Volume 25 (4) December 2022

ISSN 0975-1963

Insect Environment

Not-for-profit journal promoting Insect Science

Quarterly journal

Silver Jubilee Year

Insect Environmentalist Awards
Silver Jubilee celebration of
Insect Environment
see inside

Articles with DOI

NAAS ID I128

Abstract/ Full text uploaded in

CABI · Google Scholar · Crossref · ResearchGate · ZooBank

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

Published by
Rashvee-International Phytosanitary Research & Services (IPRS) Pvt. Ltd.

Recognized by
The DIPP, Ministry of Commerce and Industry, Government of India

Editorial Board

Cover Page:** ***Cecidochares connexa **(Macquart)**
Photo by: Dr. Nagaraj, D. N, Project Head (Entomologist) Ento Proteins Pvt. Ltd., Mangalore.

Identified by: Dr. K. J David, Sr. Scientist, ICAR-NBAIR, Bengaluru

Insect Environment

(Quarterly journal to popularize insect study and conservation)

ISSN 0975-1963

The first issue of the Insect Environment was published in 1996. The sole objective of the 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.

Insect Environment subscription is free; articles can be downloaded from the website https://insectenvironment.com/ or anyone requesting by email to IE will receive a copy of the journal.

Author guidelines

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 on insects.

The blogs are for quick dissemination of insect "news". These will be published within a week of submission. Blogs should be about 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

Editorial processing fee per article/blog for each author (Note all authors have to pay):

India: Students Rs. 300, Others Rs. 400, Overseas 10 USD for each author

Photos: Rs 300/author (may submit >one photo)

Send to A/c No: 520101048085843; IFSC: UBIN0907979

Swift Code: UBININBBPEE, AD CODE: 02903GQ (for remittance from abroad)

Product announcement: Eco-friendly products for plant protection, eco-agri inputs, seeds and any product announcement of human interest is solicited in colour @ Rs. 3000/- per page.

Mail your papers/notes/queries/photos related to *Insect Environment* to *einsectenvironment@gmail.com*

Contents

Volume 25 (4) December 2022

IE Blog Contents

Editorial

Editorial: From Silver on to Gold……

Insect Environment is celebrating its 25th jubilee volume with the release of this issue- Volume 25 (4) December, 2022. Typical of our team, we 'edited' out the fanfare, noise and pomp, such pageantry is usually accompanied with. Our jubilee celebration was marked by the Insect Environmentalist Award function on 17th December, 2022. But, what made the jubilee ceremony gracious, pleasant and scientific were the presence of Dr. J. P. Singh, Plant Protection Adviser to Government of India, Dr. S. N. Sushil, Director, ICAR-National Bureau of Agricultural Insect Resources, Bengaluru, Dr. Father Maria Packiam, Director, Entomological Research Institute, St. Loyolla College, Chennai, Dr. D. K. Nagaraju, Deputy Director, Regional Plant Quarantine Station, Bengaluru and 48 awardees -all from students to officials, declared "**Insect Environmentalist**". We wish all awardees a bright academic future. The venue of the function was the faculty hall of the Regional Plant Quarantine Station, Hebbal, Bengaluru. See more in pictures in the following pages.

This quarter has been dominated by the FIFA fever! FIFA and Fruit Flies, besides having two 'Fs' in them, have another quadrennial commonality. The International Seminar on Fruit Flies of Economic Importance is being conducted every quadrennial, almost synchronizing with the FIFA. This year ISFFEI was held at Sydney during November, almost the same period as FIFA. In 2010, when Spain won the world cup, we had a little later the ISFFEI at Valencia, Spain. I presented a paper on "Area-wide management of the mango fruit fly, *Bactrocera dorsalis*" and ended the thank you slide with a picture of the Spanish soccer team! The frenzy and applause that followed in the auditorium, for that gesture of mine, almost overshadowed my scholastic presentation! That is the soccer fever in Spain!

Talking of fruit flies, the Insect Environment on request can mail the abstracts of the just concluded fruit fly symposium (2022) at Sydney to any of our readers, at request.

In December, we need to remember the tragedy caused by the leakage of 45 tons of the dangerous gas, methyl isocynate that escaped the Union Carbide Corporation Plant. It was the 3rd of December, 1984. Human mortality as some estimate put it was 18,000 deaths. The environmental pollution to water and soil may be still around. *Insect Environment* and its authors commemorates the death and loss, and sincerely hope no such leaks ever occur and emphasize on greening of all pesticides as an important way forward.

We at, **Rashvee-International Phytosanitary Research Services Pvt. Ltd**., the publishers of *Insect Environment* have been mounting surveillance of *Thrips parvispinus* and have been able to extend valuable and relevant inputs for the management of the thrips to farmers.

Insect Environment blogs continue to dominate attention. Anybody can be a blogger on *Insect Environment*. It takes only three days to upload. A small note on anything interesting or important (100 -150 words) with a photo, reaches >4000 readers automatically every Monday. We request all of you to take advantage of this- India's only blog for regular Insect News! These blogs are also quotable!

Insect Environment team is also associated with two other Indian journals – *Pest Management in Horticulture Ecosystem* and *Journal of Biocontrol*. I request prioritized submission of longer versions of articles to these and of course also to *Indian Journal of Entomology*, *Entomon*, and *Indian Journal of Plant Protection*. In these we have an excellent repertoire of insect journalism. We need to send our best papers to these not 'secondary' papers. The international business journals have managed to garner the best of insect writers and their research works through 'impact factorism'! NAAS simply benchmarks a score of six and bunches the impact factor with it to give its own score! Young and bright entomologists are perforce publishing in such 'high impact journals' only to keep their promotional score counts ticking, while often paying huge page charges. Their papers are marketed by publishers- now a huge dollar business! The tragedy is, if Indian journals have a business outlook, they are branded 'predatory'. Surely, a big fish will not allow a small fish even to skim!

Insect Environment and the downloads of papers published in it are FREE.

Come to think of it, it is often not the journal that impacts, but each paper published in it. So, our suggestion is to give impact utility factors to each paper as and when a scientist presents them when he appears for advancement of any kind. Like benefit of doubt to a batsman, let a good paper be given high credence, even if published in a 'low' score journal.

It is again with a sense of pride and duty that we web-place this issue on to your systems. While we bid *adieu* to 2022, we at *Insect Environment* wish all our valuable authors, readers and bloggers a tremendously great 2023 with plenty of insecty excitement which hopefully would get converted to useful lexical forms in our next volume! We eagerly look forward to your involution.

Abraham Verghese
Editor-in-Chief

M. A. Rashmi
Co-Editor-in-Chief

S. Deepak
Associate Editor

WE ALL WISH YOU THE BEST FOR THE NEW YEAR, AS WE BID GOOD BYE TO OUR SILVER JUBILEE AND EMBARK ON THE GOLDEN HIGH WAY.

Insect Environmentalist Awards, Silver Jubilee celebration of Insect Environment

Chief Guest, Dr J.P. Singh, Plant Protection Adviser, Govt. of India, Directorate of Plant Protection Quarantine and storage, Ministry of Agriculture and Farmers Welfare, Faridabad, New Delhi

Guest of Honour Dr S.N. Sushil, Director, ICAR- National Bureau of Agricultural Insect Resources, Bengaluru

Distribution of Insect Environmentalist Awards

Distribution of Insect Environmentalist Awards

Distribution of Insect Environmentalist Awards












Distribution of Insect Environmentalist Awards

Research articles

DOI 10.55278/OKCN2453

Current status of cassava mealybug, *Phenacoccus manihoti* Matile-Ferrero (Hemiptera: Pseudococcidae) and its indigenous natural enemies observed under field conditions in Namakkal district of Tamil Nadu, India

Thimmegowda P R.*, M. Ayyamperumal, S. Sivarama krishnan, S. N. Shivakumar, C. Elangovan, J. Raju, N. Vasu, R. Karunakaran, D.K. Nagaraju, Om Prakash Verma and J. P. Singh

Directorate of Plant Protection, Quarantine and Storage, Ministry of Agriculture & Farmers Welfare, Department of Agriculture & Farmers Welfare, *Government of India, NH-IV, Faridabad, Haryana -121001.*

Corresponding author: tgowda123@gmail.com

Abstract

The cassava mealybug *Phenacoccus manihoti* Matile-Ferrero (Hemiptera: Pseudococcidae) is one of the most severe pest of cassava in the world. It causes severe damage by stunting the growth points of cassava plants, sometimes totally defoliating the plants and storage root yield loss up to 84 % have been reported from Congo- Central Africa and hence present study was undertaken to assess the current status of invasive pest with respect to its incidence and yield loss. The cassava growing area of nearly 120 ha was surveyed during July and August 2021 in ten number of blocks of Namakkal district of Tamil Nadu. The crop age varied from six to eight months, level of infestation varied from 30 to 100 per cent and yield loss ranges from 30 to 90 per cent. It was observed that, crops namely groundnut, banana and sugarcane were found adjacent to cassava were not infested by the mealybug. *Parthenium hysterophorus*, *Corchorus olitorius* and *Digera arvensis* were some of weeds found infested by mealybug. Two hemipteran predators' viz., nymphs of reduviid bugs and anthocorid bugs, three ladybird beetles namely, *Scymnus coccivora*, *Cheilomenes sexmaculata* and *Hyperaspis maindroni* (Coleoptera: Coccinellidae), two neuropteran *Mallada* sp., *Chrysoperla* sp., both grubs and adults were found to be predating on the cassava mealybug.

Keywords: Cassava mealybug, *Phenacoccus manihoti, natural enemies, incidence, invasive pest impact.*

Introduction

Cassava (*Manihot esculenta* Crantz) also known commonly as Tapioca, is an important industrial crop native to North-East Brazil and it is continuing to be a crop of food security for the millions of people especially in the developing countries of the globe. It is an important alternate source of energy to meet the demands of increasing population. Cassava is a good source of dietary fiber as well as vitamin C, thiamin, folic acid, manganese, and potassium. Cassava was introduced into India by the Portuguese when they landed in the Malabar region, presently part of Kerala state during the 17th century, from Brazil (Edison *et al.*, 2013). Cassava crop is cultivated predominantly in the southern states, of which Tamil Nadu and Kerala accounts for 51.9 per cent and 31.7 per cent of area with a production of 57.8 per cent and 34.9 per cent respectively. It is also grown in Andhra Pradesh, Karnataka, Madhya Pradesh, Northeastern states and to some extent in Pondicherry and Andaman and Nicobar group of Islands (Sampath kumar *et al.*, 2021).

The cassava mealybug *Phenacoccus manihoti* Matile-Ferrero (Hemiptera: Pseudococcidae) is one of the most severe pest of cassava in the world (Yonow *et al.*, 2017). *Phenacoccus manihoti* is indigenous to South America, where it is found in Argentina, Bolivia, Brazil, Colombia, Guyana and Paraguay. It was accidentally introduced from South America to the Congo Republic in 1973 (Herren and Neuenschwander, 1991). It has spread in Africa to practically all countries where cassava is grown, in a broad belt from West through to East Africa and down to the eastern edge of South Africa.

Phenacoccus manihoti causes severe damage by stunting the growth points of cassava plants, sometimes totally defoliating the plants and storage root yield losses up to 84 % have been reported from Congo- Central Africa (Nwanze *et al*., 1982a). *Phenacoccus manihoti* was first detected in Thailand in 2008 (Winotai *et al*., 2010; Muniappan *et al.*, 2009) and remains a threat to the cassava cultivating areas of southern Asia. Further, its expansion in Asian distribution was also detected at Vietnam, Cambodia, Myanmar and threatens to engulf the cassava growing areas of southern China, Indonesia and Philippines (Wu and Wang, 2011; Parsa *et al.*, 2012). This exotic pest has a wide host range. However, damage and reproduction potential of mealybug is high in cassava compared to other host species. The host range is likely to expand as the species becomes more established and now it has spread into Tamil Nadu.

In India, *P. manihoti* infestation was first reported from Kerala in a students' experimental plots at the Department of Agronomy, College of Horticulture, Kerala Agricultural University, Vellanikkara, Thrissur, Kerala (Joshi *et al*., 2020). Later infestations of cassava mealybug were reported from Salem, Namakkal, Erode and Dharmapuri districts of Tamil Nadu (Sampathkumar *et al*., 2021). It is likely that the pest has gained entry into the country through trade in tuber crops. For the effective pest management of this exotic pest, identifying exotic or indigenous natural enemies of *P. manihoti* is very essential. Hence, the surveys were undertaken by Central Integrated Pest Management Centre during July and August 2021 to record per cent infestation levels, to estimate the approximate yield losses incurred by the farmers and to identify naturally occurring enemies of cassava mealybug under field conditions.

Material and Methods

The cassava growing area of nearly 120 ha was surveyed during July and August 2021 in ten blocks of Namakkal district of Tamil Nadu. Blocks surveyed were Elachipalayam, Thiruchengode, Kabilarmalai, Mohanur, Namakkal, Erumapatti, Mallasamudram, Vennandur, Rasipuram and Paramathi. Per cent infestation of cassava mealybug was assessed by using parameters namely the number of plants showing Rosette symptoms in a fixed area 100 sq. m at different fields divided by total plants was used. Scoring and per cent infestation level was calculated as described by Nwanze, 1982b. Cassava mealybug specimens and its natural enemies found in the field were carefully collected from the mealybug infested plants using camel brush and transferred into 70% ethyl alcohol. The samples thus, collected were brought to the laboratory at Central Integrated Pest Management Centre (CIPMC), Tiruchirapalli for further studies and identification. The cassava mealybug infested plant parts were also removed from the plant along with mealybug with help of a sharp knife and placed in to polythene bags (25 x15cm) which were sealed with rubber bands and labelled with date and locality of the collection and kept for parasitoids emergence.

Results and Discussion

During the survey, the infestation of mealybug, *Phenacoccus manihoti* in Cassava with all the stages such as ovisacs, nymphs and adults were observed (Figure1.) in all the inspected blocks of Namakkal District of Tamil Nadu. The symptoms such as stunted growth (rosette like appearance), bunched terminal shoots, honey dew excretion with sooty mould (Figure 2.), curling and distortion of leaf shape were observed (Figure 3). Finally the severely affected cassava plants get stunted (Figure 4.) and dried (Figure 5), exhibited less number of tubers with reduced tuber length (Figure 6). As a result, some of the farmers destroyed the severely affected cassava fields by ploughing the soil and burying the affected plants into the soil (Figure 7.). There were no fields which were free from cassava mealybug infestation and all most all the fields were infested. However, there were crops adjacent to cassava fields such as groundnut, banana and sugarcane which was non-infested by *P. manihoti.* There are no authorized nurseries for supplying planting material; hence, farmers usually collect the propagative material from the cassava plants from the previous season and through these setts mealybug eggs may enter into the new crop as unnoticed. Overall infestation level varies from 30 to 95 per cent and yield loss is raging from 30 to 90 per cent in different blocks of Namakkal district of Tamil Nadu in the month of August 2021 (Table 1).

The natural enemies observed under field conditions were two hemipteran predators' viz., reduviid bug nymphs and anthocorid bugs; three ladybird beetles namely, *Scymnus coccivora* Ayyar, *Cheilomenes sexmaculata* (Fabricius) and *Hyperaspis maindroni* Sicard (Coleoptera: Coccinellidae) Figure 8a. (*Hyperaspismaindroni* **grubs feeds on ovisacs)**, Figure 8b (pu**pa**) and Figure 8c (Adult); two neuropteran predators were *Mallada* sp. and *Chrysoperla* sp., both grubs and adults were found feeding on the cassava mealybug in the infested fields.

Invasive pests such as papaya mealybug, *Paracoccus marginatus Williams and Granara de Willink (Hemiptea: Pseudococcidae)* introduced during 2002 was successfully controlled by encyrtid parasitoid, *Acerophagus papayae Noyes & Schauff* (Hymenoptera: Encyrtidae) in the initial stage of the invasion. This was one of the biggest milestone of classical biological control in India. Likewise, an effective natural enemy, *Anagyrus lopezi* (De Santis) (Hymenoptera: Encyrtidae) of cassava mealybug was recorded in South America (Lohr *et al*., 1990). This host specific parasitoid was then introduced in to West Africa for biological control of the mealybug (Herren and Neuenschwander, 1991). This biological control program was very successful using *A. lopezi* and has provided good control of the cassava mealybug pest in Africa (Zeddies *et al.,* 2001).

Factors responsible for high infestation of cassava mealybug.

a. **Drought:** High infestation level of cassava mealy bug was observed in those plots, where cassava is being grown under rainfed conditions. Here, due to the water stress coupled with high temperature the crop was already under stress and hence, cassava plants may not be able to withstand the infestation of mealybugs. Whereas, flood irrigated or drip irrigated cassava plots are not under water stress and thus these plots could be able to sustain the effect of cassava mealybug better than the crops grown under rainfed condition.

