrier, impeding beetle feeding. Observations also indicated that beetles showed reduced mobility, likely due to the abrasive nature of the ash. Importantly, no phytotoxic effects such as leaf discoloration or wilting were observed in treated plants.

The findings from this preliminary investigation indicate that wood ash could serve as a cost-effective and sustainable pest control method against *A. foveicollis* infestations in cucurbits. The mechanism appears to involve both feeding deterrence and physical obstruction, though further controlled studies are required to quantify efficacy, optimize application techniques, and assess ecological impacts.

Given its readily available and low-cost nature, wood ash presents a potential alternative to chemical insecticides, aligning with sustainable pest management principles. Future research should focus on large-scale trials, determining long-term impacts on beetle populations, and evaluating its broader environmental effects to solidify its role in integrated pest management strategies.

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New records of *Mixochlora vittata* (Moore, 1868) (Geometridae: Lepidoptera) from Samalbong, Kalimpong District, West Bengal, India

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A new distribution record of *Mixochlora vittata* (Moore, 1868), a geometrid moth, is documented from Samalbong, Kalimpong district, West Bengal, India (27° 0'58.93"N, 88°29'43.02"E). This species belongs to the family Geometridae under the order Lepidoptera and is distinguished by its more acute forewing apex, which differentiates it from *M. argentifusa* (Spitsyn et al., 2017).

The adult moth displays dark green markings with vibrant green hues interspersed with silvery-white shades. The forewing features a lunule at the end of the cell, along with antemedial, subbasal, postmedial, and submarginal bands arranged obliquely. The hindwing presents medial, postmedial, and submarginal bands, complemented by an orange-yellow suffused underside. Males and females exhibit greyish-green coloration with less prominent darker transverse bands, while the forewings bear three oblique bands outside a discal spot and two straight subbasal bands, forming a distinctive pattern (Singh, 2021).

The larval host plants include *Quercus incana* (Fagaceae) (Anonymous, 2025), *Quercus leucotrichophora*, and *Castanea crenata*. In India, the primary host is *Quercus*, though Japanese subspecies have been observed feeding on Fagus (same family) and Corylus (Singh, 2021).

Previous records indicate that *M. vittata* was found in Himachal Pradesh, Sikkim, Assam, Meghalaya, Uttarakhand, and West Bengal (Darjeeling district). Beyond India, it has been reported from Nepal, Bhutan, China (multiple provinces), Taiwan, Korea (Jeju Island), Japan (Honshu, Shikoku, Kyushu, Tsushima, Yakushima), Thailand, Malaysia, Indonesia (Sumatra, Borneo, Java), the Philippines, and Myanmar (Kachin) (Spitsyn et al., 2017).

This study marks the first report of *Mixochlora vittata* from Samalbong, extending its documented range within West Bengal. The specimen was collected on October 16, 2024, and subsequently identified based on morphological characteristics and prior distribution records. This finding updates the known geographical range of *M. vittata*, further contributing to knowledge of its habitat and distribution patterns.

Figure 1: *Mixochlora vittata* (Moore, 1868)

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First observational record of *Cryptochaetum* sp. (Diptera: Cryptochaetidae) as a parasitoid of mango mealy bugs in Northern India

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Abstract

Mealy bugs are a major concern in mango cultivation, causing direct damage. Current investigation revealed first time a dipteran parasitoid belonging to the genus *Cryptochaetum* (Diptera: Cryptochaetidae) emerging from female mango mealy bugs collected from an orchard in Northern India. The parasitoid was observed causing internal mummification of the host, followed by adult emergence. This finding suggests a potential biological control agent and adds to the limited records of dipteran parasitoids associated with mango mealy bugs in India.

Keywords: Mango mealy bug, *Cryptochaetum*, Diptera, biological control, first record

Introduction

Mealy bugs, particularly species like *Drosicha mangiferae* and *Rastrococcus iceryoides*, are significant pests of mango (*Mangifera indica*), affecting yield and fruit quality (Singh and Baradevanal, 2021). Biological control efforts have mostly focused on hymenopteran parasitoids; however, dipteran parasitoids remain underreported. Members of the genus *Cryptochaetum* are known endoparasitoids of pseudococcids and coccids (Thorpe, 1934), but the report about their association with mango mealy bugs in India has been scarcely explored.

Materials and Methods

The study was conducted at ICAR-Central Institute for Subtropical Horticulture (ICAR-CISH), Lucknow, Uttar Pradesh (26°20’42.34” N, 82°8’30.213” E) in May 2024. Following fruit set (April–May), descending adult females of *Drosicha mangiferae* were collected from stems, ground surfaces, and orchard boundaries to observe potential parasitoid activity.

Collected specimens were reared in the laboratory under ambient conditions in Petri dishes lined with moist filter paper. The emergence of adult parasitoids was recorded, and specimens were preserved in 70% ethanol for subsequent identification and taxonomic studies.

Results and Discussion

The mummified infected mealy bugs were characterized by a reddish, hardened body and lack of movement. Several parasitized mealy bugs were found with internal changes suggestive of parasitoid development. Single puparia were found near cadavers of mealy bugs (**Fig. 1**) and later single adult dipteran wasp was observed emerging.

Figure 1. Adult females of *Drosicha mangiferae* (Pseudococcidae: Hemiptera); mummified females; puparia; Adult *Cryptochaetum* spp.

The average pupal duration was 11 days and adult survived for about 3 days. Among the collected females 18.89% were found parasitized by the flies. The adult parasitoid was small (approx. 2 mm), with red compound eyes, a pale-yellow body, and clear membranous wings morphologically consistent with the genus *Cryptochaetum* (NBAIR, 2025). However, definitive species identification is still pending.