Outbreaks of natural populations of cassava mealybugs occur on cassava every year during the dry season in Africa and South America. In drought-stressed cassava, nutrients such as sucrose and amino acids are either more concentrated or better balanced, such plants are more suitable for the development and reproduction of mealybugs. This has been demonstrated with *Phenacoccus herreni* Cox and Williams. Simultaneously, it has been demonstrated with *P. manihoti* that, the partial resistance of cassava (both antixenosis and antibiosis) decreases during the dry season. All the above-mentioned conditions were combined to ensure that, the drought-stressed plants are physiologically more favourable for infestation by the cassava mealybugs, and serve to enhance mealybug infestation build up during long dry seasons in the field (Paul-Andre Calatayud and Bruno Le Ru., 2006).

b. **Planting time:** High level of infestation was observed in late planted cassava plots (during November) than the early planted cassava plants (Mar-April). This could be due to the weather conditions and rainfall because the setts which are planted in November 2020 to January 2021 were found severely infested during summer period (March to June). Whereas, setts planted in the months of March to April had low infestation levels. This is due to the rainfall, most of the mealybug population would get washed off due to rain splashes and this could lead to low infestation level. Similar observations were also recorded by Sampathkumar *et al*., 2021.

c. **Type of variety or host resistance:** The cassava variety Mulluvadi released by Tamil Nadu Agricultural University is highly susceptible than the white Thailand variety. Among these two varieties, Mulluvadi was most predominantly grown variety because of its drought resistant character. Since *P. manihoti* is a newly introduced and invasive pest, there have been no resistant varieties available as of now and efforts are needed in this regard to identify resistant or tolerant varieties for Cassava mealybug.

d. **Irrigation and Plant Nutrition:** Irrigated fields with balanced nutrition and well maintained fields recorded low infestation levels compared to the crop grown under rainfed conditions and poorly nourished cassava fields. Infestation by *P. manihoti* is rarely observed in forest regions and in soils which are rich in organic elements (Neuenschwander *et al.*, 1989; 1990). The impact of improved soil fertility in diminishing cassava infestation by *P. manihoti* has been reported also by Schulthess and colleagues (1997), and this finding has been supported by the evidence of Tertuliano and colleagues (1999). Mulching and manures are the best fertilizers in enhancing cassava resistance to *P. manihoti,* as shown by a higher defensive response (*i.e.* the increase of rutin level in leaves after infestation).

e. Natural enemies: Even though *Hyperaspis maindroni* Sicard (Coleoptera: Coccinellidae) and two neuropteran predators *Mallada* sp. and *Chrysoperla* sp., were found feeding on the cassava mealybug in the unsprayed fields, their population in the field conditions were very low when compared to population density of mealybug. In addition to this, the biocontrol potential of *H maindroni* was severely hampered due to parasitization by a parasitoid, *Homalotylus turkmenicus* Myartseva (Hymenoptera: Encyrtidae) as mentioned in the earlier studies conducted by Gupta *et al*., 2020.

f. **Field sanitation and crop hygiene:** The cassava fields which are not maintained well were most severely infested when compared to fields with good sanitary practices like free from weeds and other alternate host of the pest. Some of the weeds like ***Parthenium hysterophorus* (Figure 9),** *Corchorus olitorius* **(Figure 10) and** *Digera arvensis* **(Figure 11) were found infested with cassava mealybug** *Phenacoccus manihoti*. These weeds may act as alternate hosts for the survival of mealybug during off season or between two cropping periods. Further, systematic investigations are needed to find out whether the pest can survive and complete all its growth stages on these weeds is the question. Although, it has been collected on plants in various families, such as citrus and tomato, there is no evidence that it can survive for more than one generation on plants other than Manihot and perhaps certain other Euphorbiaceae (Williams and Granara de Willink, 1992).

g. **Pesticide sprayed v/s non sprayed fields:** The cassava fields which are sprayed with Profenophos 50% EC had low infestation level when compared to fields sprayed with other pesticides. At present there are no label claim pesticides available in the market for the control of mealybugs.

Cassava mealybug had spread across the width of Africa in a period of 16 years. Its accidental introduction damaged a staple crop that is particularly important in times of drought, leading to famine. At present, *P. manihoti* poses a threat to other cassava growing states of India as the invasive pest is reported only from Kerala and Tamil Nadu. Accidental introduction to new territories is possible through the movement of infested living cassava material for propagative purposes through shipping, air transport or by road. *Anagyrus lopezi* (De Santis) (Hymenoptera: Encyrtidae), a parasitoid native to Central America, is being used for the management of cassava mealybug in African and other Asian countries. *Anagyrus lopezi* is host-specific, and environmentally-adaptable (Wyckhuys *et al*., 2018a) it has attained maximum parasitism levels of 97% (in late dry season), which greatly surpass the 33–36% established threshold (of maximum parasitism rate) for successful biological control (Wyckhuys *et al*., 2017). Host specificity studies conducted in different countries indicated that *A. lopezi* could develop only on cassava mealybug (Wyckhuys *et al*., 2018b). In a combined effort of International Institute of Tropical Agriculture (IITA), CABI, Inter-African phytosanitary council (IAPSC) and other agencies, *Anagyrus lopezi* (De Santis) was shipped to Africa, mass reared and released in the field trials. This was successful throughout sub-Saharan Africa, thus cassava mealybug is now under control and no longer possess threat to cassava production (Cock *et al.*, 2009). This indicates that internal collaborations and free exchange of biocontol agents would bring solutions to this invasive pest. Thus in the event of non-availability of effective biocontrol agents, it may be advisable to regulate the trade and movement of propagative material in fresh planting material of cassava from these two southern states (Kerala and Tamil Nadu) to other states of the country. Planting material should be inspected in the growing season previous to shipment and should be free from infestation. Use of certified planting materials might help in restricting or delaying the further spread of the invasive pest.

Figure 1. Nymphs and adults of *Phenococcus manihoti*

Figure 2. Bunched terminal shoot, honeydew secretion with sooty mold.

Figure 3a. Curling (rosette appearance) of infested leaves

Figure 3b. Distortion of leaves.

	
Figure 4. Stunting of infested cassava plants.	Figure 5a. Infested plants getting dried
	
Figure 5b.	Figure 6. Infested plant showing reduced tuber numbers and length.
	
Figure 7. Ploughing and burying of mealybug affected plants.	Figure 8a *H. maindroni* grubs feeding on ovisacs of *P. manihoti*.

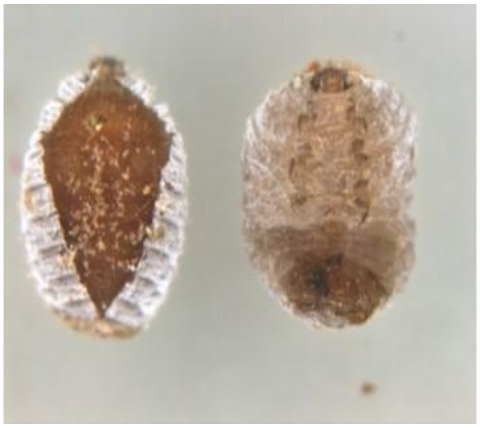


Figure 8b. Pupa of *H. maindroni*.

Figure 8c. Adults of *H. maindroni*.

Figure 9. *Parthenium hysterophorus* infested by *P. manihoti*.

Figure 10. Weed *Corchorus olitorius* infested with *P. manihoti*.

Figure 11. Weed *Digera arvensis* infested with *P. manihoti*.

Table 1. Per cent infestation of cassava mealy bug and approximate yield loss (*Phenacoccus manihoti* Matile- Ferrero) in different blocks of Namakkal district, Tamil Nadu.

Sl. No.	Name of the Block	Variety	Age of the Crop (in months)	Crop area (ha)	Per cent infestation (Average)	Approximate yield loss (In %)	Adjacent crops grown	Adjacent crops/weeds infested
1.	Erumapatti block	White rose	6	4	50	60	Banana	Parthenium and *Digeraarvensis* weeds were infested
2.	Namakkal	Mulluvadi	6-8	13	40-60	50-60	Cassava	Yes
							Sugarcane	No
3	Mohanur	Mulluvadi	7-8	21	30-70	30-40	Sugarcane	No
							Groundnut	No
							Coconut	No
4	Paramathi	Mulluvadi	6-8	13	90-100	85-90	Groundnut	No
							Onion	No
							Sugarcane	No
5	Kabilarmalai	Mulluvadi	6-7	8	50-60	50-60	Groundnut	No
6	Thiruchengode	Mulluvadi	7-8	27	60-100	60-90 (Rain fed)	Groundnut	No
7	Elachipalayam	Mulluvadi	7-8	11	100	90	Onion	No
							Sugarcane	No
8	Malasamudram	Mulluvadi	7	10	50-75	60-88	Groundnut	No
9	Rasipuram	Mulluvadi	8	4	80	70	Sugarcane	No
		Thailand white	8	5	90	90	Cassava	Yes
10	Vennanthur	Mulluvadi	7	4	70	60	Groundnut	No
			Total area	**120 ha**				

Acknowledgements

The authors are grateful to the Joint Secretary, Department of Agriculture, Ministry of Agriculture and farmers' welfare, Government of India, New Delhi for having given the opportunity to conduct this study. Also, we are grateful to Dr. J.Poorani, Principal Scientist, National Research Centre for Banana (through personal communication) and Dr. Sunil Joshi Principal Scientist, National Bureau of Agricultural Insect Resources for Coccinelid and mealybug identification respectively. We sincerely thank the Dr. R. Arulprakash, Assistant Professor (Agricultural Entomology), Seed center, TNAU, Coimbatore and Dr. S. Suganya Kanna, Assistant Professor (Agricultural Entomology), ICAR-KVK, Sandhiyur, Salem for their critical comments and observations during survey. Shri. T. Tamilselvam, Shri. P. Chinadurai and Smt. S. Jayaprabha, Assistant Directors of Horticulture, State Department of Horticulture and Plantation crops, Tamil Nadu. Shri. P. Prakash, Shri. Sathiyaraj, Shri. Suvedhanan, Shri. Anandakumar, Shri. Ganesh, Shri. Gunasekaran, Shri. Sundar Raju, Assistant Horticulture officers of Namakkal district are gratefully acknowledged for their timely help and Co-operation in conducting this study. We also thank the farmers of all blocks of study area for their interaction, field assistance and for having shared their experience.

References

Cock, M.J.W., Lenteren, J. C. V., Brodeur, J., Barratt, B.I.P., Bigler, F., Bolckmans, K., Cônsoli, F.L., Haas, F., Mason, P.G. and Parra, J.R.P., 2009. The use and exchange of biological control agents for food and agriculture. In Background Study Paper No. 47. Commission on Genetic Resources for Food and Agriculture, FAO, Rome.

Edison, S., Anantharaman, M. and Srinivas. T., 2013. Status of Cassava in India an Overall View, Technical Bulletin Series: 46, the Director Central Tuber Crops Research Institute Sreekariyam, Thiruvananthapuram 695 017. Kerala, India.

Gupta, A., Mohan, M., Sampathkumar, M., Shylesha, A.N, Venkatachalam, S.R. and Bakthavatsalam, N., 2020. Cautionary note on the presence of *Homalotylus turkmenicus* Myartseva (Hymenoptera: Encyrtidae) in the colonies of *Phenacoccus manihoti* MatileFerrero (Hemiptera: Pseudococcidae) in southern India. *Journal of Biological Control*, **34**(2): 158–160.

Herren, H.R. and Neuenschwander, P., 1991. Biological control of cassava pests in Africa. Annual Review of Entomology, 36: 257-283.

Joshi, S., Sachin, G.P., Deepthy, K.B., Ballal, C.R., Watson, G.W., 2020. The cassava mealybug, *Phenacoccus manihoti* Matile-Ferrero (Hemiptera: Coccomorpha: Pseudococcidae) arrives in India. *Zootaxa.*, **4772**(1): 191–194.

Lohr, B., Varela, A.M. and Santos, B., 1990. Exploration for natural enemies of cassava mealybug, *Phenacoccus manihoti* (Homoptera: Pseudococcidae), in South America for biological control of this introduced pest in Africa. *Bulletin of Entomological Research,* **80:** 417–425.

Muniappan, R., Shepard, B.M., Watson, G.W., Carner. G.R. and Rauf, A., 2009. New Records of Invasive Insects (Hemiptera: Sternorrhyncha) in Southeast Asia and West Africa. *Journal of Agricultural Urban Entomology*, **26:** 167–174.

Neuenschwander, P., Hammond, W.N.O., Ajuono, O., Gado., A., Echendu, N., Bokonon-Ganta A. H., Allomasso, R. and Okon, I. 1990. Biological control of the cassava mealybug, *Phenacoccus manihoti* (Hom., Pseudococcidae) by *Epidinocarsis lopezi* (Hym., Encyrtidae) in West Africa, as influenced by climate and soil. *Agricultural Ecosystem & Environment.,* **32,** 39-55 (1990).

Neuenschwander, P., Hammond, W.N.O., Gutierrez, A.P., A.R. Cudjoe, J.U. Baumgaertner, U. Regev. and R. Adjakloe., 1989. Impact assessment of the biological control of the cassava mealybug, *Phenacoccus manihoti* Matile-Ferrero (Hemiptera: Pseudococcidae) by the introduced parasitoid Epidinocarsis lopezi (De Santis) (Hymenoptera: Encyrtidae). *Bulleting of Entomolgical Research,* **79,** *579*-594 (1989).

Nwanze, K.F., Leuschner, K.H.C. Ezumah, 1982a: The cassava mealybug, *Phenacoccus* sp. in the Republic of Zaire. *PANS*, **25**(2): 125–130.

Nwanze, K.F., 1982b: Relationships between cassava root yields and crop infestations by the mealybug, *Phenacoccus manihoti. Tropical Pest Management*., 28(1):27-32.

Parsa, S., Kondo. T. and Winotai A., 2012, The Cassava Mealybug **(***Phenacoccus manihoti***)** in Asia: First Records, Potential Distribution, and an Identification Key. *PLoS ONE.*, **7**(10): e47675.

Paul-Andre Calatayud (ed.). and Le Ru, Bruno (ed.), 2006. Cassava-Mealybug interactions. New edition [online]. Marseille: IRD Éditions, 2006. ISBN: 9782709922814.

Sampathkumar, M., Mohan, M., Shylesha, A. N., Sunil Joshi, , Ankita Gupta, S. Vennila, S. R. Venkatachalam, M. Vijayakumar, Madhu Subramanian, M. Yoganayagi, T. R. Ashika and N. Bakthavatsalam: Occurrence of cassava mealybug, *Phenacoccus manihoti* Matile-Ferrero (Pseudococcidae: Hemiptera), a new invasive pest on cassava in India and prospects for its classical biological control, *Curr. Sci.*, **120**(2), 432-435 (2021).

Schulthess, F., P. Neuenschwander. and S. Gounou: Multitrophic interactions in the cassava, *Manihot esculenta*, cropping system in the sub-humid tropics of West Africa. *Agric. Ecosyst. Environ.*, **66**: 211-222 (1997).

Tertuliano, M., P. A. Calatayud, and Le Ru, Bruno: Seasonal changes of secondary compounds in the phloem sap of cassava in relation to fertilisation and to infestation by the cassava mealybug. *Insect Sci. Appl.*, **19**, 91-98 (1999).

Williams, D. J. and M.C. De Granara Willink: Mealybugs of Central and South America, Wallingford, UK: CAB International (1992).

Winotai, A., G. Goergen, M. Tamò. and P. Neuenschwander: Cassava mealybug has reached Asia. Inf. *Bio-control News*., **31**: 10N–11N (2010).

Wu, S.A. and Y.P. Wang: Precaution of cassava mealybug, *Phenacoccus manihoti* Matile-Ferrero in China. *Environ. Entomol*. **33**: 122–125 (2011).

Wyckhuys, K. A. G., Zhang, W., Prager, S. D., Kramer, D. B., Delaquis, E., Gonzalez, C. E. and van der Werf, W., Biological control of an invasive pest eases pressures on global commodity markets. Environ. Res. Lett., 2018a, 13(9), 094005.

Wyckhuys KAG, Wongtiem P, Rauf A, Thancharoen A, Heimpel GE, Le NTT, Fanani MZ, Gurr GM, Lundgren JG, Burra DD, Palao LK, Hyman G, Graziosi I, Le VX, Cock MJW, Tscharntke T, Wratten SD, Nguyen LV, You M, Lu Y, Ketelaar JW, Goergen G, Neuenschwander P. 2018b. Continental-scale suppression of an invasive pest by a host-specific parasitoid underlines both environmental and economic benefits of arthropod biological control.

Wyckhuys, Kris A. G.; Burra, Dharani Dhar; Tran, D.H.; Graziosi, Ignazio; Walter, Abigail Jan; Nguyen, T.G.; Trong, H.N.; Le, B.V.; Le, T.T.N.; Fonte, S.J: Soil fertility regulates invasive herbivore performance and top-down control in tropical agroecosystems of Southeast Asia. Agric. Ecosyst. Environ., 2017, 249, 38–49.

Yonow, T., D.J. Kriticos. and N. Ota: The potential distribution of cassava mealybug (Phenacoccus manihoti), a threat to food security for the poor. *PLoS ONE* 12(3): e0173265 (2017).

Zeddies, J., R.P. Schaab, P. Neuenschwander., and H. R. Herren: Economics of biological control of cassava mealybug in Africa. *Agric. Econ.*, **24**(2), 209–219 (2001).