Previous studies, such as those conducted in Malda, West Bengal, have documented the parasitization of mango mealy bugs by *Cryptochaetum* sp. nr. *iceryae* (Roy *et al.,* 2024). Additionally, *Cryptochaetum jorgepastori* has been recorded in Jordan, parasitizing the giant date palm mealybug, *Pseudaspidoproctus hyphaeniacus* (Bader & Al-Jboory, 2022).

This study presents the first observational report from Northern India, confirming natural parasitism of mango mealy bugs by *Cryptochaetum* sp. under orchard conditions. Although dipteran parasitoids remain relatively underexplored, their potential as biological control agents could contribute significantly to sustainable mango mealy bug management in India. Further investigations into their lifecycle, host specificity, and field efficacy could pave the way for integrating these parasitoids into long-term pest management strategies.

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Selected Insect Environment Blogs

DNA Barcoding Unveils Black Fly Species in North Bengal: A Step Towards Combating River Blindness

20 April 2025

Dhriti Banerjee and Atanu Naskar, Zoological Survey of India, Kolkata, India

River blindness, scientifically known as *Onchocerciasis*, is a debilitating parasitic disease transmitted by blood-sucking black flies. These tiny yet formidable vectors thrive in fast-flowing rivers and streams, making regions such as Darjeeling and Kalimpong in North Bengal, India, potential hotspots for disease transmission.

A groundbreaking study conducted by the Zoological Survey of India (ZSI) has shed light on the diversity of black fly species in the central Himalayan landscape of West Bengal. Through DNA barcoding techniques, researchers accurately identified four distinct species—*Simulium dentatum, S. digitatum, S. prelargum*, and *S. senile*. This precise species identification marks a crucial advancement in monitoring and controlling these potential disease vectors.

The significance of this study cannot be overstated. Black flies serve as carriers for *Onchocerca* parasites, which can cause severe visual impairment and even total blindness if left unchecked. By pinpointing species-specific distribution patterns, scientists are paving the way for targeted interventions that bolster public health protections and vector control strategies.

The research, published in *Vector-Borne and Zoonotic Diseases*, represents the first-ever DNA barcode study of black flies in this region—an essential milestone towards robust species identification and improved disease surveillance. With North Bengal's rivers providing an ideal breeding ground for black flies, such scientific breakthroughs are imperative for preemptive action.

For a deeper dive into the study, refer to: Molecular Identification of Onchocerciasis Vectors (Diptera: Simuliidae) from the Central Himalayan Landscape of India: A DNA Barcode Approach. Arka Mukherjee, Oishik Kar, Koustav Mukherjee, Bindarika Mukherjee, Atanu Naskar, and Dhriti Banerjee. *Vector-Borne and Zoonotic Diseases*, Volume 25, Number 4, 2025.

IE Blog No. 248
All IE blogs are available on website https://insectenvironment.com

A Plastic-Free Future for Insects: World Environment Day 5th June 2025

Protecting insects is saving the planet: A uniquely celebrated mission by AVIAN Trust

8 June 2025

Abraham Verghese and M. A. Rashmi

The AVIAN Trust and Insect Environment have consistently contributed to addressing environmental challenges, particularly in the conservation of birds and insects.

World Environment Day presents a valuable opportunity to engage with students and society beyond the confines of academia. While many institutions mark the occasion with symbolic activities such as tree planting sessions or quiz programs, we broke these symbolic conventions, by taking action into the field.

This year, reaffirming our commitment to rural and underprivileged students, especially those from small and labour-farming communities, we took a significant step in reaching out to their children ensuring that our efforts are not just symbolic but truly transformative. On June 5, 2025, at Channarayapattana Government Primary School, Devanahalli, Karnataka where Insect Environment, AVIAN Trust, Rashvee IPRS, Bengaluru, and Shreenidhi Plant Health Clinic, Vijayapura, Devanahalli together organized the World Environment Day.

This year's theme, "Ending Global Plastic Pollution," underscored the urgent need to address the widespread environmental crisis affecting biodiversity, with a particular emphasis on the threats plastic waste pose to environment including insects.

Dr. Abraham Verghese, Chairman of AVIAN Trust, delivered an insightful address in Kannada to the students, emphasizing the vital role of insects in maintaining ecological balance and inspired the young audience to adopt eco-friendly practices and engage in conservation efforts.

Despite their crucial ecological functions, plastic pollution severely disrupts insect populations. Many species suffer from entanglement, getting physically trapped in discarded plastic debris, which limits their mobility and survival. Others ingest microplastics, mistaking them for food, leading to digestive toxicity and impaired reproduction. Plastic waste also degrades habitats, contaminating nesting sites and disrupting insect colonies, while harmful additives leach into soil and water, affecting insect physiology, reproduction and behavior. Bees experience nectar and pollen contamination, impacting hive health and honey production. Dr. M.A. Rashmi., CEO Rashvee-IPRS, highlighted in Kannada, sustainable alternatives to plastic that can mitigate harm to insect biodiversity.

To encourage awareness and environmental stewardship among school students, the event incorporated several impactful activities.

Jute bags were distributed to promote sustainable lifestyle choices, and an interactive environmental quiz engaged students and teachers in knowledge-driven discussions, generating enthusiasm for conservation. A pledge ceremony reinforced commitments to reducing plastic use, while tree planting activities provided a hands-on opportunity for students to actively contribute to ecological preservation.

Distinguished representatives from Bhartiya Kisan Sangh, including President Nagarajaiah and Vice President Prabhakar, stressed the importance of agroecological sustainability, advocating for community-driven efforts to eliminate plastic pollution from agricultural practices.

Raghavendra V.G., Head of Shreenidhi Plant Health Clinic, enriched the event by sharing valuable insights on environmental conservation. After an engaging session, everyone-children, teachers, and esteemed guests-gathered to enjoy healthy snacks in a warm and convivial atmosphere, generously sponsored by Raghavendra.