MS Received 30 September 2022

MS Accepted 26 November 2022

DOI 10.55278/IZCV6301

A short term observation on butterfly diversity at College of Forestry, Ranichauri

Shikhar Kaushik[1] and M. Jayashankar[2]
[1] *College of Forestry, VCSG Uttarakhand University of Horticulture and Forestry, Ranichauri, Distt. Tehri Garhwal, Uttarakhand-249199*
[2] *St. Joseph's University , School of Life Sciences, Bengaluru-560027*
Corresponding author: jayashankar.m@sju.edu.in

Abstract

Thirty-nine species of butterflies belonging to six families were recorded from the College of Forestry, Ranichauri. The survey was carried out at three sites from March 2022 to July 2022. Out of total butterfly diversity, five species are protected under different schedules of the Wildlife Protection Act 1972. The maximum species recorded belongs to the family Nymphalidae. Common Sailer, Indian Tortoiseshell, Large Cabbage White, Blue Pansy and Chocolate Pansy account for the most common butterflies in the study area. Minimum species were recorded from Site 3 (Agriculture Block of College of Forestry, Ranichauri) probably due to high anthropogenic pressure which includes heavy agriculture machinery, use of fertilizers and low diversity of nectar plants.

Key words: Biodiversity, butterfly, Ranichauri, Tehri Garhwal.

Introduction: Butterflies play a vital role in the terrestrial ecosystem chiefly as a pollinator of flowering plants, food to various insectivorous animals in different metamorphic forms such as larvae and adults, and as an indicator of a healthy ecosystem. Kunte *et al.* (2012) reported 1504 species of butterflies from Indian subcontinent. Singh and Sondhi (2016) reported 407 species of butterflies Garhwal region of Uttarakhand. Butterflies are sensitive arthropods and climate change can highly impact their breeding phenology which involves reproduction, egg-laying, caterpillar development and emergence of adults (Radchuk *et al.* 2013).Various anthropogenic factors such as deforestation, habitat fragmentation, extensive use of pesticides and climate change are resulting in the decline of butterfly populations around the world. According to IUCN 35 species of butterflies are critically endangered in India. The present observations were undertaken in College of Forestry, Ranichauri (30.3111° N, 78.4096° E) situated in Tehri Garhwal district at a distance of 9.1km from nearby town Chamba (30.3455° N, 78.3947° E). It has an elevation of 1875m from MSL, forest type consists of montane temperate forest

(Champion Seth, 1968) which accounts for oak, rhododendron, pine, deodar, and toon species. The temperature of Ranichauri varies between 9.4 to 27.20°C (Negi *et al.* 2015).

Material and Methods

Survey method: The survey for butterfly diversity was conducted from March 2022 to July 2022 at three different sites to document diversity of butterflies which were considered on basis of different elevations and vegetation types. Rainy days were excluded from study period. The survey was carried out during early morning and afternoon weekly. Photographic identification method was used for identifying specimens, gear used was Sony point-and-shoot camera and GPS points for recorded species were also taken from different sites.

Survey site: Three sites based on vegetation type, anthropogenic pressure and elevation were selected for the study in the College of forestry campus (Map 1). These were Site 1: Dandachili Forest Block, Site 2: D-Block and Site 3: Agriculture Block.

Site 1: - Dandachili Forest Block. (30°18'26.11"N 78°24'34.16"E)

Elevation: 2006m

Vegetation type: Area dominated by *Cedrus deodara*, *Quercus leucotricophora*, *Quercus serrata*, along with individual trees of *Rhododendron arboreum*, *Pinus wallichiana* and *Myrica esculenta*.

Anthropogenic pressure: Low

Site 2: - D Block, College of Forestry, Ranichauri. (30°18'49.34"N 78°24'47.01"E)

Elevation: 1725m

Vegetation type: Region dominated by pure stands of *Pinus roxburghii* along with individual trees of *Cupressus torulosa*, *Aesculus indica*, *Castanea sativa*. The nearby area consists of a horticulture block where various horticulture crops are planted.

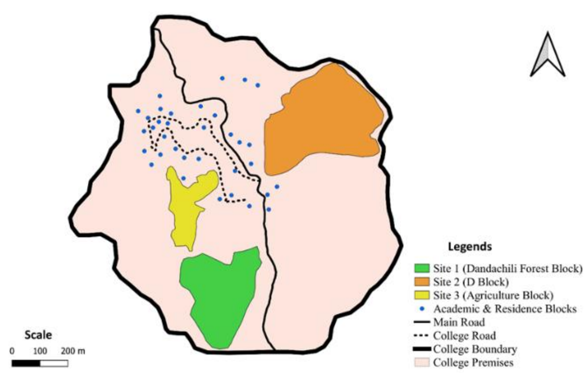
Anthropogenic pressure: Low

Site 3: - Agriculture Block, College of Forestry, Ranichauri. (30°18'40.13"N 78°24'28.47"E)

Elevation: 1927m

Vegetation type: region dominated by various arable crops along with *Quercus leucotricophora* and *Rhododendron arboreum* in agroforestry system.

Anthropogenic pressure: High



Map 1. Study sites in the selected area

Identification of species: The coloured photographs of specimens were used for identification. Morphological features like colour, wing design, wing span, wing pattern were compared for identification using available literature (Smetacek, 2017; Kehimkar, 2008; Singh and Sondhi, 2016).

Results and Discussion: A total of thirty-nine species belonging to six families were recorded from three sites during study period (Table 1) of five months study duration. Four species belonged to Papilionidae (10.26%), seven species belonged to Pieridae (17.95%), one species belonged to Riodinidae (2.56%), seven species belonged to Lycaenidae (17.95%), nineteen species belonged to Nymphalidae (48.72%) and one species belonged to Hesperiidae (2.56%) among these five species are protected under the Wildlife Protection Act (1972) (Figure 1**).** Six representative species photographed are presented (Figures 2-7)

Maximum species were recorded in April accounting for thirty-four species and minimum species were recorded in July which accounted for sixteen species. Highest specie diversity was recorded from Site 2 i.e., twenty-five species in April and lowest specie diversity was recorded from Site 3 i.e., three species in July. Minimum species diversity was recorded from Site 3 due to high levels of anthropogenic pressure which includes daily agricultural practices involving use of heavy machinery, use of fertilizers and low diversity of nectar plants. Whereas, the maximum species diversity was observed from Site 2 due to low anthropogenic pressure and high diversity of host and nectar plants (Figure 8). Short term pilot studies on butterfly diversity are pivotal for long term assessments (Alexander *et al*., 2016). However, a long-term study is required to document species diversity of the Ranichauri region of district Tehri Garhwal to understand the eco-behaviour of butterflies with reference to changing climate and increasing anthropogenic pressure.

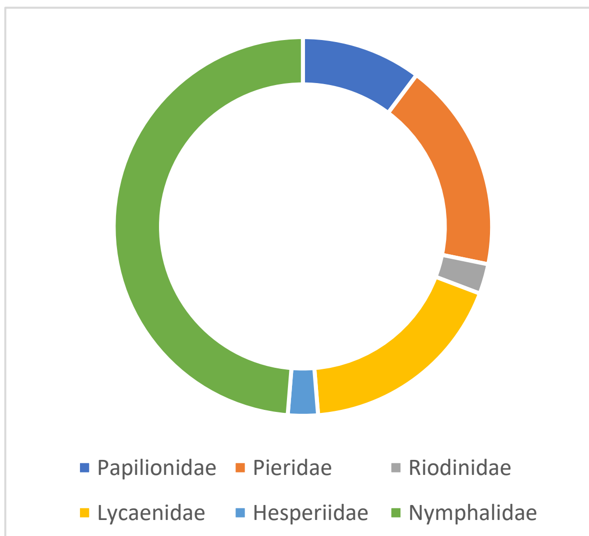


Figure 1. Representation of butterfly species belonging different families observed during fieldwork

Table 1. Checklist of butterfly species recorded from three study sites at College of Forestry, Ranichauri

S.No.	Common name	Scientific name	WPA Status	March			April			May			June			July		
				Site 1	Site 2	Site 3	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
	Papilionidae																	
1	Golden Birdwing	*Troides aeacus*	-				*	*		*	*			*				
2	Spangle	*Papilio protenor*	-	*			*	*		*	*		*			*		
3	Common Yellow Swallowtail	*Papilio machaon*	-					*										
4	Common Bluebottle	*Graphium sarpedon*	-					*										
	Pieridae																	
5	Common Brimstone	*Gonepteryx rhamni*	-				*		*	*		*	*			*	*	
6	Spotless Grass Yellow	*Eurema laeta*	-		*	*			*		*	*						
7	Dark Clouded Yellow	*Colias fieldii*	-					*	*		*			*				
8	Great blackvein	*Aporia agathon*	WPA-IV				*	*		*	*		*	*		*		
9	Large Cabbage White	*Pieris brassicae*	-		*	*		*	*		*	*		*			*	*
10	Indian Cabbage White	*Pieris canidia*	-		*	*			*		*	*		*	*		*	
11	Hill Jezebel	*Delias belladonna*	-				*			*				*				
	Riodinidae																	
12	Common Punch	*Dodona durga*	-		*		*	*		*	*		*	*		*		
	Lycaenidae																	
13	Common Copper	*Lycaena phlaeas*	-		*		*	*		*			*	*			*	
14	Sorrel Sapphire	*Heliophorus sena*	-		*			*			*			*				
15	Eastern Blue Sapphire	*Heliophorus oda*	-	*			*											
16	Tailless Bushblue	*Arhopala ganesa*	WPA-II	*	*		*	*										
17	Pea Blue	*Lampides boeticus*	WPA-II					*			*							
18	Red Pierrot	*Talicada nyseus*	-							*	*		*	*				
19	Tailed Cupid	*Everes argiades*	-		*		*	*		*	*							
	Hesperiidae																	
20	Small Branded Swift	*Pelopidas mathias*	-						*	*		*			*			
	Nymphalidae																	
21	Western Courtier	*Sephisa dichroa*	-				*		*	*	*		*	*		*		
22	Northern Common Jester	*Symbrenthia lilaea*	-				*			*								
23	Indian Tortoiseshell	*Aglais caschmirensis*	-	*	*	*	*	*	*	*	*		*	*	*	*	*	
24	Blue Admiral	*Kaniska canace*	-	*	*		*	*		*		*	*					
25	Painted Lady	*Vanessa cardui*	-					*			*			*				
26	Indian Red Admiral	*Vanessa indica*	-		*			*			*			*			*	
27	Blue Pansy	*Junonia orithya*	-		*	*		*	*		*	*		*	*		*	
28	Chocolate Pansy	*Junonia iphita*	-	*		*	*		*	*			*		*	*		
29	Tropical Fritillary	*Argynnis hyperbius*	-					*										
30	Himalayan Queen Fritillary	*Issoria issaea*	-					*		*	*		*	*				
31	Common Sailer	*Neptis hylas*	-	*	*		*	*	*	*	*	*	*	*	*	*		*
32	Hill Sergent	*Athyma opalina*	-													*		
33	Grand Duchess	*Euthalia patala*	WPA-II										*					*
34	Banded Treebrown	*Lethe confusa*	-	*	*			*		*			*					
35	Common Treebrown	*Lethe rohria*	-							*								
36	Common Wall	*Lasiommata schakra*	-				*	*			*			*			*	
37	Ringed Argus	*Callerebia annada*	WPA-I					*		*	*		*					
38	Common Four-ring	*Ypthima huebneri*	-					*			*			*				
39	West Himalayan Five-ring	*Ypthima nikaea*	-							*		*	*		*			

Figure 2. Blue Admiral

Figure 3. Common Brimstone

Figure 4. Ringed Argus

Figure 5. Great Blackvein

Figure 6. Hill sergent

Figure 7. Grand Duchess

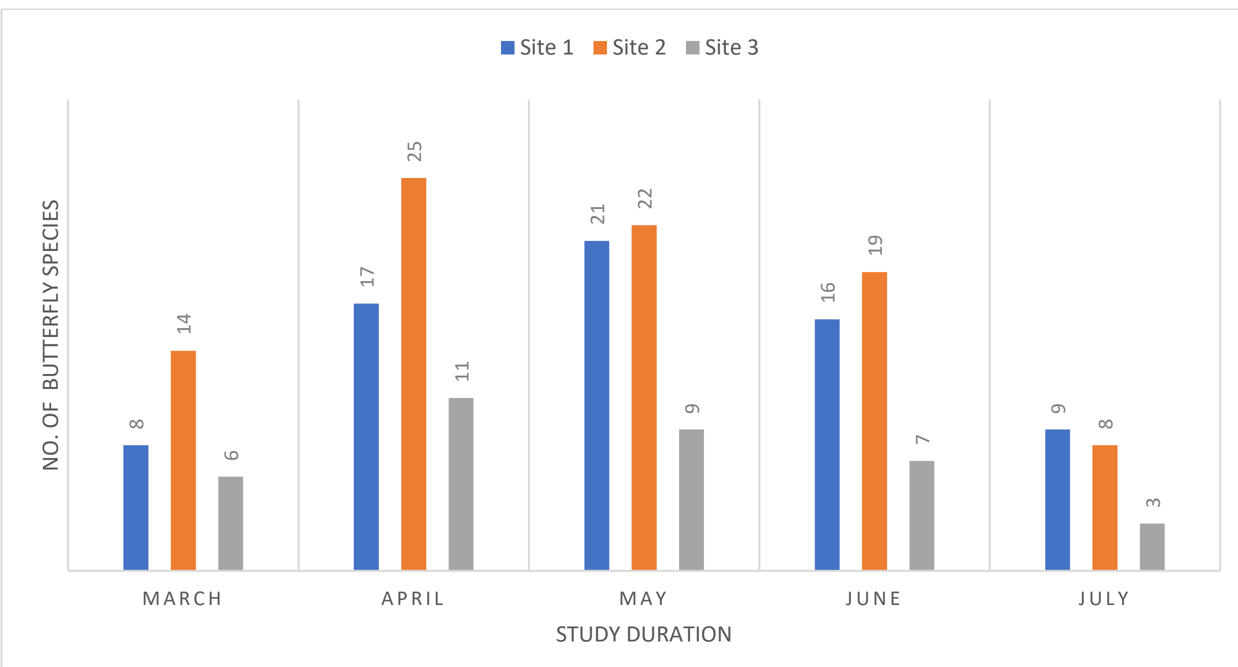


Figure 8. Butterfly diversity observed at different study sites

References

Alexander, R., Avinash, K., Phalke, S., Manidip, M. and Jayashankar, M. 2016. Rapid assessment of butterfly diversity in an ecotone adjoining Bannerghatta National Park, Bengaluru. *Bugs R All*. **22**: 28–29

Champion, H.G. and Seth, S.K. 1968. A Revised Survey of the Forest Types of India. The Manager of Publications, Delhi-6.

Kehimkar, I. 2008. The Book of Indian Butterflies. Bombay Natural History Society and Oxford University Press, Mumbai. 520 pages. ISBN13: 978-0-19-569620-2ISBN10: 0-19-569620-4

Kunte, K., Sondhi, S., Samgma, B. M., Lovalekar, R., Tokekar, K. and Agavekar, G. 2012. Butterflies of the Garo Hills of Meghalaya northeastern India: Their diversityand conservation. *Journal of the Threatened Taxa*. **4**(10): 2933-2992

Radchuk, V., Turlur, C and Schtickzelle N. 2013. Each life stage matters: the importance of assessing the response to climate change over the complete life cycle in butterflies. *Journal of Animal Ecology*. **82**: 275–285

Singh, A.P. and Sondhi S. 2016. Butterflies of Garhwal, Uttarakhand, Western Himalaya, India. *Journal of the Threatened Taxa*. **8**(4): 8666–869

Smetacek, P. 2017. A Naturalist's Guide to the: Butterflies of India. Prakash Books. 176 pages. ISBN: 9788175994065, 9788175994065

Upadhyay, R.G., Ranjan, R and Negi, P.S. 2015. Climatic variability and trend at Ranichauri (Uttarakhand). Journal of Agrometeorology. **17** (2): 241-243

Websites

https://indiabiodiversity.org/

https://www.ifoundbutterflies.org/

MS Received 15 October 2022

MS Accepted 18 December 2022

DOI 10.55278/IFVR4080

Report of Egyptian cottony cushion scale, *Icerya aegyptiaca* (Douglas) (Monophlebidae: Hemiptera) on *Casuarina equisetifolia* from Gujarat (India)

Patel N. M*. Patel N. B and Raghunandan B. L.
AICRP on Biological Control of Crop Pests, Anand Agricultural University, Anand, Gujarat-388110 India
****Corresponding author: nehampatel25@gmail.com***

Abstract

During *kharif* season of the year 2022, survey was carried to document the activity of insect pests and bio-agents under biodiversity research trial of All India Co-ordinated Research Project on Biological Control of Crop Pests (AICRP-BC), Anand Agricultural University (AAU), Anand (Gujarat). During the survey period the infestation of Egyptian cottony cushion scale, *Icerya aegyptiaca* was observed on *Casuarina equisetifolia.* The die back of seedlings was observed and it was primarily attributed to sap sucking by the pest. The mature parthenogenetic females were orange-red, oval to pyriform shaped body partially or entirely covered with white wax and long white waxy fringe around the body. The present study appears to be the first report of Egyptian cottony cushion scale, *I. aegyptiaca* on *C. equisetifolia* from Gujarat, India.

Keywords: *Icerya aegyptiaca*, Egyptian cottony cushion scale, *Casuarina equisetifolia*, Gujarat

Introduction:

In the 19th century, *Casuarina equisetifolia* L. (Casuarinaceae) was introduced to India from Australia (Warrier *et al*., 2014). It thrives on sandy shores and is salt-tolerant. It is widely planted to minimise coastal erosion and serve as a windbreak. The wood is sturdy and durable and is mostly used for fuel, scaffolding and poles. Additionally, a tree that fixes atmospheric nitrogen. Though, it is considered to be a hardy woody tree, 70 species of insects have been recorded to infest this tree in India (Sasidharan, 2004). The genus *Icerya* includes about 35 species in the world that are commonly known as fluted scales because of the fluted appearance of the ovisac (El-Sobky, 2020). *Icerya aegyptiaca* Douglas (Hemiptera: Monophlebidae) is commonly known as Egyptian cottony cushion scale, Egyptian fluted scale or breadfruit mealybug. It is a highly polyphagous sucking pest known to feed on about 123 species of plants belonging to 49 plant families (Ben-Dov *et al*., 2009).

Monophlebidae, often known as giant scales or monophlebids, is a family of scale insects. Giant scales can be found on various host plants, although the majority of them are trees or woody shrubs. They can be found all over the world, but the tropics have more genera than anywhere else. (Anon, 2018). A study was conducted to document the diversity of insect pests and their natural enemies in research fields of AAU, Anand, Gujarat during *kharif* season of the year 2022. Here we have described Egyptian cottony cushion scale, *I. aegyptiaca* Douglas, that was observed during the survey.

Materials and Methods

A biodiversity research trial is being carried out under the ambit of the All India Co-ordinated Research Project on Biological Control of Crop Pests. Regular surveys were carried out in *kharif* 2022 to record the activity of several pests and their natural enemies in diverse crop environments. During the survey the tree *C. equisetifolia* was found infested with scale insects. The scale insects collected and preserved in 70% ethyl alcohol and sent to Division of Germplasm Collection and Characterization, ICAR–NBAIR (National Bureau of Agricultural Insect Resources), Bengaluru, India for identification.

Results

During the study period (May-June 2022), we reported the infestation of *C. equisetifolia* by scale insects. The scale insects were identified as Egyptian cottony cushion scale, *I. aegyptiaca*.

Nature of damage

It was observed that Egyptian cottony cushion scale, *I. aegyptiaca* found congregated on needles and feeding the trees by sap sucking. The severely infested seedlings were stunted with die back symptoms. It was also excreting honeydew, promoting the growth of sooty mold fungus that block photosynthesis.

Morphological description

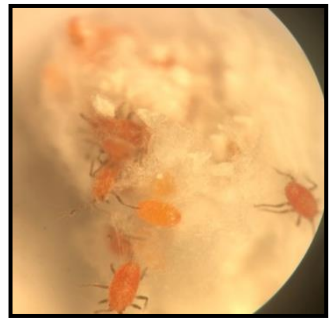
Egyptian cottony cushion scale, *I. aegyptiaca* can be identified by its prominent, thick fluted egg sac, which is often more than twice as long as the adult body (Figure 1). Adults were orange or reddish in colour ranging from pyriform to oval shape. The body was partially or completely covered with white wax and around 20 long white waxy fringes (Beshr, 2015). On the tip of the abdomen, an ovisac was observed that contained between 70 and 200 oval-shaped, orange-yellow eggs. The newly emerged nymphs known as "crawlers" were orange brownish to black coloured legs and antennae. They settle down on a tree needles after a day and became covered with white wax.

Host

Tomato, capsicum, grapes, sapota, apple, banana, guava, jack, mango, custard apple, citrus, hibiscus, lantana, casuarina, *Ficus* spp., teak, cocoa, arhar, papaya and castor etc (Anon, 2013, CPCI 2005; Akintola and Ande, 2009)).

Conclusion

Infestation of this scale insect was recorded on casuarina grown along the research fields of Anand Agricultural University Anand (Gujarat). The present investigation appears to be the first report documenting the infestation of Egyptian cottony cushion scale, *I. aegyptiaca* on *C. equisetifolia* from Gujarat, India.

	
Eggs	Nymphs
	
Mature females of Egyptian cottony cushion scale, *I. aegyptiaca*	Egyptian cottony cushion scale, *I. aegyptiaca* on the *C. equisetifolia*
Figure 1. Life stages of Egyptian cottony cushion scale, *I. aegyptiaca*	

Acknowledgement:

The authors are highly thankful to Dr. Sunil Joshi, Principal Scientist & Head, Division of Germplasm Collection and Characterization, ICAR-NBAIR, Bengaluru, India for authentic identification of specimens.

References

Akintola, A. J. And Ande, A. T. 2009. Pest status and ecology offive mealy bugs (Family: Pseudococcidae) in the southern Guinea Savanna of Nigeria.

Journal of Entomological Research, 33 (1): 9-13.

Anonymous, 2018. https://en.wikipedia.org/wiki/Monophlebidae.

Anonymous, 2013.http://www.nbair.res.in/Agriculturally important insects/*Icerya aegyptiaca*

Ben-Dov, Y., Miller, D. R. and Gibson, G. A. P. 2009. ScaleNet: a database of the scale insects of the world http://www.sel.barc.usda.gov/scalenet/scalenet.htm.

Beshr, S. M 2015. Scanning Electron Microscopy of *Icerya aegyptiaca* (Douglas, 1890) (Hemiptera: Monophlebidae). Alexandria Science Exchange Journal, **36** (4): 365-372.

Crop Protection Compendium on Internet (CPCI), accessed in 2005. Wallingford, UK CAB International.

El-Sobky, H. F. 2020. Ecological studies on two mealybug species (Hemiptera) and their predator on navel orange trees at Qalubiya Governorate, Egypt. Egyptian Journal of Plant Protection Research Institute, **3** (4): 1067-1074.

Sasidharan, K. R. 2004. Studies on the insect pests of *Casuarina equestifolia* L. in Tamil Nadu and their management. Ph. D. thesis, F.R.I. Deemed University, Dehradun.

Warrier, K. C. S., Singh, B. G. and Kumar, N. K. 2014. Twenty-Five Years of Research on Casuarinas at IFGBT. Institute of Forest Genetics and Tree Breeding Coimbatore, Tamil Nadu, 144p.

MS Received 26 September 2022

MS Accepted 20 November 2022

DOI 10.55278/UATH8565

Investigation on the impact of Invasive Alien Species upon local fauna

Mohammad Danish Masroor[1*], Zakkia Masrror[2], & Siddhnath Prasad Yadav "Deen"[3]
1 P. G. Department of Zoology, Magadh University, Bodhgaya, Bihar 824234, India.
2 DR. B. R. Ambedkar College of education, Matiyani, Bodhgaya, Bihar 824234, India.
3 P. G. Department of Zoology, Magadh University, Bodhgaya, Bihar 824234, India.
Corresponding author: mohammaddanishmasroor@gmail.com

Key words: Invasive Alien Species, Magadh, species diversity, native species.

Invasive Alien Species (IAS) refers to species introduced and successfully established outside their native range by overcoming or outcompeting pre-existing native species. For the last centuries, the number of invasive alien species belonging to multiple taxonomic groups has increased. The intensification of transport and global trade has been particularly driven the trend of biological invasions (Hulme, 2009). Besides being a result of globalization, biological invasion is also considered a major factor of global biodiversity change (IPBES, 2019). These species can have negative impact on agriculture, forestry, plants, animals and cause irreparable harm to local or global economics and the ecosystems in which they invade. The worldwide estimated damage by invasive species is more than $1.4 trillion, about 5% of the global economy (Pimentel *et. al.* 2001). In India about $ 91 billion per year economic damage is estimated due to invasion of invasive species to forestry and agricultural commodities (The wire, 2016). The changing climate, increasing trade due to globalization has aggravated the introduction of new insect pest species as well as their range expansion in the introduced areas. In recent years, scientists have documented multiple species shifting their range be it at local or at global level due to either climate change or due to adaptation to new climatic regime. In recent draft of the post-2020 global biodiversity framework convention on biological diversity also fixed the target to manage the introduction pathway of invasive alien species and or reducing the rate to introduction and establishment of invasive alien species (CBD/WG2020/REC/2/1). An average cost to control weeds and invasive insects is about 35% of the agricultural budget. Which includes labor costs and insecticide treatment. The continuous introduction and establishment of IAS is harmful for soil health also. Till now in India, there are no existing policies to address the emerging issue of IAS while there is a big gap in assessment of impacts emerging due to establishment and introduction of IAS on biodiversity, economy and agricultural commodities is remain unsolved. Thus, a detailed informative data about invasive alien Species dynamics is of great significance for science and local fauna of Bihar.

Figure 1. *Spodoptera frugiperda* caterpillar infesting on tassel tube of maize

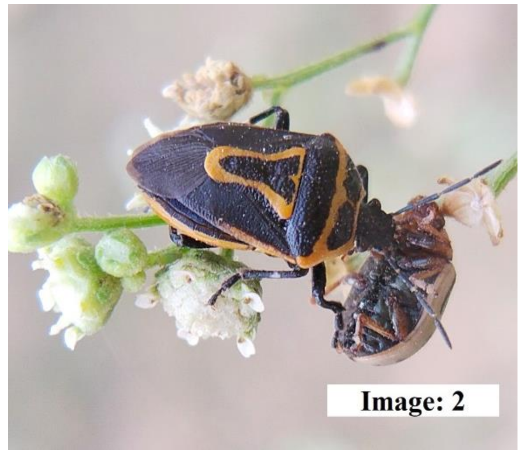


Figure 2. *Perillus bioculatus* adult feeding on *Zygogramma* ***bicolorata***

Figure 3. *Bagrada hilaris* adults and nymphs sucking the sap of sunflower.

Thereby, documenting, listing, locating, identifying, eradicating and preventing them before they become widespread and problematic for endemic species and biodiversity is need of the hour. The Invasive species pests has been recorded infesting over 80 different types of agricultural crops which has high potential and also showing competition with native species of local fauna. It also has an impact on the yield and thus the economy of local farmer.

This the known fact that, the fundamental role of introduction of new IAS in new environmental fauna happen due to accidental transportation or human-mediated deliberation (Russo, 2016). Complex introduction and different biotic network for newly introduced species and their new hosts in new environmental fauna pose multiple competition with native species and the current and future establishment or invasion of that introduced IAS is mandatory to predict and manage.

In some cases, intercontinental spread of species happened in very short time and the range expansion is ongoing in introduced area, where the invasion was most recent (not clear, may explain, which species and in which regions) (Bila Dubail *et. al.*, 2021). The successful establishment and invasion of some IAS species may be correlated with their social traits and have potential to rapid spread, high population, well established dispersal and in general horrifying competitors (Russo *et. al.*, 2021). Invasive alien species are a primary threat to specific as well as global level and resulting great loss of productivity and species extinction due to serious invasion. In some cases, flood driven introduction of alien species from illegal aquaculture also reported in recent years. Most of the IAS which introduced or established their population in India are due to ornamental use of species and thereafter by releasing or escaping in new non-native habitat.

According to CBD 40% of floral species in India are alien, of which 25% are invasive. A total of 37 species including tree, plant, shrubs, insects, bird, fish and mollusc having status of major invasive alien species and about 28 species native to India have been reported to be invasive in other geographical zones around the globe. (can discuss about insects) Among all the reported invasive alien species *Lissachatina fulica, Spodoptera frugiperda, Citripestis eutraphera, Perillus bioculatus Parthenium hysterophorus, Lantana camara* and some others possess multiple impact on the major crops and endemic species of Bihar (reference and quantification of the data). In the view of seriousness, we consider it as a priority and started to investigate the actual impact and distribution range of IAS in Magadh division (may mention the results of the investigation).

In order to prevent them in distribution range expansion and management as well as nature of impact according to ecological relation on major crops, need to be investigated. The government bodies along with NGO's and scientist working on the similar issue should be on a single platform and the gap among them need to filled. There is an urgent need to understand the pathways of introduction along with the factors triggering introduction and establishment of IAS in Bihar as well as India.

References

Bila Dubaić, J., Lanner, J., 2021. *Megachile sculpturalis* (Hymenoptera: Megachilidae): a valuable study organism for invasive pollinators and the role of beekeepers in ongoing monitoring programs. Bee world in rev.

Convention on Biological Diversity (2021): First draft of the post-2020 global biodiversity framework, (CBD/WG2020/REC/2/1).

Hulme, P. E. (2009): Trade, transport and trouble: Managing invasive species pathways in an era of globalization. Journal of Applied Ecology, 46(1), 10–18. https://doi.org/10.1111/j.1365-2664.2008.01600.x

IPBES (2019): Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science- Policy Platform on Biodiversity and Ecosystem Services. S. Díaz, J., Settele, E.S. Brondizio, H.T. Ngo, M. Guèze, J. Agard, & C. N. Zayas (Eds.). Bonn, Germany: IPBES Secretariat. https://doi.org/10.5281/zenodo.3553579

India Knows Its Invasive Species Problem but This Is Why nobody can deal with it properly (2016). https://thewire.in/environment/invasive-species-prosopis-lantana

Pimentel, D., McNair, S., Janecka, J., Wightman, J., Simmonds, C., O'Connell, C., Wong, E., Russel, L., Zern, J., Aquino, T. and Tsomondo, T. (2001): Economic and environmental threats of alien plant, animal and microbe invasions. Agriculture, Ecosystem and Environment. 84: 1-20.

Russo, L., 2016. Positive and negative impacts of non-native bee species around the world. Insects 7, 69. https://doi.org/10.3390/insects7040069

Russo, L., de Keyzer, C.W., Harmon-Threatt, A.N., LeCroy, K.A., MacIvor, J.S., 2021. The managed-to-invasive species continuum in social and solitary bees and impacts on native bee conservation. Current Opinion in Insect Science S221457452100002X. https://doi.org/10.1016/j.cois.2021.01.001

MS Received 10 October 2022
MS Accepted 16 December 2022

DOI 10.55278/KUEU7638

Apivectoring: Managed pollinators as vectors of biocontrol agents for diseases and pests

Priyanka Rani*[1], R K Thakur[2], P L Sharma[3], Meena Thakur[4], Sawraj Jit Singh[1], Diksha Devi[1], and Babita Kaushal[1]

[1,2,4]*Department of Entomology, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, H.P.(173230), India*

[3]*College of Horticulture and Forestry, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Thunag, Mandi, H.P. (175048), India*

Corresponding author:priyankabhargava019@gmail.com

Abstract

Insect pollinators are indispensable in global agriculture for their valuable pollination services. In managed pollination honey bees, bumble bees, stingless bees and megachilid bees of genus *Osmia* are most commonly introduced in fields /orchards at the blooming period of the crop in open as well as in protected cultivation for pollination services. Apivectoring/ entomovectoring, is the use of pollinating insects for the precision delivery of microbial control agents (MCA) that kill target pests. It uses an innovative method of control in which the inoculation of bees with biocontrol agents is dispersed by insects in this process and allows managing populations of pathogens and pests, mainly flowers and fruits. As pollinator leave hive, it exits through a specialized dispenser containing the MCA, coating it with a fine powder. When it alights on a flower, some of this biocontrol agent is left behind. As it flies through the field, the powder is also deposited on the leaves, such that it returns to the colony “clean” and can unload its gathered pollen and nectar. The left over MCA on flowers, leaves may go to work immediately against insects and pathogens, or it may colonize the flower and act as a prophylactic for the developing fruit and later dissemination. This technology represents a sustainable alternative for the preventive management of pests and diseases and implemented in crops such as apple (storage rot disease), blueberries (mummification, grey mould), coffee (coffee berry borer), pear (fire blight), raspberry, tomato (grey mould), sweet pepper (plant bug, western flower thrips), strawberry (grey mould), rapeseed (plant bug) and sunflower (*Sclerotinia* rot). The ultimate success will depend upon a number of interacting factors, including dispenser design for proper MCA distribution, selection of the most efficient bee species in a production system, transport and delivery of the MCA, and the safety of bio control agent for the environment and humans (Smagghe *et al.*, 2012). So, apivectoring provides dual benefits of crop pollination and crop protection by reducing pest pressure and pesticide applications, improves pollination which subsequently results in higher yields and better crop quality.