Moving forward, AVIAN Trust and its partners aim to expand grassroot initiatives, implementing plastic-free strategies and reinforcing insect conservation. As World Environment Day 2025 reminds us, protecting insects is integral to protecting the planet. A plastic-free future is not just an ideal- it is a necessity for ecological resilience.

Photo credits: Prathika R.
IE Blog No. 254
All IE blogs are available on website https://insectenvironment.com

A New Scheme to Empower Farmers in the Field

Viksit Krishi Sankalp Abhiyan: A Transformative Initiative for Greater Agricultural Development

25 May 2025

Abraham Verghese and M. A. Rashmi

India's agricultural sector will be witnessing a historic movement with the launch of Viksit Krishi Sankalp Abhiyan, a nationwide farmers' awareness campaign running from May 29 to June 12, 2025. Spearheaded by the Ministry of Agriculture & Farmers Welfare, this initiative aims to reach 1.3 crore farmers across 723 districts, equipping them with modern agricultural technologies like climate-resilience, improved seed/varieties, ecologically and economically viable plant health practices, pest and disease management, water management, soil conservation etc.,

PC: ICAR-Directorate of Knowledge Management in Agriculture, New Delhi

Over 2,170 teams of agriculture scientists, specialists, and officials will be actively engaging with farmers, according to the ministry, providing expert agricultural insights to farmers at their fields. The campaign will also raise awareness about government schemes, subsidies, and financial assistance, ensuring farmers maximize available resources. Farmers will have the opportunity to interact directly with agricultural scientists of ICAR.

Honorable Union Agriculture Minister Shri Shivraj Singh Chouhan, along with Honorable Union Ministers of State for

PC: ICAR-Directorate of Knowledge Management in Agriculture, New Delhi

Agriculture, Shri Ramnath Thakur and Shri Bhagirath Choudhary and the Secretary of the Department of Agricultural Research and Education (DARE) and the Director General of ICAR Dr. Mangi Lal Jat, have been praised by farmers for their leadership in launching the Viksit Krishi Sankalp Abhiyan. Many farmers are looking forward to this program as communicated to us.

Rashvee International Phytosanitary Research and Services, which operates a Plant Health Clinic, aims to leverage this farmer-scientist interactions to further the cause of plant protection in South India, where we as agricultural scientists are actively engaged.

Viksit Krishi Sankalp Abhiyan is an innovative initiative aligned with Honorable Prime Minister Shri Narendra Modi's 'Lab to Land' vision, aiming to bridge the gap between research and the real needs of farmers.

Read more: https://icar.org.in/union-agriculture-minister-shri-shivraj-singh-chouhan-virtually-interacts-state-agriculture

IE Blog No. 252

All IE blogs are available on website
https://insectenvironment.com

Obituaries

Dr. Kishan Lal Chadha (1936–2025)

My first encounter with Dr. K.L. Chadha was in a peculiar and fascinating manner in 1981. At that time, I was a young scientist at the Central Mango Research Station (CMRS) in Lucknow, then under the Indian Institute of Horticultural Research (IIHR). One Sunday, I had an article published in the *Northern India Patrika* on the birds of Lucknow. Dr. Chadha, then Director at IIHR, happened to read it while traveling from Delhi to Lucknow on a Sunday. Intrigued by the author's name, he called a scientist from CMRS and asked if this Abraham Verghese was the same person working at the mango research station. Upon confirmation, he summoned me the next day.

When asked why I wrote for newspapers, I explained that I was a passionate birdwatcher and had a diploma in journalism. Writing was something I truly loved. Probably impressed by my language, he asked me to help edit the IIHR newsletter. I did so for the first few issues incognito, without anyone knowing. This marked my first interaction with Dr. Chadha, and I was grateful for his appreciation of my writing.

Later, he told me about his plans to organize an International Mango Symposium in Bangalore in 1986 and asked me to help with publicity. I requested that, once I fulfilled my minimum requirements in Lucknow, he facilitate my transfer to Bangalore. True to his word, he did, and I ensured extensive media coverage for the symposium. Afterward, he left IIHR to become Horticultural Commissioner and later Deputy Director General, at ICAR.

Dr. K. L. Chadha was truly a phenomenon who strode across the horticultural arena like a colossus. I have never seen a more outstanding horticultural scientist than him, and I doubt I ever will. He stood tall both in stature and in vision. He single-handedly transformed horticulture from an 'art' into a technology-driven discipline, encompassing every aspect of fruit, vegetable, and flower cultivations. Under his leadership, horticultural production soared beyond 300 million metric tonnes by 2010.

Dr. Chadha strongly advocated for horticulture to be recognized as a science- fruit science, vegetable science, and beyond. He emphasized the critical role of upscaling technologies, especially in post-harvest innovations, and his pioneering work never lost momentum. A staunch proponent of plant protection, he frequently sought my insights on entomological reports, papers, and lectures.

He deeply valued the contributions of Dr. R. D. Rawal, an experienced plant pathologist, and nurtured a generation of exceptional students and mentees, many of whom went on to become vice chancellors and directors. Among them, Dr. G. S. Prakash continues to uphold the legacy of viticulture with remarkable dedication, keeping its banners flying highly afloat.

Dr. Abraham Verghese (right) greeting Dr. Chadha at NRC Grapes Pune. In the centre is a scientist from NRC, Grapes

Dr. Chadha and I frequently met at symposia and conferences, and he continually impressed me. His greatest editorial achievement was the monumental *Advances in Horticulture*, spanning 13 volumes and over 9,000 pages, an indispensable reference for students and researchers even to this day. I am deeply indebted to him for granting me the first ICAR Adhoc scheme on computer modelling of pests in mango in 1993. His guidance provided invaluable leads and insights that enriched my entomological research. He read every issue of *Insect Environment* with keen interest and often quoted from them. For my part, I accepted him not only as a mentor but as a beloved guide.