Keywords: Insect pollinators, dispenser, bio-control agents, pollination,

Introduction

The importance of pollinators, both managed and wild pollinators, cannot be overestimated. The reliance of global food production on animal pollination has increased in recent decades (Lautenbach *et al.*, 2012). More than 80% of flowering plants rely on animal pollination for sexual reproduction (Kearns et al., 1998; Klein *et al.*, 2007). Infestation by pests and diseases can seriously affect agriculture. For example, grey mold can damage fruit crops such as strawberries and raspberries. The fungus that causes mummification can destroy blueberry crops if left unchecked. Tomatoes and peppers in greenhouses can also be infested with clouded beetles (TPB), western flower thrips (WFT), whiteflies, and peach aphids. These pests and diseases can destroy crops and have a significant economic impact on farmers. Farmers often rely on cumbersome and costly spraying of insecticides and fungicides to control pests and diseases. Although effective in the short term, the potential adverse effects of chemical pesticides and fungicides on pollinators and natural enemies in agroecosystems resulting in the decline of their population. The ecological viability of farming is often highly questionable, regarding the health of consumers and farm workers. For bee-pollinated crops such as apples, strawberries, tomatoes, raspberries, canola, and sunflowers, etc. the use of vectors as biocontrol agents is a sustainable alternative to control the diseases and pests such as apple core rot, blight gray mold, sunflower borer, western thrips, aphids, and coffee bean borer etc. (Al-mazra's awi *et al.*, 2006; Kevan *et al.*2008). This method of using pollinators to precisely deliver biological control agents to kill target pests is known as apivector, entomovector, or bee vector technology. The ultimate success lies in donor design for appropriate MCA distribution, selection of the most efficient bee species in the production system, transport and delivery of MCA,environmental and human safety of biocontrol agents, and much more interacting factors (Smagghe *et al.* a., 2012). Apivectoring therefore provides the dual benefits of crop pollination and crop protection, reducing pest pressure and pesticide use and improving pollination. This increases yield and improves crop quality.

The Importance of Pollinators

As the population grows rapidly, so does our need for food. To cope with the future, our agricultural systems need to produce more food sustainably. Pollinators are key to these systems. Both wild and controlled pollinators provide essential pollination services, either natural or provided by humans.

Several global statistics show the magnitude of the contribution of pollinators to agriculture and food security:

- Of the world's 115 major crops for human consumption, i.e. about 35% of the crops are dependent on pollination (Beenow, 2018)

The total amount of food we eat is measured by the amount produced worldwide and is partly dependent on pollination done by animals (Brittain *et al.* , 2013)

- An estimated 5-8% of global crop production with an annual market value of $235-577 billion (Camillo, 2003) is directly attributable to animal pollination.

Animal pollination increases the quantity and quality of many crops, increasing their value to farmers. Pollinator-plant relationships range from generalists (plants with many different pollinators (such as bees) visiting or having many pollinators) to highly specialized one-to-one relationships (specialists relationship). These relationships are not fixed. Plant species may be visited by different pollinators in different regions, and relationships may change throughout the year due to changes in pollinator densities. And for the millions of people around the world who depend on pollinators for their livelihoods, it matters. Given the importance of pollinators in the agricultural sector, there is a need to increase knowledge about which crops require which pollinators and to identify the best techniques and methods to protect and enhance both wild and managed species in our ecosystem.

Background

Pollination by bees and other animals greatly improves crop yield and quality. Bees also transfer biological control agents to control crop pests and diseases, using entomovector technology Entomovector technology is an environmental friendly control strategy for economically important plant pathogens and pests, using pollinators to deliver powdered formulations of crop protection products to the flowers and foliage of crops. Bee vectoring is a technique that uses controlled pollinating bees to disperse beneficial microbial agents into flowering plants to control pests and suppress plant diseases (Peng et al. 1992; Kevan et al. 2008). Hokkanen and Menzler-Hokkanen (2007) and Hokkanen et al. (2015) used the term as 'entometeor technology' to describe the use of controlled pollinators as applicators of biological control agents against crop pests. Apivectoring technology combines knowledge developed over thousands of years and sustainable alternatives for the active management of plant pests and diseases, and multi-tropical relationships among pollinators, plants and pathogens. It uses an innovative control method: bees are inoculated with a biocontroller that is distributed by the insect when it peaks. This mechanism makes it possible to control the population of pathogens and pests, especially attacking flowers and fruits. This technology is used in crops such as strawberries, raspberries, pears, apples, sunflowers, oilseed rape and tomatoes. Increasing production challenges have led to technological advances and innovations that have enabled better crop production in many countries around the world (Plan, 2016). However, such technology needs to be validated in different regions for easy adoption. Biovector technology is one of the remarkable new technologies transforming agriculture from a labor-intensive to a capital-intensive industry (Mommaerts and Smagghe, 2011). This technology uses insects as vectors for biological control agents. The aim of this technique is to minimize the use of synthetic pesticides and pest resistance while maximizing crop quality and yield. Entomovector technology achievements are mainly realized in some developed countries. This technique is especially useful for many pollination-dependent crops. Farm bees, honeybees, and bumblebees are used to transfer fungal, bacterial, and viral inoculum from hives to flowers (Kevan *et al.*, 2003).

Can pollinators deliver a dual benefit combining pollination and protection of crops?

It is nothing new, given that it involves the spread of biopesticides (pollen) in most flowering plants. This idea, combined with the knowledge that some important plant diseases (such as gray mold, rot, and mummies) are also transmitted by pollinators, has led to research into the potential dual benefits of combining crop pollination as well as crop protection. In 1992, John Sutton's lab, the work led by Peng Gang, in collaboration with Kevan group, initiated project B52 to extract honey bees (*Apis mellifera*) from *Clonostachys roseum* to strawberry flowers (*Fragaria x ananassa*) to control gray mould. They used it as a vector (bomber) for control of mold (*Botrytis cinerea*) (Peng et al., 1992). Commercial formulations of *Trichoderma harzianum*, another botrytis antagonist, are available for pollinating honeybees in Italy (Maccagnani et al., 1999) and honeybees and bumblebees in the United States (Kovach *et al.*, 2000). The conclusion from this study is that *T. harzianum* bee delivery is also a viable option for strawberry growers interested in controlling botrytis with minimal use of fungicides. Around the same time as the B52 project, research was focused in the western United States by Sherman Thomson's team in Utah (Thomson *et al*., 1992) and Kenneth Johnson's team in Oregon (Johnson *et al.*, 1993). They provide the bacterium *Pseudomonas fluorescens* as an antagonist for the fungus *Erwinia amylovora* in core cultures. This research has also met with some success and continues at a moderate pace in Washington (Pusey, 2002).

The story behind the development of the concept that pollinators can be used as carriers and propagators of microbial biological agents is as follows:

Honey bees as a vector for *Clonöstachys roseum* to the flowers of strawberries (*Clonystachis roseum*) inhibits gray mold (*Botrytis cinerea*). Yu and Sutton used bumblebees and honeybees to bombard strawberry flowers with *C. roseum* (Yu and Sutton, 1997). A commercial preparation of *Trichoderma harzianum*, another *Botrytis* antagonist, is available in Italy (Maccagnani *et al.*, 1999). The same commercial formulation of the botrytis antagonist *Trichoderma harzianum* was applied to strawberries by honeybees and bumblebees in the United States (Kovach *et al*., 2000). Honeybees were used to transmit *Heliothis* nuclear polyhedrosis virus (NPHV) to control the red clover (*Trifolium incarnatum*) from *Helicoverpa zea*, the maize earwig (Lepidoptera: Noctuidae). Bees are effective vectors of Bt (*Bacillus thuringiensis* var. *kurstaki*) can be used on sunflower blossoms (*Helianthus annuus*) for control (equivalent to hand spraying) of sunflower moths (*Cochylis hospes* (Lepidoptera: Tortricidae)). with increased pollination and seed formation. (North Dakota study by J.L. Jyoti and Garry Brewer (1999). The B52 technique was initiated in response to a cloudy plant bug (TPB) (*Lygus lineolaris*) outbreak in Canola in Alberta in 1998.

Are pollinators efficient in delivering biocontrol agent?

This approach is possible due to the interaction between crops, pests (weeds, diseases, or herbivores), pollinators (vectors), biological control agents, powder products, donors, and environmental safety and human health (Kevan *et al.* 2008). Vectors are bee species that have a high rate of flower visitation and the ability to deposit a microbial control agent (MCA) on target plants. MCA selection depends on the target crop pest or disease and should be safe for bees and the environment. In general, commercial MCA powder formulations are often used in the BAT approach (Mommaerts and Smagghe, 2011). MCA powder formulations are often mixed or diluted with a carrier to reduce concentration and maximize contact between the MCA and the body of the bee (Kevan *et al.* 2008; Al-Mazra'awi *et al.* 2006). A designed dispenser placed in front of the hive allows contact between the bees and the MCA. So, as the bees pass through the repellent in the dispenser at the entrance to the hive, they introduce an inoculum of microbial agents (fungi, bacteria and viruses) into their body and hair. The bees then visit the flowers to collect nectar and pollen, self-pollinate the leaves of the plants, and deposit the inoculum on the flowers and leaves of the target crop (Kevan *et al.*2008). Some studies have reported success with vector bee technology (Carreck *et al.* 2007; Mommaerts *et al.* 2010). According to Hokkanen *et al.* (2015) control of strawberry gray mould caused by *B. cinerea* using the biocontrol fungus *Gliocladium catenulatum*, transmitted by honeybees or bumblebees, was conducted for strawberry cultivation in five countries. The results showed that under high disease pressure, vectorization of honeybees reduced disease incidence by an average of 47%. This is similar to multiple fungicide sprays. However, at moderate disease pressure, biocontrol reduced gray mold by an average of 66% and was more effective than fungicide sprays. It was then effective against many crop pests and diseases (Kovach *et al.*, 2000; Maccagnani *et al.*, 2005; Shafir *et al.*, 2006). Management of bumblebees to deliver biological control agents has been studied for over two decades (Peng *et al.* 1992; Yu and

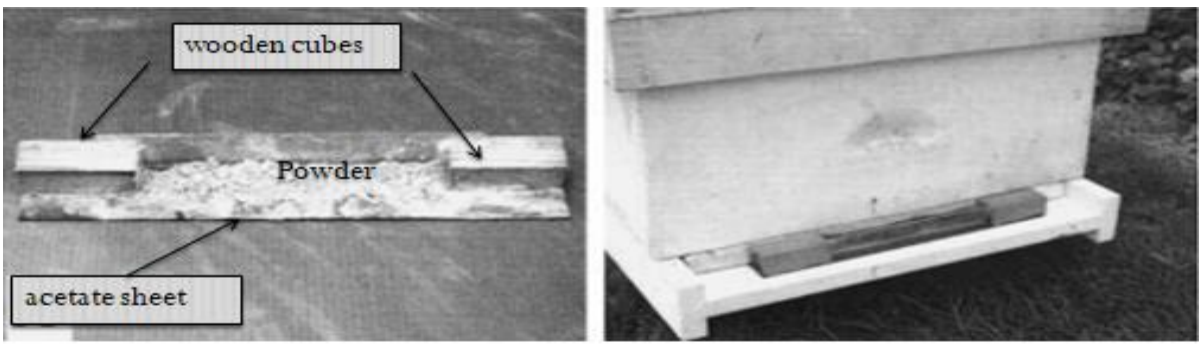
Sutton 1997). However, most studies have been conducted primarily in laboratory or greenhouse conditions (Kevan *et al.* 2003; Mommaerts *et al.* 2011). The reason of using honeybees as vectors for biocontrol agents (BCAs) is due to their morphological and behavioral characteristics. Bumblebees have a relatively large body surface area covered with split ends that aid in the capture and transport of pollen grains (Free and Williams 1972; Batra *et al.* 1973). The commercial availability of bumblebee colonies has led to increased use of *Bombus terrestris* L. in Europe and the common eastern bumble bee *B. impatiens* Cresson (Hymenoptera: Apidae) in North America, not only in greenhouses (Mommaerts *et al*. 2011) (Kovach *et al.* 2000; Dedej *et al.* 2004; Carise *et al.* 2016). Results from the BICOPOLL project shows that bumblebees successfully infuse the biofungicide Prestop-Mix formulation of *Gliocladium catenulatum* strain J1446 as active organism, Verdera OY, Finland) under field conditions. Prestop Mix is a safe biological product for both humans and beneficial organisms visiting the field (Verdera, 2015). The distribution of bumblebees on the field was uniform over a distance of 100 m.

Dispensers for entomovectoring

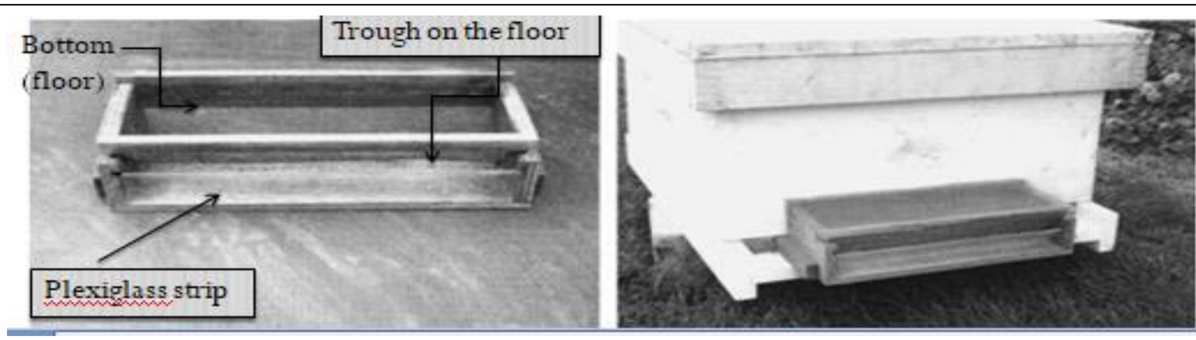
An important step in transferring additional pollen and/or biological control organisms (BCO) to pollinators is efficient loading of the vector with microbial agent to ensure adequate loading so that it can be delivered to target site in appropriate amount. A suitable dispenser must be designed to achieve this goal. The main purpose of the dispenser is to fill the carrier (bees) with powdered product (pollen and/or formulated BCO product) on its way out of the hive and distribute it to the target crop. Efficient dispensers should not only optimize vector loading, but should also have short dispenser, refill intervals, be easily attached to hives, and should not affect vector foraging behavior (Mommaerts and Smaghe, 2011). Dispensers previously used in entomovector studies can be divided into two groups: single-use and double-use dispensers (Smagghe *et al.* 2012). In single-use dispensers, the chamber in which the vector exits the dispenser is the same or not completely separate from the chamber in which the vector enters the dispenser. The vector therefore passes through the powder both when exiting and entering the hive. In a two-way dispenser, the outlet and inlet chambers are completely separated, and only the vector leaving the nest is in contact with the powder. For bees, disposable dispensers such as Harwood dispensers and Tub dispensers were originally used to fill bees with pollen to achieve cross-pollination.

Harwood Container: A Harwood container consists of a wooden box with an inner roof that curves down to the ground. The bees have to crawl through the gap that exists between the bottom of the box and the roof, crawl over the powder placed in the floor trough, and climb over the perspex strip to exit the dispenser.

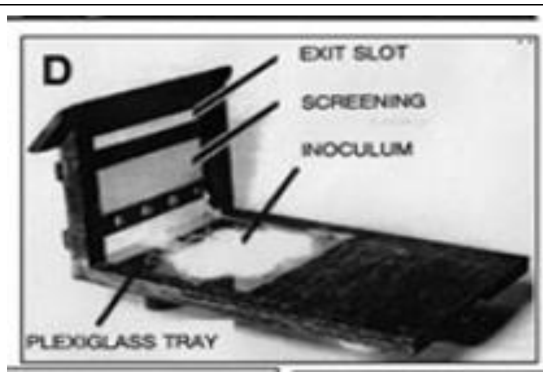
Tub Tray: This tub tray consists of two wooden cubes that hold flexible acetate sheets to form tubs that can be filled with powder. Such donors used for biological control resulted in poor management of the honeybees used in the study. Bill *et al*. (2004) confirmed that this is mainly due to the bees opening up the powder ducts, concentrating bee activity there, resulting in less contact with the powder and less exposure. This phenomenon has also been previously observed in pollen eaters (Legge 1976). The performance of disposable dispensers is relatively low, so we need better dispensers. Various types of dispensers suitable for honeybee experiments include the Peng dispenser (Peng et al. 1992), the Gross dispenser (Gross et al. 1994), the Triwaks dispenser (Bilu et al. 2004), and the Houledispenser (Albano et al. 2009).



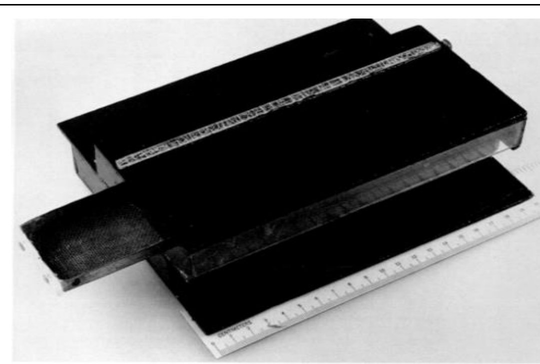
Harwood Dispenser



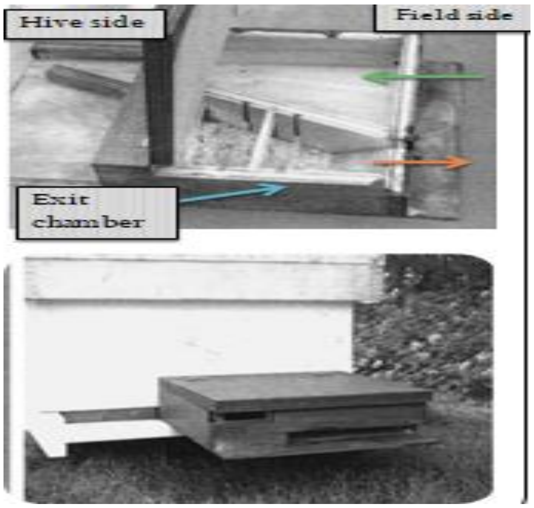
Tub Dispenser



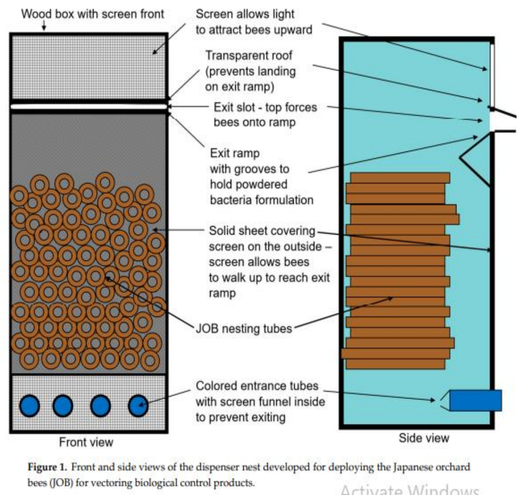
Peng Dispenser



Gross Dispenser



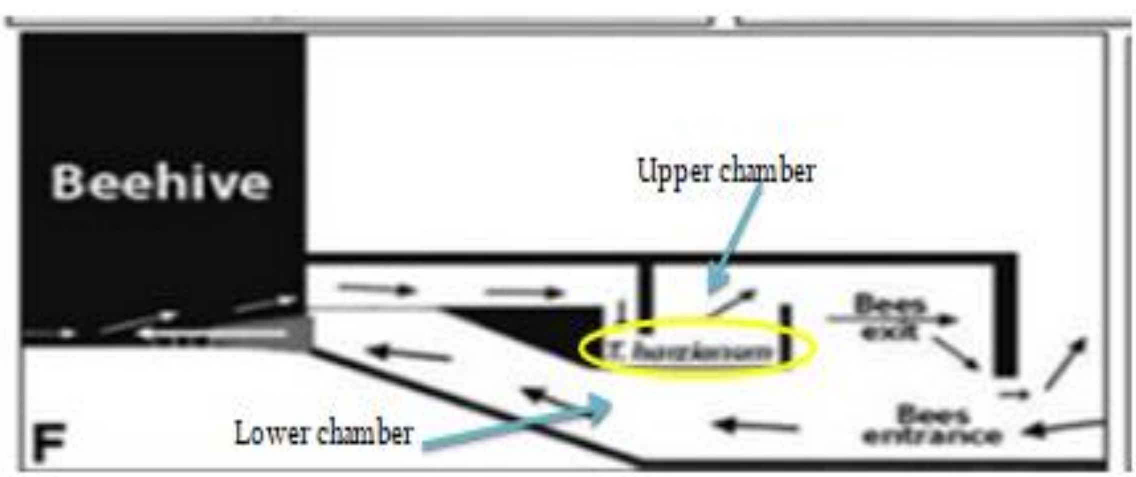
Triwaks Dispenser



Osmia dispenser

Flying doctors

Bee Treat



Houle dispenser

Figure 1 Different types of dispensers

Peng box: The Peng box consists of a wooden platform with a plexiglass tub containing powder that can be placed on the floor of the hive. Plexiglass panels are mounted vertically on the platform, and light coming in from outside the hive lures the bees through the powder and up the panel toward an exit slot a few inches above the wooden platform. Returning bees enter the hive through a slot under the wooden platform to avoid walking through the dust as they enter the hive.

Gross magazine: Designed to fit in the front center of a modified beehive floorboard, the Gross Magazine features a removable magazine that can be inserted from the side to load powder into the magazine.The hatched bees pass through the tub on their way back to the hive on their own.

Triwaks dispenser: The Triwaks consist of a wooden box with an extended bottom that fits in the opening of a standard Langstroth hive. The dispenser is divided diagonally into two triangular compartments, one entering the hive and one exiting the hive. The exit chamber is divided into three sub-chambers containing powder formulations. It has the longest side in the hive and ends with the shortest side forming the outlet part of the dispenser that attracts the hatched bees thanks to the light coming from the outside. Returning foragers find a large landing platform that forms the longest side of the receiving box and terminates on the shortest side of the hive, ensuring that the bees enter the hive through the powder-free portion of the dispenser.

Houle Dispenser: The Houle Dispenser can be mounted on a hive and is divided horizontally into an upper compartment with a powder container and a lower compartment without powder. Abandoned bees leave the hive through the upper compartment, but returning bees avoid the dust and enter the hive through the lower compartment. There are many new types of dispensers on the market, including: B. Cartridge Applicator and Beet Treats for bees, Flying Doctor for bumblebees.

Pollinator safety

The biological pest control agents used in Apivectors are considered safe and are registered. Microbial control agent registrations are usually specific to the target culture and method of application. Even entomopathogenic pathogens have been shown to be safe unless in very high concentrations such as commercial powder or liquid formulations (Al-mazra'awi, 2004). *B*eauveria *bassiana* was formulated from 2 x 10^{11} conidia/g product to 6 x 10^{10} to minimize bee mortality and maximize pest mortality. Bees that passed through cornmeal acquired more conidia (e.g., 1.5×10^{6} CFU (colony forming units) per bee) than if bees passed wheat flour, durum wheat semolina, corn flour, potato starch, potato flakes, oat flour, barley flour.

Conclusions

Apivectoring techniques is an interdisciplinary approach to pest management that integrates diverse ecosystem components such as pollinators, microbial agents and pests into one crop production system. It offers the dual benefits of crop pollination and crop protection as it reduces pest pressure and pesticide use and improves pollination. The development of pollination vector technologies to control insect and fungal pests reduces pest populations and pesticide use while improving crop pollination. Benefits from new pesticides that reduce risk, use less chemicals, and improve crop pollination, leading to higher yields and better crop quality.

Future Prospects

Apivectoring offers the advantage of increasing yields by producing higher quality and quantity of plants through a combined pollination and biocontrol agent service. This technology has been tested in field and greenhouse production. Other benefits include reduced need for biocontrol agents compared to spraying, lower fuel consumption and less heavy equipment use, lowering costs for farmers, and a continuous supply of crop protection products during flowering. Benefits include reduced water and synthetic pesticide usage. Making populations resistant to insecticides makes apivectoring technology economically viable. Apivector registrations have begun in several countries thanks to intensive studies by researchers who have shown the technology to be safe for vectors, the environment and human consumption. Government contributions and support are required to implement apivectoring technology and its many benefits. There are many ways to expand research in apivectoring. Testing this technology on new crops such as gourds, almonds, apples, peaches and cherries is essential. Apivector research has also expanded to include solitary stingless bees and the use of donors to treat colonies internally against disease and parasites. More information, can be obtained from the International Organization for Biological Control (IOBC) and the International Commission on Plant Pollinator Relations (ICPPR).

References

Albano S, Chagnon M, De Oliveira D, Houle E, Thibodeau P, Mexia A. 2009. Effectiveness of Apis mellifera and Bombus impatiens as dispensers of the Rootshield® biofungicide (Trichoderma harzianum, strain T-22) in a strawberry crop. *Hell Plant Prot J* 2:57–66.

Al-mazra'awi M S, Shipp J L, Broadbent A B, Kevan P G. 2006. Biological control of *Lygus lineolaris* (Hemiptera: Miridae) and *Frankiniella occidentalis* (Thysanoptera: Thripidae) by *Bombus impatiens* (Hymenoptera: Apidae) vectored *Beauveria bassiana* in greenhouse sweet pepper. *Biological Control* 37: 89-97.

Batra L R, Batba S W T andBohart G E. 1973. The mycoflora of domesticated and wild bees (Apoidea). *Mycopathol Mycol Appl* 49:13–44.

Bilu A, Dag A, Elad Y, Shafir S. 2004. Honey bee dispersal of biocontrol agents: an evaluation of dispensing devices. *Biocontrol Sci Tech* 14:607–617.

Carreck N L, Butt T M, Clark S J, Ibrahim L, Isger E A, Pell J K, Williams I H. 2007). Honey bees can disseminate a microbial control agent to more than one inflorescence pest of oilseed rape. *Biocontrol Science and Technology* 17(2):179-191.

Dean R, Van J A L, Pretorius Z A, Hammond K K E, Di P A, Spanu P D, Foster G D. 2012. The Top 10 fungal pathogens in molecular plant pathology. *Molecular Plant Pathology* 13(4): 414–430.

Dedej S, Delaplane K S, Scherm H. 2004. Effectiveness of honey bees in delivering the biocontrol agent Bacillus subtilis to blueberry flowers to suppress mummy berry disease. *Biological Control* 31:422–427.

Espinosa S S, Andrés S A, Kevan P G and Figueroa J R. 2018. Tecnología Apivector: origen, componentes y desarrollo. *CienciAgro*. 2018(1): 42 - 57.

Free J B, Williams I H. 1972. Hoarding by honey bees (Apis mellifera L.). *Animal Behaviour* 20: 327–334.

Gross H R, Hamm J J, Carpenter J E. 1994. Desing and application of a hive-mounted device that uses honey-bees (Hymenoptera, Apidae) to disseminate Heliothis nuclear Polyhedrosis virus. *Environtal Entomolology* 23:492–501.

Hokkanen H, Menzler-H I, Lahdenperä M-L. 2015. Managing bees for delivering biological control agents and improved pollination in berry and fruit cultivation. *Sustainable Agricultural Research* 4: 89-102.

Hokkanen H M, Menzler-H L, Lahdenpera M L. 2015. Managing Bees for Delivering Biological Control Agents and Improved Pollination in Berry and Fruit Cultivation. *Sustainable Agriculture Research* 4(3):89.

IOBC Enkegaard, A (Editor). 2005. Integrated Control in Protected Crops, Temperate Climate. *IOBC wprs Bulletin*. 28 (1).

Johnson K B, Stockwell V O, Burgett D M, Sugar D and Loper J E. 1993. Dispersal of Erwinia amylovora and Pseudomonas fluorescens by honey bees from hives to apple and pear blossoms. *Phytopathology* 83, 478–484.

Jyoti J and Brewer G J. 1999. Honey Bees (Hymenoptera: Apidae) as Vectors of Bacillus thuringiensis for Control of Banded Sunflower Moth (Lepidoptera: Tortricidae). *Biological Control* 28(6): 1172-1176.

Karise R, Dreyersdorff G, Jahani M, Veromann E, Runno-Paurson E, Kaart T, Smagghe G, Mänd M. 2016. Reliability of the entomovector technology using Prestop-Mix an and Bombus terrestris L. as a fungal disease biocontrol method in open field. *Sci Rep* 6:31650.

Kevan P G, Kapongo J P, Al- Al-mazra'awi M S and Shipp J L. 2008. Honey bees, bumble bees and biocontrol. Bee Pollination in Agricultural Ecosystems. Oxford University Press, 65-79 pp.

Kevan P G, Al-Mazra'awi M S, Sutton J C, Tam L, Boland G, Broadbent B, Thompson SV, Brewer GJ. 2003. Using pollinators to deliver biological control agents against crop pests. In: Downer RA, Mueninghoff JC, Volgas GC (eds) Pesticide formulations and delivery systems: meeting the challenges of the current crop protection industry. *American Society Testing and Materials*, W Conshohocken, pp 148–153

Kevan P G. and Menzel R. 2012.The plight of pollination and the interface of neurobiology, ecology and food security. *The Environmentalist* 32(3):300-310.

Kovach J, Petzoldt R, Harman G E. 2000. Use of honey bees and bumble bees to disseminate Trichoderma harzianum 1295-22 to strawberries for Botrytis control. *Biological Control* 18(3):235-242.

Legge A. 1976. Hive inserts and pollen dispensers for tree fruits. *Bee World* 57:159–167.

Maccagnani B, Mocioni M, Ladurner E, Gullino M L, Maini S. 2005. Investigation of hivemounted devices for the dissemination of microbiological preparations by Bombus terrestris. *Bull Insectol* 58:3–8.

Maccagnani B, Mocioni M, Gullino M L and Ladurner E. 1999. Application of Trichoderma hartzianum by using Apis mellifera for the control of grey mould of strawberry: first results. *IOBC/WPRS Bulletin* 22: 161–164.

Mommaerts V, Jans K and Smagghe G. 2010. Impact of Bacillus thuringiensis strains on survival, reproduction and foraging behaviour in bumblebees (Bombus terrestris). *Pest Management Science* https://doi.org/10.1002/ps.1902

Mommaerts V, Put K and Smagghe G. 2011. Bombus terrestris as pollinator-and-vector to suppress Botrytis cinerea in greenhouse strawberry. *Pest Management Science* 67:1069–1075.

Mommaerts V, Smagghe G. 2011. Entomovectoring in plant protection. *Arthropod-Plant Interactions* 5(2):81-95.

Peng G, Sutton J C, Kevan P G.1992. Effectivenes of honey bees for applying the biocontrol agent Gliocladiu roseum to strawberry flowers to suppress Botrytis cinerea. Can J Plant Pathol Revue Can *Phytopathol* 14:117–129.

Plan S. 2016. Agriculture and Food Authority (AFA) 2016 - 2021 Strategic Plan Contents.

Pusey P L. 2002. Biological control agents for fire blight of apple compared under conditions limiting natural dispersal. *Plant Disease* 86: 639-644.

Shafir S, Dag A, Bilu A, Abu T M, Elad Y. 2006. Honey bee dispersal of the biocontrol agent Trichoderma harzianum T39: Effectiveness in suppressing Botrytis cinerea on strawberry under field conditions. *European Journal of Plant Pathology* 116(2):119- 128.

Smagghe G, Mommaerts V, Hokkanen H, Menzler-H I. 2012. Multitrophic interactions: The entomovector technology. In G Smagghe and I Diaz (eds), Arthropod-Plant Interactions: Novel Insights and Approaches for IPM, Progress in *Biological Control* 14: 127- 157pp.

Smagghe G, Boecking O, Maccagnani B, Mänd M and Kevan P G. (Editors). 2020. Entomovectoring for precision biocontrol and enhanced pollination of crops: exploiting synergy of ecosystem services. Springer Verlag, Switzerland.

Thomson S V, Hansen D R. Flint K M and Vandenberg J D. 1992. Dissemination of bacteria antagonistic to Erwinia amylovora by honeybees. *Plant Disease* 76: 1052–1056.

Verdera: Safety Data. Available at: http://verdera.fi/en/products/horticulture/prestop-mix/safetydata/. Accessed 7 Dec 2021.

Yu H and Sutton J. 1997. Effectiveness of bumble bees and honey bees for delivering inoculum of *Gliocladium roseum* to raspberry flowers to control Botrytis cinerea. *Biological Control* 10:113–122.

MS Received 03 November 2022
MS Accepted 20 December 2022

DOI 10.55278/IRRD5123

Insect fauna of soybean at different growing seasons: A comparative study

Rohit Pattar[1*] and Subhash B. Kandakoor[2]
[1]*Department of Agricultural Entomology, University of Agricultural Sciences, Dharwad-580005, Karnataka, India*
[2]*Agricultural Research Station, Bailhongal-591102, UAS, Dharwad, Karnataka, India*
Corresponding author: rohitppattar5@gmail.com

Abstract

Present investigation was a field experiment to document the insect pests of soybean at different growth stages during *rabi*-summer season of 2020-21 and comparing them with the *Kharif* season pests in order to know the incidence pattern. Among sucking pests, leaf hoppers and thrips were causing considerable damage while whiteflies and aphids considered as minor during *rabi* and summer. Leaf miner and leaf folder were considered as major defoliators during *rabi*-summer which are replaced by *Spodoptera litura* and Bihar hairy caterpillar in *Kharif.* Among the pod borers *Etiella zinckenella* and *Cydia ptychora* were major and caused considerable damage during summer and *Kharif*, respectively. Stem fly was absent during early *rabi* while it was present in late *rabi*, *Kharif* and summer. The insect pest incidence spectrum varied in different growing seasons of soybean crop in this region.

Keywords: Insect pests, soybean.

Introduction

Soybean (*Glycine max* (L.) Merrill) is an important oilseed crop in the whole world due to its multiple uses as it contributes about 25% global edible oil and 2/3rd of world's protein concentrate for livestock feeding, poultry, fish feed and soybean meal as human diet supplements for protein (Alexander, 1974). Global soybean production of 336.11 million tonnes in an area of 121.69 million hectares was remarked during 2019-20 (Anon., 2019a). In India, Madhya Pradesh, Maharashtra and Rajasthan are leading states with 92-93 per cent contribution in both area and production. In Karnataka, Belgaum, Dharwad, Bidar, Bagalkot and Haveri districts are the major contributors. The soybean production was influenced by different biotic and abiotic factors. Among many biotic factors insect pests and diseases play an important role because of the luxurious growth of plant, succulent shoots and soft tender foliage. The crop is known to harbor by more than 380 species of insect pests in the world and with 10-12 species in India initially (1970's) and then it has increased to 270 pests, besides mites, millipedes, vertebrates and snail (Singh, 1999).