The last time I met Dr. Chadha was in Pune in 2019, just before the COVID-19 pandemic. I was attending a meeting with him as the Chairman of the Regional Advisory Committee for NRC Grapes. On the third day after the meeting, it was my privilege to accompany him from NRC Grapes to Pune airport, as both our flights were scheduled around the same time. That one-hour drive was rich in anecdotal conversations, brimming with his wealth of experience. At the airport, we parted ways at the departure lounge. As he walked away, he turned to the glass pane, of the departure area, and looking out he waved and softly said, “Goodbye, Pune”- audible enough for me to hear. Looking back, I realize he had a strange intuition that this would be his last visit to the city!

One of his most sorrowful moments was the loss of his wife, Mrs. Chadha, in 2015. From *Bhabhiji’s* hands, I often experienced warm hospitality during his stay in Malleswaram, Bangalore. On his passing, Dr. Chadha leaves behind a monumental legacy in horticulture, having founded and shaped numerous institutions, colleges, scientific bodies, students, and seminal books. His favourite institution was ICAR- Indian

Institute of Horticultural Research which he built almost from scratch. It will be appropriate if the main building at ICAR-IIHR be named after Dr. K L Chadha, for he was responsible for building of all main laboratories. I am sure that we may not see another horticultural scientist of his calibre for a long, long time.

Insect Environment, which he deeply admired and encouraged, pays its highest tribute and homage in memory of Dr. K.L. Chadha.

As his mentee, I have only one thing to say: **"Sir, I miss you".**

Abraham Verghese
Chief-In-Editor
Insect Environment

Tribute to Dr. R.D. Gautam (1950-2025)

Former Principal Scientist & Professor,
Division of Entomology, IARI, New Delhi

The sudden passing of Dr. R.D. Gautam, Retired Principal Scientist and Professor at the Division of Entomology, Indian Agricultural Research Institute (IARI), New Delhi, at the age of 75, has come as a shocking and heartbreaking loss. I still vividly recall our conversation just two weeks ago, along with our message exchanges on WhatsApp. Never did I imagine that such a tragic turn of events would arrive so suddenly.

Dr. Gautam Sir was not only my Ph.D. advisor but also a guiding light in my personal and professional life. His role went far beyond that of an academic mentor—he was a father figure to us students, especially those like me, who lived far from home. His calm, compassionate demeanor made him someone we could approach with any challenge, always finding in him a source of wisdom, warmth, and support.

Under his invaluable mentorship, I completed my Ph.D. at IARI between 2007 and 2010. Our lab fostered a vibrant and collegial environment: I worked closely with seniors like Dr. Sachin Suroshe (now Project Coordinator, AICRP on Honeybees), and with his own daughter, Dr. Sudhida Gautam Parihar (currently Professor of Zoology at Delhi University). A number of M.Sc. and Ph.D. students flourished under his tutelage, and our camaraderie thrived because of the atmosphere he nurtured.

A stalwart in the field of *biological pest control*, Dr. Gautam authored the widely respected book *Biological Pest Suppression*, which remains a favorite among students. He was part of an elite team deputed by the Government of India to the Caribbean to deploy *ladybird beetles* in the biocontrol of mealybugs—an exceptional achievement. His leadership was also central to India's efforts in controlling the invasive weed *Parthenium hysterophorus* (Congress grass) using the *Mexican beetle* (*Zygogramma bicolorata*). Amid concerns about its potential impact on sunflower crops, Sir was appointed by ICAR to a special investigative team. His evidence-based clarity helped dispel myths: while the beetle may nibble on other plants, it completes its life cycle only on Parthenium, thereby posing no true threat to agricultural crops.

Thanks to his efforts, Delhi witnessed a successful campaign against the Parthenium menace, which was also associated with mosquito-borne diseases. For this, he was honored by the Delhi administration for excellence in research. *Agrowon*, Maharashtra's leading agricultural daily, extensively covered this achievement—leading to my first meeting with then-journalist, now dear friend, Mr. Santosh Dukare, at IARI.

What I achieved under his mentorship bears testimony to his quiet strength and visionary guidance. He trusted me with independence in research, which helped me top the national ARS examination on my first attempt. I completed my Ph.D. on time and was awarded the Gur Prasad Pradhan Medal for Best Student of Entomology and ICAR's Jawaharlal Nehru Award for Outstanding Ph.D. Research. These honors reflect not just my efforts, but the empowering support of a true guru.

This morning, when I heard the news of Sir's demise from Dr. Sachin Sir, I was devastated. Though we remained in occasional contact and met during my visits to Delhi, it still feels unreal to imagine a world without him. And yet, as Saint Kabir reminds us:

"Aaya hai, so jaayega, raja, rank aur fakir.
Koi sinhasan chadh chala, koi bandha zanjeer, Kabira."
(He who is born must leave one day, whether a king, pauper, or saint.
Some ascend the throne, others are bound in chains—such is life.)

There is solace in knowing that Sir lived a life of purpose, humility, and impact. He lovingly fulfilled his responsibilities as a family man—his daughter is an esteemed professor and his son serves in a senior banking role. Through his students and his research, he left behind a legacy rooted in service, knowledge, and humaneness.

To quote Saint Tukaram Maharaj:

"Deh jhijavava chandanapari, parimḷu tayacha jaaye digantari."

(One should wear out the body like sandalwood, spreading fragrance in all directions.)

Such was the noble, fragrant life of Dr. Gautam Sir.

With tearful eyes and boundless gratitude, I offer my humble tribute. May his noble soul rest in eternal peace. My heart goes out to his family—may they find strength and comfort in the legacy he leaves behind.