So, over time the incidence of different insect pests and number of insect pests attacking soybean have increased. As soybean is majorly a *Kharif* crop many studies were undertaken in this particular season while, *rabi* and summer season crops are also a very important factor of soybean production in north Karnataka region in particular Belagavi region as the farmers growsoybean during *rabi*-summer for seed production to avoid losses from shattering. Hence, this study is very helpful for the farmers to understand the occurrence of insect pests in different growth stages of soybean crop.

Material and methods

Present study was conducted in Agricultural Research Station, ARS, Bailhongal, Karnataka. A field experiment which was carried out during *rabi*-summer season of 2020-21. Bailhongal is a taluk place in Belagavi district, Karnataka with an altitude of 699.31 meter above MSL with the annual rainfall of 370-630 mm annually. The variety JS-335 was sown (5 rows of 10 m^2 with spacing 30×10 cm) on different dates from November to January with fortnight intervals. November and December sown crops were considered as *rabi* crop while, January sown crops were considered summer crop. Observations on incidence of insect pests at different growth stages were recorded in both *rabi* and summer crops. The observations were compared with other similar studies from the past. The conclusions on the occurrence and persistence of insect pests of soybean during *rabi*- summer was drawn.

Results and Discussions

The occurrence of soybean pests was recorded during *rabi* and summer season. The results of present investigation are explained in Table 1. The occurrence of sucking pests started from two weeks after sowing and they remained throughout crop period. Among them, leaf hoppers and thrips were causing considerable damage while whiteflies and aphids considered as minor pests. The results were in line with Krishna (2021) who recorded similar results in summer season at Dharwad. Spiraling whitefly was also recorded on soybean during *rabi*-summer season in Belagavi region of Karnataka (Fig. 1). Leaf miner and leaf folder were considered as major defoliators during *rabi*-summer while the semiloopers were absent (Fig. 2). During *kharif*, *Spodoptera litura* and Bihar hairy caterpillar were considered as major defoliators (Anon., 2021 & Swati, 2018). Stem fly incidence was observed in later sown crops while it was absent in early sown crop. Among different pod borers *Etiella zinckenella* is the only recorded. While, others are absent during the study period. Similarly, in *Kharif* season *Cydia ptychora* was considered as major pod borer on soybean (Madhurima, 2015 & Anon., 2021). Some other pests were also recorded such as hairy caterpillars, pod sucking bug, pumpkin beetle *etc*. Due to the insufficient

Table 1. Occurrence of soybean insect pests during different growing seasons.

Sl. No.	Insect pests	Order/ Family	Occurrence of insect pests		
			***Rabi* season (Nov. & Dec. sown crops)**	**Summer season (Jan. sown crops)**	**Other/Previous studies (Dharwad & Belagavi region)**
Sucking pests					
01	Aphids *Aphis glycines*	Hemiptera/ Aphididae	First week after sowing till 4 weeks (Nov. sown crops) & absent in Dec. sown crops.	Absent	-
02	Whiteflies *Bemisia tabaci*	Hemiptera/ Aleyrodidae	Two weeks after sowing till maturation (70 DAS) (48^{th} MSW–8^{th} MSW).	Two weeks after sowing till maturation (2^{nd} MSW-12^{th} MSW)	Two weeks after sowing till maturation (2^{nd} MSW- 14^{th} MSW) at Dharwad during summer (Krishna, 2021).
03	Leafhoppers *Empoasca sp.*	Hemiptera/ Cicadellidae	Three weeks after sowing till maturation (50^{th} MSW–10^{th} MSW). Peak population of 10.50 hoppers/top 3 leaves.	Three weeks after sowing till maturation (3^{th} MSW–15^{th} MSW). Peak population of 10.33 hoppers/top 3 leaves.	Two weeks after sowing till maturation (3^{rd} MSW- 12^{th} MSW) at Dharwad during summer (Krishna, 2021).
04	Thrips	Thysanoptera/ Thripidae	Three weeks after sowing till maturation (50^{th} MSW–8^{th} MSW). Peak population of 10.34 thrips/top 3 leaves.	Three weeks after sowing till maturation (4^{th} MSW–12^{th} MSW). Peak population of 10.80 thrips/top 3 leaves.	Two weeks after sowing till maturation (3^{rd} MSW- 11^{th} MSW) at Dharwad during summer (Krishna, 2021).
Defoliators					
05	Leaf miner *Aproaerema modicella*	Lepidoptera/ Gelechiidae	Three weeks after sowing (WAS) till 10 WAS (49^{th} MSW–7^{th} MSW). Peak population of 14.30 larvae/MRL.	3 WAS till 8 WAS (4^{th} MSW–11^{th} MSW). Peak population of 14.30 12.56 larvae/MRL.	-

Sl. No.	Insect pests	Order/ Family	Occurrence of insect pests		
			Rabi season (Nov. & Dec. sown crops)	Summer season (Jan. sown crops)	Other/Previous studies (Dharwad & Belagavi region)
06	Leaf folder *Omoides indicata*	Lepidoptera/ Crambidae	4 WAS till maturation (51st MSW- 10TH MSW). Peak population of 15.10 larvae/MRL.	3 WAS till 8 WAS (4th MSW–12th MSW). Peak population of 12.65 larvae/MRL.	Five weeks after sowing till maturation (32nd MSW- 39th MSW) during *Kharif* at Dharwad with 22.35% infestation (Anon., 2019b).
07	Tobacco caterpillar *Spodoptera litura*	Lepidoptera/ Noctuidae	40 DAS till maturation (53rd MSW- 10th MSW). Peak population of 3.68 larvae/MRL.	45 DAS till 70 DAS (8th MSW- 14th MSW). Peak population of 3.80 larvae/MRL.	i. 31st MSW to 39th MSW during *Kharif* at Dharwad (Anon., 2021). ii. 30 DAS to 75 DAS during *Kharif* at Dharwad (Swati, 2018).
08	Bihar hairy caterpillar *Spilosoma obliqua*	Lepidoptera/ Erebidae	Absent	Absent	i. 33rd MSW to 40th MSW during *Kharif* at Dharwad (Anon., 2021). ii. 50 DAS to 75 DAS during *Kharif* at Dharwad (Swati, 2018).
09	Semiloopers *Thysanoplusia orichalcea*	Lepidoptera/ Noctuidae	Absent	Absent	i. 32nd MSW to 38th MSW during *Kharif* at Dharwad (Anon., 2021). ii. 30 DAS to 60 DAS during *Kharif* at Dharwad (Swati, 2018).
Pod Borers					
10	*Cydia ptychora*	Lepidoptera/ Tortricidae	Absent	Absent	i. 33rd MSW to 42nd MSW with 36% pod damage (Madhurima, 2015) ii. 37th MSW to 42nd MSW with 52.34% pod damage (Anon., 2021).

Sl. No.	Insect pests	Order/ Family	Occurrence of insect pests		
			***Rabi* season (Nov. & Dec. sown crops)**	**Summer season (Jan. sown crops)**	**Other/Previous studies (Dharwad & Belagavi region)**
10	*Etiella zinckenella*	Lepidoptera/ Pyralidae	60 DAS and lasts till harvesting (2nd MSW- 11th MSW)	60 DAS and lasts till harvesting (9th MSW- 15th MSW). up to 44.67 % pod damage.	-
11	*Helicoverpa armigera*	Lepidoptera/ Noctuidae	Absent	Absent	33rd MSW to 40th MSW during *Kharif* at Dharwad (Anon., 2022).
Other insect pests					
12	Pod sucking bug *Nezara viridula*	Hemiptera/ Pentatomidae	Minor pest present during pod development stage	Minor pest present during pod development stage	34th MSW to 40th MSW during *Kharif* at Dharwad (Anon., 2022).
13	Stem fly *Melanagromyza sojae*	Diptera/ Agromyzidae	Absent in Nov. sown crops & Less incidence in Dec. sown crops (up to 14.26% seedling mortality).	2 WAS and continued up to 30 days (up to 29.15% seedling mortality).	30th MSW to 36th MSW during *Kharif* at Dharwad (up to 3.94% stem tunneling) (Anon., 2021).
14	Girdle beetle *Obereopsis brevis*	Coleoptera/ Cerambicidae	Absent	Absent	32nd MSW to 40th MSW during *Kharif* at Dharwad (up to 6.57% infestation) (Anon., 2021).
Minor pests observed during the study period					
Pumpkin beetle, Spiralling whitefly, *Eurybrachus tomentosa*, *Creotiades dilutus*, Hairy caterpillars.					

* MSW- Meteorological standard week, WAS- Weeks after sowing, DAS- Days after sowing

Figure 1. Spiralling whitefly on soybean (Image by: Rohit Pattar)

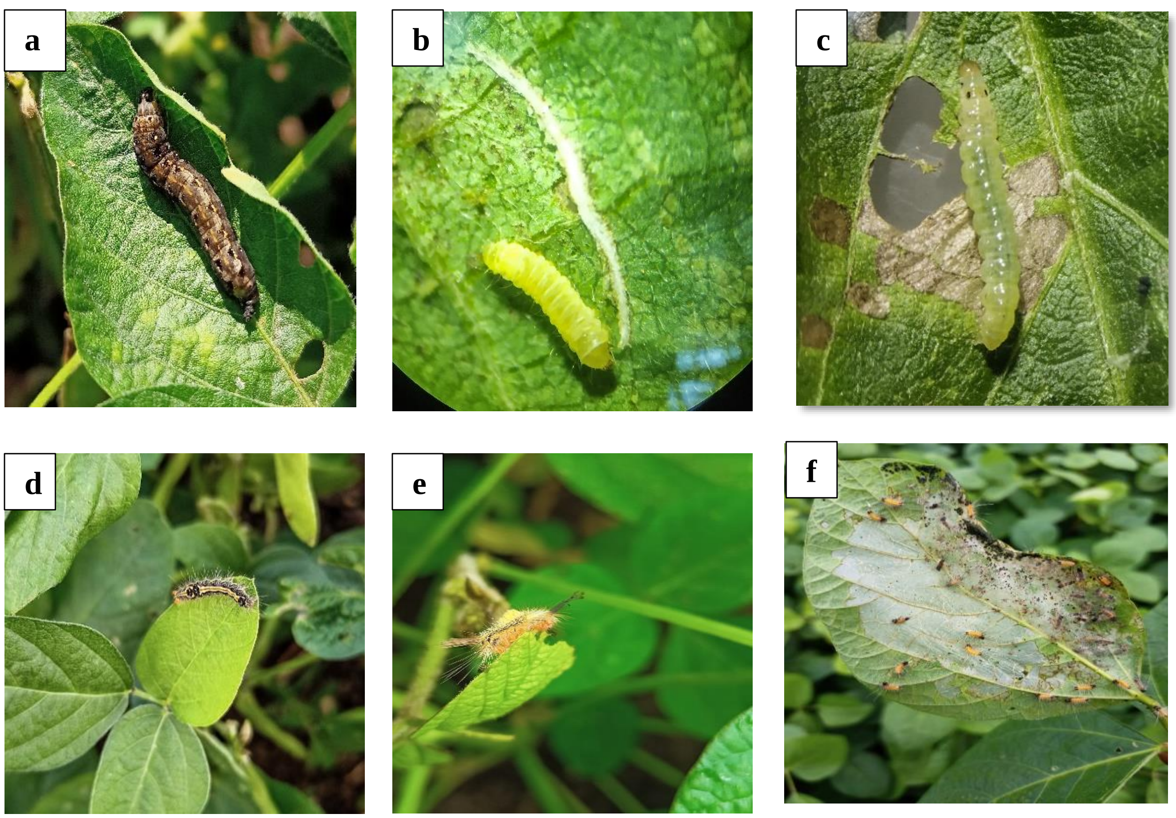


Figure 2. Defoliator pests of Soybean. a. *Spodoptera litura*, b. *Aproaerema modicella*, c. *Omoides indicata*, d. *Somena* sp., e. Hairy caterpillar, f. *Spilosoma obliqua*. (Image by: Rohit Pattar).

literature on incidence of soybean pests during *rabi*-summer, *Kharif* season literature were taken to compare the results (Table 1).

Conclusions

During rabi-summer season the incidence of soybean pests varied from the traditional *Kharif* season. This study was helpful for the farmers of this region to know the pest spectrum and to manage them effectively on time to reduce the losses.

Acknowledgements

Author expresses heartfelt gratitude to Dr. Shankara Murthy M. Assistant Professor, College of Agriculture, Bheemarayanagudi for identifying the major Pyralidae pests of soybean.

References

Alexander, M. V. 1974. Soybean production in Virginia experimentation division. *Virginia Polytechnic institute and State University*, pp. 44.

Anonymous, 2019a. ICAR- Indian Institute of Soybean Research, Soybean area, production and productivity, *Annual Report 2019-20*, pp. 7.

Anonymous, 2019b. All India Co-ordinated Research Project on Soybean: Principal investigators report. 2018-19, pp. 113.

Anonymous, 2021. All India Co-ordinated Research Project on Soybean: Principal investigator's report. 51st *All India soybean research workers meet*, *March 12-13, 2021*, pp. 200.

Anonymous, 2022. All India Co-ordinated Research Project on Soybean: Principal investigator's report. 52nd *Annual group meet on AICRP on Soybean*, *May 17-18, 2022*, pp. 196.

Krishna, V. R. 2021. Studies on sucking insect pests and their management in soybean during summer. *M. Sc. (Agri.) Thesis*, Univ. Agric. Sci., Dharwad, Karnataka (India).

Madhurima, V. 2015. Studies on pod borers and their management on soybean with special reference to *cydia ptychora* (Meyrick). *M. Sc. (Agri.) Thesis*, Univ. Agric. Sci., Dharwad, Karnataka (India).

Singh, O. P. 1999. Perspective and prospects of insect pest control in India with reference to sustainable environment in India in: *Proceedings of world soybean conference-VI*, *Aug.4-7, 1999*, Chicago, Illionois, U.S.A., pp. 638-640.

Swathi, V. K. 2018. Screening of genotypes and management of defoliators in soybean. *M. Sc. (Agri.) thesis*, univ. agric. Sci. Dharwad.

MS Received 12 October 2022

MS Accepted 05 December 2022

DOI 10.55278/IHRD8411

Plumeria alba* an alternate host for mass multiplication of papaya mealybug parasitoid, *Acerophagus papayae

S. Sheeba Joyce Roseleen[1] and K. Kumanan[2]
Tamil Nadu Agricultural University
[1]Sugarcane Research Station, Sirugamani, Tiruchirappalli - 639 11
[2] Agricultural College and Research Institute, Kudimiyanmalai, Pudukkottai 62 2104
Corresponding author: sheeba@tnau.ac.in

Abstract

The papaya mealybug, *Paracoccusmarginatus* Williams and Granara de Willink (Hemiptera: Pseudococcidae) is native to Mexico and Central America. *Acerophagus papaya* is distributed for control of papaya mealybug in India. The mass multiplication requires potato tubers and regulated environment for the multiplication of papaya mealybug and was unsuccessful due to high temperature at Trichy, Tamil Nadu. Hence a study was under taken to find the feasibility of rearing of *A. papaya* on *Plumeria.*

Key words: Papaya mealybug, *Plumeria* sp., *Acerophagus papayae,* arasitization

Introduction

The papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Pseudococcidae) is native to Mexico and Central America. Between 2008 and 2009 it was detected variously in South India, Indonesia, Malaysia, Sri Lanka and Thailand (Muniappan *et al.*, 2008). Mealybugs are generally difficult to control chemically due to their thick waxy secretion covering the body, and their ability to hide in the damaged buds and leaves without being exposed to the insecticide. Hence, biological control agents like parasitoids and predators are preferred for the control of papaya mealybug.

The identified natural enemies are solitary and parasitic wasps that belong to the family Encyrtidae in the order Hymenoptera collected in Mexico as potential biological control agents. They are *Acerophagus papayae*, *Anagyrus loecki*, *Anagyrus californicus* and *Pseudoleptomastix mexicana*. *Acerophagus papayae, Anagyrus loecki and Pseudoleptomastix mexicana* are three parasitoid species that are currently used in the biological control of papaya mealybug. Of these *Acerophagus papayae* was found to be more efficient and is under commercial distribution for control of papaya mealybug in India. The mass multiplication of *A. papayae* was done by rearing the papaya mealybug in potato sprouts followed by parasitizing by *A. papayae.*

The mass multiplication requires potato tubers and regulated environment for the multiplication of papaya mealybug and was unsuccessful due to high temperature. Hence a study was undertaken to find the feasibility of rearing *A. papayae* in plumeria.

Materials and Method

The economically important host range of the papaya mealybug includes papaya, hibiscus, acalypha, plumeria, avocado, citrus, cotton, tomato, eggplant, pepper, beans and peas, sweet potato, mango, cherry, mulberry and pomegranate (Chellappan *et al*., 2013)

The plumeria plant was taken for the study since it is hardy, the leaves have numerous lateral veins which aids in easy development of mealybug, needs zero maintenance, easily infested by papaya mealybug. It can withstand heavy population of papaya mealy bug and can recover after a heavy infestation and thus acts as a natural mass multiplication centre for the parasitoid *Acerophagus papayae*.