Babasaheb B. Fand
Senior Scientist (Agricultural Entomology),
ICAR-Central Institute for Cotton Research
Panjari - Wardha Road, Nagpur
Maharashtra, India

INSECT LENS

Tussock moth, Lymantria marginata (Eribidae: Lepidoptera)

Author: *Dr. Nagaraj, D.N., Project Head (Entomologist) Ento. Proteins Pvt. Ltd., Mangalore*
Location: *Bengaluru*
Email: *nasoteya@yahoo.co.in*

Oriental spiny orb-weaver, Gasteracantha geminate (Araneidae: Araneae) Robber fly (Asilidae: Diptera) with its hunt - most likely a hymenopteran parasitoid.
Author: *Dr. Sevgan Subramanian*
Location: *Nairobi, Kenya (May, 2025)*
Email: *ssubramania@icipe.org*

Jewel beetle, Sphenoptera sp. (Buprestidae: Coleoptera)
Author: *Dr. Nagaraj, D.N., Project Head (Entomologist) Ento. Proteins Pvt. Ltd., Mangalore*
Location: *Bengaluru*
Email: *nasoteya@yahoo.co.in*

Common Indian Crow caterpillar, Euploea core (Nymphalidae: Lepidoptera)

Author: *Dr. Nagaraj, D.N., Project Head (Entomologist) Ento. Proteins Pvt. Ltd., Mangalore*
Location: *Bengaluru*
Email: *nasoteya@yahoo.co.in*

Plain tiger Butterfly, Danaus chrysippus (Nymphalidae: Lepidoptera)

Author: *Dr. Nagaraj, D.N., Project Head (Entomologist) Ento. Proteins Pvt. Ltd., Mangalore*
Location: *Bengaluru*
Email: *nasoteya@yahoo.co.in*

Yellow Banded Wasp, Vespa tropica (Vespidae: Hymenoptera)
Author: *Dr. Nagaraj, D.N., Project Head (Entomologist) Ento. Proteins Pvt. Ltd., Mangalore*
Location: *Bengaluru*
Email: *nasoteya@yahoo.co.in*

Chalcid wasp, Torymus sp. (Torymidae: Hymenoptera)
Author: *Dr. Nagaraj, D.N., Project Head (Entomologist) Ento. Proteins Pvt. Ltd., Mangalore*
Location: *Bengaluru*
Email: *nasoteya@yahoo.co.in*

Picture winged fly, Physiphora alceae (Ulidiidae: Diptera)

Author: *Dr. Nagaraj, D.N., Project Head (Entomologist) Ento. Proteins Pvt. Ltd., Mangalore*
Location: *Bengaluru*
Email: nasoteya@yahoo.co.in

Common grass yellow, Eurema hecabe (Pieridae: Lepidoptera)

Author: *Dr. Nagaraj, D.N., Project Head (Entomologist) Ento. Proteins Pvt. Ltd., Mangalore*
Location: *Bengaluru*
Email: nasoteya@yahoo.co.in

Hover fly, Syrphus sp. (Syrphidae: Diptera)

Author: *Dr. Nagaraj, D.N., Project Head (Entomologist) Ento. Proteins Pvt. Ltd., Mangalore*
Location: *Bengaluru*
Email: *nasoteya@yahoo.co.in*

Broad Headed Bug, Riptortus linearis (Alydidae: Hemiptera)

Author: *Dr. Nagaraj, D.N., Project Head (Entomologist) Ento. Proteins Pvt. Ltd., Mangalore*
Location: *Bengaluru*
Email: *nasoteya@yahoo.co.in*

Oriental lemon migrant caterpillar, Catopsilia pomona (Pieridae: Lepidoptera)
Author: *Dr. Nagaraj, D.N., Project Head (Entomologist) Ento. Proteins Pvt. Ltd., Mangalore*
Location: *Bengaluru*
Email: *nasoteya@yahoo.co.in*

One of the oldest examples of classical biological control - Cottony cushion scale, Icerya purchase predated by Vedalia beetle grub, Novius cardinalis.
Author: *Dr. Sevgan Subramanian*
Location: *Parklands, Nairobi (May, 2025)*
Email: *ssubramania@icipe.org*

Long Horned Spiny orb Spider, Gasteracantha sp. (Araneidae: Araneae)

Author: *Dr. Nagaraj, D.N., Project Head (Entomologist) Ento. Proteins Pvt. Ltd., Mangalore*
Location: *Bengaluru*
Email: *nasoteya@yahoo.co.in*

Snouted hoverfly, Rhingia sp (Syrphidae: Diptera) (Associated host plant: Lantana camara).

Author: *Dr. Sevgan Subramanian*
Location: *Nairobi, Kenya (May, 2025)*
Email: *ssubramania@icipe.org*

White-spotted Longicorn Beetle, Anoplophora macularia (Cerambycidae: Coleoptera)
Author: *Srinivasan Ramasamy*
Location: *Vietnam*
Source: *Whatsapp*

Black soldier fly, Hermetia illucens (Stratiomyidae: Diptera)

Author - Miss Pratiksha Balasaheb Khedkar
Location - Latur, Maharashtra
Email – pratibk11@gmail.com

Honey bee, Apis sp. (Hymenoptera: Apidae)

Author*: Srinjoy Das, JRF, Zoological Survey of India (Bird Section), Kolkata-700053, India.*
Location*: Newtown, Kolkata, India.*
Email*: srinjoydas1998@gmail.com*

Robber fly (Asilidae: Diptera)

Author*: Mr. Rushikesh Rajendra Sankpal*
Location: *Pune, Maharashtra*
Email: *rushisankpal@gmail.com*

Blister beetle in red gram, Hycleus pustulatus Thunberg (Meloidae: Coleoptera)
Author: *Navin Kumar R, PhD scholar, Dept. of Entomology, Annamalai University*
Location: *Vallampadugai village, Cuddalore (dt), Tamil Nadu, India*
Email: *r.navinkumar24@gmail.com*

Lemon pansy, Junonia lemonias Linnaeus (Nymphalidae: Lepidoptera)
Author: *Navin Kumar R, PhD scholar, Dept. of Entomology, Annamalai University*
Location: *Vallampadugai village, Cuddalore (dt), Tamil Nadu, India*
Email: *r.navinkumar24@gmail.com*

IE Extension

Raghavendra V.G., Rashvee team in Pomegranate field

International Plant Health Day: Diagnostics and advisory to farmers at our Plant Health Clinic

Empowering Farmers: Insights from Our Plant Health Clinic

Annual Report 2024-25

Government of India
Department of Science & Technology
Ministry of Science & Technology
New Delhi

- **Rashvee-International Phytosanitary Research & Services Pvt Ltd (R-Iprs) - Incubated At Nidhi Itbi At Siddaganga Incubation Foundation:** Rashvee-International Phytosanitary Research & Services Pvt Ltd (R-IPRS) is an innovative agri-startup founded in 2022. The startup has developed a herbal fortified adjuvant wooden block/ stick for dispensing non-insecticidal repellent of Bruchid/ storage pests. The product has been tested and developed with the funding from DST NIDHI iTBI Scheme, incubated and supported by Siddaganga Incubation Foundation. The startup is operating in Karnataka and neighbouring districts of Chittoor, Vellore, and Madanapalle reaching 1000+ farmers in 2024 and generating revenue of close to Rs. 4 lakhs.

Figure: Herbal fortified adjuvant wooden stick developed by Rashvee-International Phytosanitary Research & Services Pvt. Ltd.

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Annual Report 2024-25

Innovative product for stored grain pests, Rashvee Tab published in DST annual report 2024-2025

Field Wisdom Meets Lab Science: Bridging Knowledge Gaps with Every Interaction

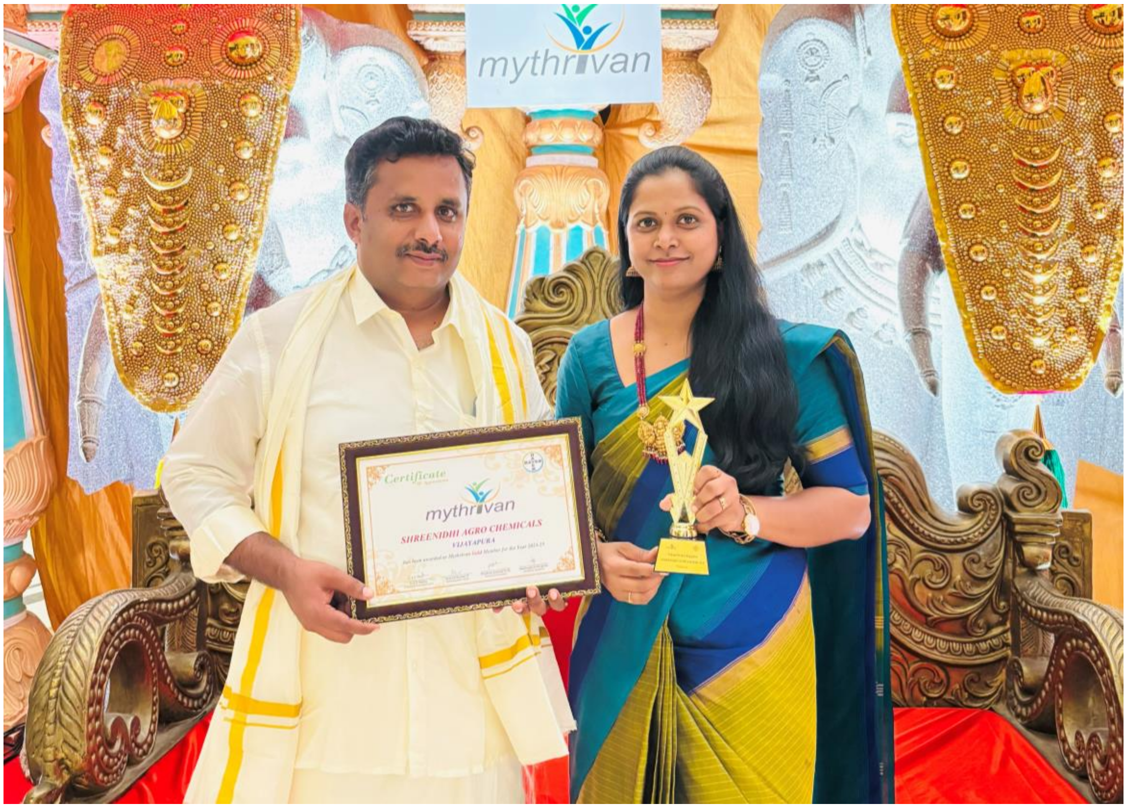
From Bloom to Beyond Borders: Quality Inspection of Export Roses

Dr. M.A. Rashmi was felicitated by the Gowdasani Group, Bengaluru, during the Women's Day celebration in recognition of her contributions to sustainable agriculture and community empowerment

World Biodiversity Day by AVIAN Trust and Insect Environment with Dr. K. Shreedevi, ICAR-NBAIR and Dr. G.T. Geetha, NCBS, Bengaluru.

A Biodiversity Trail through Maize Rows

The Rashvee team participated in the Agri Exhibition organized by UAHS, Bagalkot, featuring meaningful interactions with Chief Guest Mr. Vishwanath K, Hon'ble MLA, and with farmers from Rajanakunte, Doddaballapura



The Shreenidhi Plant Health Clinic team was honoured with a Business Excellence Award from Bayer Crop Science in recognition of the innovative pest management solutions to farmers

At the Bayer meet with Mr. Mohan Babu, Chief Operating Officer, Bayer CropScience (India, Bangladesh, and Sri Lanka), and Mr. Bhimsen Vadvadgi, Founder of Sri Venkateshwara Farm Supplies—celebrating collaboration and innovation in sustainable agriculture

A Plastic-Free Future for Insects: World Environment Day

On June 5, 2025, at Channarayapattana Government Primary School, Devanahalli, Karnataka where Insect Environment, AVIAN Trust, Rashvee IPRS, Bengaluru, and Shreenidhi Plant Health Clinic, Vijayapura, Devanahalli together organized the World Environment Day.


ART
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KNOWLEDGE IS POWER
SAVE ELECTRICITY
SAVE ENERGY
ವಿಶ್ವ ಪರಿಸರ ದಿನ
World Environment Day
5th June 2025 at Government Primary School
Channarayapattana Village, Devanahalli
ಜಾಗತಿಕ ಪ್ಲಾಸ್ಟಿಕ್ ಮಾಲಿನ್ಯ ನಿರ್ಮೂಲನೆ
Ending Global Plastic Pollution
A Plastic-Free Future for Insects
ಪ್ಲಾಸ್ಟಿಕ್ ಮುಕ್ತ ಭವಿಷ್ಯ: ಕೀಟ ಸಂರಕ್ಷಣೆ
ವಿಶ್ವ ಪರಿಸರ ದಿನ
2025


World Environment Day
ಜಾಗತಿಕ ಪ್ಲಾಸ್ಟಿಕ್ ಮಾಲಿನ್ಯ ನಿರ್ಮೂಲನೆ
Ending Global Plastic Pollution
A Plastic-Free Future for Insects

Felicitation of government primary school teachers by AVIAN Trust for their exemplary efforts in educating rural children on environmental conservation and leading impactful tree-planting initiatives

ಪ್ಲಾಸ್ಟಿಕ್ ಮುಕ್ತ ಭವಿಷ್ಯಕ್ಕೆ ಶ್ರಮಿಸಿ

ಬೆಂಗಳೂರಿನ ಎವಿಎನ್ ಟ್ರಸ್ಟ್ ಅಧ್ಯಕ್ಷ ಡಾ.ಅಬ್ರಹಾಂ ವರ್ಗೀಸ್ ಸಲಹೆ

■ ವಿಜಯವಾಣಿ ಸುದ್ದಿಜಾಲ ವಿಜಯಪುರ

ಬಾಲ್ಯದಿಂದಲೇ ಮಕ್ಕಳಿಗೆ ಪರಿಸರದ ಬಗ್ಗೆ ಕಾಳಜಿ, ಕೀಟ ಸಂರಕ್ಷಣೆ ಸೇರಿ ಮುಂತಾದವುಗಳ ಬಗ್ಗೆ ಜಾಗೃತಿ ಮೂಡಿಸಿದರೆ ಮಕ್ಕಳಲ್ಲಿ ಪರಿಸರ ಪ್ರೇಮ ಹೆಚ್ಚುತ್ತದೆ ಎಂದು ಬೆಂಗಳೂರಿನ ಎವಿಎನ್ ಟ್ರಸ್ಟ್ ಅಧ್ಯಕ್ಷ ಡಾ.ಅಬ್ರಹಾಂ ವರ್ಗೀಸ್ ತಿಳಿಸಿದರು. ಪಟ್ಟಣ ಸಮೀಪದ ಚನ್ನರಾಯಪಟ್ಟಣ ಸರ್ಕಾರಿ ಪ್ರಾಥಮಿಕ ಶಾಲೆಯಲ್ಲಿ ವಿಜಯಪುರದ ಶ್ರೀನಿಧಿ ಪ್ಲಾಂಟ್ ಹೆಲ್ತ್ ಕ್ಲಿನಿಕ್ ಹಾಗೂ ಬೆಂಗಳೂರಿನ ಎವಿಎನ್ ಟ್ರಸ್ಟ್ ಸಂಯುಕ್ತಾಶ್ರಯದಲ್ಲಿ ಏರ್ಪಡಿಸಿದ್ದ ಪರಿಸರ ದಿನ ಆಚರಣೆಯ ಪ್ಲಾಸ್ಟಿಕ್ ಮುಕ್ತ ಭವಿಷ್ಯ : ಕೀಟ ಸಂರಕ್ಷಣೆ' ಎಂಬ ಕಾರ್ಯಕ್ರಮದಲ್ಲಿ ಮಾತನಾಡಿದರು.

ಅಂತಾರಾಷ್ಟ್ರೀಯ ಸೈಟೋಸ್ಯಾನಿಟರಿ ಸಂಶೋಧನಾ ಸೇವಾ ಕೇಂದ್ರದ ಡಾ.ರಶ್ಮಿ ಮಾತನಾಡಿ, ಪ್ಲಾಸ್ಟಿಕ್ ಬದಲಿಗೆ ಹಿಂದಿನಂತೆ ಸಣಬಿನ ಚೀಲಗಳನ್ನು ಉಪಯೋಗಿಸುವಂತಾಗಬೇಕು ಎಂದು ಸಲಹೆಯಿತ್ತರು.

ಶಾಲಾ ಮಕ್ಕಳಿಗೆ ರಸಪ್ರಶ್ನೆ ಹಾಗೂ ಪರಿಸರಕ್ಕೆ ಸಂಬಂಧಿಸಿದ ಚಿತ್ರ ಬಿಡಿಸುವ ಸ್ಪರ್ಧೆ ಆಯೋಜಿಸಲಾಗಿತ್ತು.

ಭಾರತೀಯ ಕಿಸಾನ್ ಸಂಘದ ತಾಲೂಕು ಅಧ್ಯಕ್ಷ ಎನ್.ನಾಗರಾಜಯ್ಯ, ಉಪಾಧ್ಯಕ್ಷ ಪ್ರಭಾಕರ್, ಶ್ರೀನಿಧಿ ಪ್ಲಾಂಟ್ ಹೆಲ್ತ್ ಕ್ಲಿನಿಕ್‌ನ ರಾಘವೇಂದ್ರ, ಶಾಲಾ ಪ್ರಾಧ್ಯಾಪಕಿ ಶೈಲಾ, ಶಿಕ್ಷಕರಾದ ನಗೀನಾ ತಾಜ್ ಇದ್ದರು.

ವಿಜಯಪುರ ಸಮೀಪದ ಚನ್ನರಾಯಪಟ್ಟಣ ಸರ್ಕಾರಿ ಪ್ರಾಥಮಿಕ ಶಾಲೆಯಲ್ಲಿ ಏರ್ಪಡಿಸಿದ್ದ ಕಾರ್ಯಕ್ರಮದಲ್ಲಿ ಭಾರತೀಯ ಕಿಸಾನ್ ಸಂಘದ ತಾಲೂಕು ಅಧ್ಯಕ್ಷ ಎನ್.ನಾಗರಾಜಯ್ಯ ಮಕ್ಕಳಿಗೆ ಸಣಬಿನ ಚೀಲಗಳನ್ನು ವಿತರಿಸಿದರು.

ABN ఆంధ్రజ్యోతి

పర్యావరణ పరిరక్షణలో క్రియాశీలకం కావాలి

విజయపుర, జూన్ 6(ఆంధ్రజ్యోతి): పర్యావరణ పరిరక్షణలో విద్యార్థులు క్రియాశీలకం కావాలని బెంగళూరు వీవీఎన్ ట్రస్టు అధ్యక్షుడు డాక్టర్ అబ్రహం వర్గీస్ అభిప్రాయపడ్డారు. దేవన హళ్ళి తాలూకాలో స్థానిక చన్నరాయపట్టణ ప్రభుత్వ ప్రాథమిక పాఠశాలలో విజయపుర శ్రీనిధి ప్లాంట్ హెల్త్ క్లినిక్, బెంగళూరు వివీఎన్ ట్రస్టు సంయుక్త ఆధ్వర్యంలో శుక్రవారం ప్లాస్టిక్ రహిత భవిష్యత్తు - కీటకాల సంరక్షణ అనే కార్య క్రమాన్ని నిర్వ హించారు. అంతర్జాతీయ సైటోశ్యానిటరీ పరి శోధనా సేవా కేంద్రం డాక్టర్ రశ్మి మాట్లాడుతూ ప్లాస్టిక్ రహిత కోసం బట్టల సంచుల ఉయోగించాలని సూచించారు. కార్య క్రమంలో భార తీయ కిసాన్సంఘం తాలూకా అధ్యక్షుడు ఎన్ నాగరాజయ్య, ఉపాధ్యక్షుడు ప్రభాకర్, శ్రీనిధి ప్లాంట్ హెల్త్ క్లినిక్ రాఘవేంద్ర, పాఠశాల ప్రధానోపాధ్యాయురాలు శైల, ఉపా ధ్యాయులు నగీనాతాజ్ తదితరులు పాల్గొన్నారు.

జాగృతి కార్యక్రమంలో విద్యార్థులు తదితరులు

ಬಂತು. ಹಾಗೆಯೇ ಜಾಥವನ್ನು ನಡೆಸಲಾಯಿತು.

ಗೌಡ, ಪ್ರಕಾಶ್ ಮತ್ತು ಆರ್.ಸಿ.ಬಿ. ಅಭಿಮಾನಿಗಳು ಭಾಗವಹಿಸಿದ್ದರು.

ವಿಜಯಪುರ ಪಟ್ಟಣದ ಸರ್ಕಾರಿ ಮಾದರಿ ಹೆಣ್ಣುಮಕ್ಕಳ ಹಿರಿಯ ಪ್ರಾಥಮಿಕ ಪಾಠಶಾಲೆಯ ಮಕ್ಕಳು ವಿಶ್ವ ಪರಿಸರ ದಿನಾಚರಣೆ ಅಂಗವಾಗಿ ಗಿಡಗಳನ್ನು ನೆಡುವುದರೊಂದಿಗೆ ಹಾಗೂ ಪಟ್ಟಣದ ಮುಖ್ಯಬೀದಿಗಳಲ್ಲಿ ಪರಿಸರದ ಬಗ್ಗೆ ಜಾಗೃತಿ ಮೂಡಿಸುವ ಬಿತ್ತಿ ಪತ್ರಗಳನ್ನು ಹಿಡಿದು ಘೋಷಣೆಗಳನ್ನು ಕೂಗುತ್ತಾ ಸಾಗಿರುವುದು ಈ ಸಂದರ್ಭದಲ್ಲಿ ಶಾಲಾ ಮುಖ್ಯ ಶಿಕ್ಷಕರಾದ ಮನೋಹರ್ ಸಹಶಿಕ್ಷಕರುಗಳಾದ ಮಾಧವಿ, ದ್ರಾಕ್ಷಿ ಯಣಿ, ಸರಸ್ವತಿ, ನಿರ್ಮಲ, ರೋಹಿಣಿ, ಸೀಮಾ, ಮಮತಾ, ರಾಜ್ಯೇಶ್ವರಿ, ಅನ್ನಪೂರ್ಣೇಶ್ವರಿ, ಶೋಭ, ಎಸ್.ಡಿ.ಎಂ.ಸಿ.ಅಧ್ಯಕ್ಷರಾದ ರಾಧಾ, ಸದಸ್ಯರಾದ ಮಾಲ ಹಾಗೂ ಮಕ್ಕಳು ಹಾಜರಿದ್ದರು.

Rashvee team with UAHS professors at Agri expo organized by University of Horticultural Sciences, Bagalkot