The study was conducted at the Department of Plant Protection, ADAC & RI, NavalurKuttapattu, Tiruchirappalli, Tamil Nadu (10.755655°N 78.606448°E) Twenty five plants of plumeria were raised in cement pots and were used for the study. The mealybugs were collected from natural and infested host. The effect of plumeria on the biology parameters like the number of instars, development period of each instar, sex ratio and fecundity of *Paracoccus marginatus* was recorded.

Biology of *Paracoccus marginatus*

The development biology of *Paracoccus marginatus* was studied in a 5-cm long terminal shoot and one tender leaf was selected as a replicate. In plumeria, each terminal shoot was hydrated using a ball of cotton tied to the cut end of the shoot, and moistened daily with distilled water.

Egg sac collected from a single female was placed on the leaves of host with 10 eggs per leaf using a paintbrush. Eggs were collected within 24 h of oviposition. Dishes were checked daily for egg hatch and shed exuviae. The number of days for the egg to hatch, emergence and survival of each instar, and number of emerging adult males and females were recorded. The developmental time and the survival of eggs and first instars were not separated by gender. The gender of each individual mealybug was determined during the later part of the second instar when males change their color from yellow to pink. At this point, the developmental time of males and females were counted separately. For each plant, 35 Petri dishes (replicates) with 10 eggs were used. This experiment was repeated twice.

Freshly emerged virgin females obtained from the developmental study were used to assess reproduction. Virgin females were placed individually in Petri dishes with either a leaf or a terminal shoot prepared as mentioned above. Females were held alone to assess asexual reproduction or were provided with three newly emerged males from the same host plant for sexual reproduction. The date of oviposition, the number of eggs laid, and adult mortality were recorded. For each of the two treatments (indoor and outdoor) 10 females were used, and each female was considered a replicate. This experiment was repeated twice using newly emerged males and females collected from developmental time experiments.

The parasitization potential of *A. papayae* was assessed. Twenty *A. papayae* were released per plant infested with mealybugs and covered with a mylar film cage. One week after releasing the parasitoids in the above said experiment, the sample leaves were taken from each plant. They were transferred to plastic containers of 10 cm diameter covered with a muslin cloth. The containers were checked daily for parasitoid emergence. From this data, the development period and the duration of different life stages of *A. papayae* on mealybugs reared on plumeria was worked out. Two months after releasing the parasitoids, the parasitism rate was observed in second and third instar, and adult female mealybugs separately.

The parasitism rate was calculated using the formula:

$$\text{Parasitization rate of } A.\, papayae = \frac{\text{Number of parasitized mealybugs}}{\text{Total number of mealybugs offered}} \times 100$$

Results and Discussions

Developmental period of papaya mealy bug on plumeria

The developmental period of papaya mealybug was studied by tying a polythene cover over one of the leaves where the other instars are brushed away and the eggs alone remain. The instars were counted using the remaining exuviae which is removed after counting. The egg period was 7.2 days, while 1st, 2nd, 3rd, and 4th instar were 5.3, 3, 5.2 and 3.9 days respectively. The total duration of male and female were 23.4 days and 33 days respectively. The fecundity was observed to be 370.4 eggs per female and is in agreement with Tanwar *et al.* (2010), and Kaushalya *et al.*, (2008).

Table 1. Developmental period (in days) of papaya mealybug *Paracoccus marginatus* on *Plumeria alba*

Egg period	I Instar	II Instar	III Instar	IV Instar	Male longevity	Female longevity	Male (Total Duration)	Female (Total Duration)	Fecundity
7.2± 0.33	5.3± 0.2	3± 0.15	5.2± 0.25	3.9± 0.1	15± 0.54	20.4± 0.50	23.4± 0.4	33± 0.44	370.4± 2.76

Table 2. Developmental period (in days) of *Acerophagus papayae* and parasitic potential of *A. papayae* on *P. marginatus* in plumeria

Egg period	First Instar	Second instar	Pupa	Total life cycle	Parasitic potential of *A. papayae* on *P. marginatus* mean parasitization rate (%) *		
					2nd instar PMB	3rd instar PMB	Adult PMB
8+ 0.12	3.2+ 0.25	2.5+ 0.15	3.7+ 0.12	12.2+ 0.25	86+1.34	46.8+0.81	18.4+0.49

Parasitic potential of *A. papayae* on *P. marginatus* reared on plumeria

The results revealed that the parasitization of mealybug was noticed during the 2nd, 3rd and adult stages. The highest parasitisation of 81.2 percent was recorded in the second instar. The mean per cent parasitization in the third instar was comparatively lesser 42. 4 percent and the adult parasitization was 14.8 percent which is in accordance with Meyerdirk *et al.* (2004) and Muniappan *et al*. (2006), who reported that the second instar was the preferred stage for parasitization and the parasitisization reduces in 3rd, 4th instars and the adults.

<table>
<tr><td></td><td>
</td></tr>
<tr><td>Paracoccus marginatus on plumeria plant</td><td>Mealybug developing on the ventral side of the leaves</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Crawlers emerging from ovisac</td><td>Exit hole of parasitoid on parasitized mealybug</td></tr>
</table>

References

Muniappan, R., Shepard, B.M., Watson, G.W., Carner, G.R., Sartiami, D., Rauf, A. and Hami M.D., 2008. First report of the papaya mealybug, *Paracoccus marginatus* (Hemiptera: Pseudococcidae), in Indonesia and India. *Journal of Agricultural and Urban Entomology*. *25*(1):37-40.

Kaushalya, G., Amarasekare Catharine, M. and Mannion, E.N., 2008. Host instar susceptibility and selection and interspecific competition of three introduced parasitoids of the mealybug *Paracoccus marginatus* (Hemiptera: Pseudococcidae). *Env Entomol*, 39:1506-1512.

Meyerdirk, D.E., Muniappan, R., Warkentin, R., Bamba, J. and Reddy, G.V.P.2004. Biological control of the papaya mealybug, *Paracoccus marginatus* (Hemiptera: Pseudococcidae) in Guam. *Plant Protection Quarterly*,*19*, pp.110-114.

Muniappan, R., Meyerdirk, D.E., Sengebau, F.M., Berringer, D. D. and Reddy, G.V.P., 2006 Classical biological control of the papaya mealybug *Paracoccus marginatus* (Hemiptera: Pseudococcidae) in the Republic of Palau. *Florida Entomologist*, *89* (2): 212-217.

Tanwar, R.K., Jeyakumar, P. and Vennila, S., 2010. Papaya mealybug and its management strategies (p. 26). New Delhi: National Centre for Integrated Pest Management.

Chellappan, M., Lawrence, L., Indhu, P. Cherian, T., Anitha, S and Maria, J. 2013. Host range and distribution pattern of papaya mealy bug, *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Pseudococcidae) on selected Euphorbiaceae hosts in Kerala. *Journal of tropical Agriculture*. 51(1): 51-59.

MS Received 10 October 2022

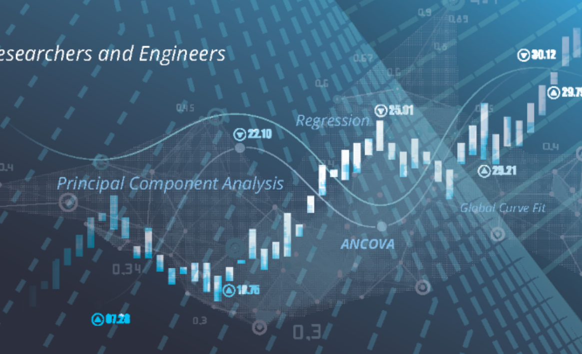
MS Accepted 30 November 2022

SIGMAPLOT
Exact Graphs and Data Analysis

SigmaPlot® 15

Designed Specifically to Meet the Needs of Scientists, Professional Researchers and Engineers

SigmaPlot® is an easy-to-use scientific graphing & statistical data analysis software package for researchers, scientists and engineers who need to create precise, publication-quality graphs that best communicates their research results for presentations, technical publications, and the web. Along with advanced curve fitting, a vector-based programming language, macro capability and over 50 frequently used statistical tests, SigmaPlot also provides more than 100 different 2D & 3D graph types from which one can choose a full range of graphing options such as technical axis scales, multiple axes, multiple intersecting 3-D graphs and much more. SigmaPlot now has SigmaStat included with it which is a perfect tool to visualize and understand basic and advanced statistics.



SigmaPlot offers:

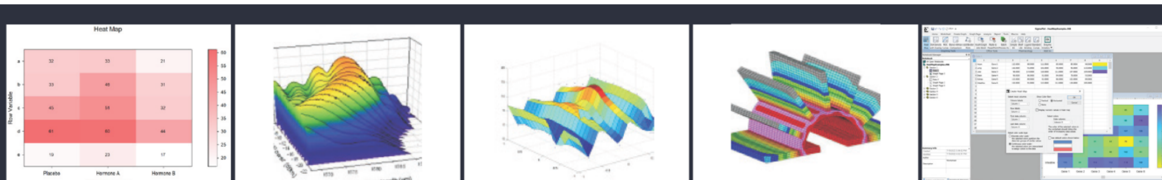
- Complete Advisory Statistical Analysis
- Award-Winning Technical Graphing Capability
- Powerful and Easy-to-use Data Analysis
- Ability to Customize every Element of Graph
- Precise Publication-Quality Graphs
- Ability to Publish your Work Anywhere

Latest updates:

- Includes a New Heat Map Macro
- Removes all dependencies on old redistributable by removing Lead Tools and uses Windows Graphics Device Interface + (GDI+) for graph export
- Uses the latest Sentinel License Manager which is compatible with the latest Microsoft Server 2022
- Uses a hosted licensing service for smooth license activation and validation
- Has a new and refreshed ribbon manager that enhances the already commendable user experience in SigmaPlot

Sigmaplot® 15 - key features offered for Biotech and Pharma industry:

- Plasma Protein Binding
- Pharmacokinetics
- Clinical Trials
- Antibiotic Determination
- Calculate reciprocal of Serum
- Repeated-dose Toxicity Studies
- Exploratory Enzyme Inhibition Analysis
  - ROC Curves Analysis
  - Standard Curves Analysis
  - Using Global Curve Fitting to Determine Dose Response Parallelism
- SigmaPlot Compliance: FDA Title 21 CFR Part 11
  - SigmaPlot Software Validation
  - Password protection of data and macros
  - Displaying Password Protected Data
  - Time-stamped Audit Trail Capability
- 21 CFR Part 11 is the United States Food and Drug Administration's (FDA) requirement for electronic record keeping.



For more Information / Demo on SigmaPlot
Email Us at saves.indiasales@inpixon.com | Call Us at +91 99002 04608

North America & South America
Inpixon USA
2479 E. Bayshore Rd, Suite 195.
Palo Alto, CA 94303
United States
saves.sales@inpixon.com

Germany, Austria, & Eastern Europe
Inpixon GmBH
Königsallee 92a
40212 Düsseldorf
Germany
saveskontakt@inpixon.com

UK & Western Europe
Inpixon UK Ltd
268 Bath Road
Slough, SLI 4DX
UK
saves.sales@inpixon.com

Asia, Middle East & North Africa
Inpixon India
Plot #56, Mythri Nagar,
Madinaguda, Hyderabad 500049,
India
saves.apac.sales@inpixon.com
saves.indiasales@inpixon.com

Review articles & Short notes

DOI 10.55278/OSKA7787

Report of *Spodoptera litura* Fabricius on lotus (*Nelumbo nucifera* Gaertn.) and water lilly *(Nymphaea nouchali* Burm. f.*)* in Kerala

Karthika S, Malini Nilamudeen and Sheena A
Department of Agricultural Entomology, RARS (South Zone)
College of Agriculture, Vellayani, Kerala Agricultural University 695522, Kerala, India
Corresponding author: malini.n@kau.in

Lotus (*Nelumbo nucifera*) and water lily (*Nymphaea nouchali*) are perennial aquatic basal eudicots belonging to the family Nelumbonaceae and Nymphaeaceae, respectively. They prefer shallow, murky water in a warm climate. The stems, leaf stalks and roots are submerged while the leaves and fragrant flowers remain above the surface of water. Lotus is the sacred flower of India. It occupies a special position in the art and mythology of ancient India. Both are important horticultural plants, with their uses ranging from ornamental, nutritional to medicinal values, especially in Southeast Asia.

Lotus and water lilies of Instructional farm, College of Agriculture, Vellayani (8.5°N latitude, 76.9ºE longitude and 29 m above MSL) were found damaged severely by a caterpillar. Their foliages were scraped and eaten away (Fig.1). Caterpillar bored into flower buds and fed from within. The buds were seen with bored holes (Fig.2). Upon careful inspection, the pest was identified as tobacco cutworm, *Spodoptera litura* Fabricius (Lepidoptera: Noctuidae). It is one of the most important insect pests of agricultural crops and is also found to feed on ornamentals such as rose, jasmine, dahlia, etc., (Ahmad *et al.*, 2013). The eggs were found laid on the upper surface of leaves in clusters, covered with the tuft of abdominal hairs of the moth. Early instar larvae were light green in colour and were found damaging the leaves by scrapping the leaf surfaces. Older instars were dark brown or black in colour with a bright yellow stripe along the dorsal surface. They fed voraciously defoliating the entire leaf (Fig. 3). The flowers were also found damaged by the caterpillars (Fig. 4). Several larval stages were found feeding inside the emerging buds and on foliage of the lotus and water lilies grown in the farm. The adult moth (Fig.5) is nocturnal in habit. The body is grey-brown in colour. *Spodoptera litura* feeding on lotus and water lily is now being reported from nurseries across Kerala.

Figure 1: Larva scraping the leaves

Figure 2: Boring symptom in bud

Figure 3: Extensive damage in leaves

Figure 4: Larva damaging water lily

Figure 5: Adult

References

Ahmad, M., Ghaffar, A. and Muhammad, A. 2013. Host plants of leafworm, *Spodoptera litura* (Fabricius) (Lepidoptera: Noctuidae) in Pakistan. *Asian J. Agri. Biol*. 1(1): 23-28.

MS Received 15 October 2022

MS Accepted 20 December 2022

DOI:10.55278/PDIO6656

Unveiling the mutualistic associations between ants (Hymenoptera) and Lepidoptera in the ecosystems

Mithra Mohan* and J. Nayanathara[1]
Department of Agricultural Entomology, College of Agriculture, Vellayani- 695 522, Kerala Agricultural University
Corresponding author: *mithramohan56@gmail.com

Ants, 'the little things that run the world' are one of the most successful hymenopteran social insects belonging to the family Formicidae with more than 28,413 species under 514 genera in 23 subfamilies, which invaded most of the geographic regions peaking in the tropics and subtropics (Antweb, 2022). The abundance of this ubiquitous, small creatures with colossal ecological roles are estimated as $20x10^5$ individuals on earth with a biomass of 12 mega tones of dry carbon (Schultheiss *et al.*, 2022). The successful evolution of ants mainly depend on the myriad of interactions exhibited in between species and with other species in the ecosystem. These associations may be mutualistic, competitive or parasitic in nature and a clear understanding of these interactions still remain a challenge to the scientific community.

Ants were evolved during the Cretaceous period, about 140 Mya whereas the first report of ant- arthropod association give proof from 80 Mya. The association between ants and honeydew-producing insects were considered to have major ecological and economic significance and most of these interactions were mutualistic in nature (Helms, 2013). The insect orders *viz.*, Hemiptera and Lepidoptera were documented as the major groups exhibiting mutualistic association with ants. About 17 families of Lepidoptera entered into associations with ants, of which the family Lycaenidae entered into mutualistic associations with more than 53 genera of ants worldwide. About 3841 species of Lycaneidae and 308 species of Riodinidae were associated with ants (Pierce *et al.*, 2002; Pierce and Dankowicz, 2022).

The ant-caterpillar associations may be obligate or facultative. Obligate ant associates are unable to complete their life cycle in the absence of ants whereas facultative ant associates are only sometimes found in association with ants. The lepidopteran caterpillars provide honeydew secretion to ants and in return ants offer protection to the larva from predators. The mutualistic associations between Lepidoptera and ants are mediated mainly through chemical and acoustic signalling.

Chemical signalling

The chemical signalling is performed with the help of specialized organs in the larva of lycaneids *viz.,* dorsal nectary organs, pore cupola organs, and tentacle organs. The most important organs determining the ant-Lepidoptera association is dorsal nectary organ on the seventh abdominal segment of the caterpillar that produces nutritious secretions for ants. This specialized exocrine gland is considered similar to the honeydew gland of hemipterans. These secretions were rich in carbohydrates (13–19%), serine (20-40 mM) and trace amounts of methionine (Pierce *et al.,* 2002; Daniels *et al.,* 2005). The quality and quantity of these secretions determine the persistence of attendant ants in tending the caterpillar.

The pore cupola organs are single celled epidermal glands, distributed over the body of caterpillar that appease the aggressive ants to prevent them from attacking the soft bodied caterpillar by secreting an amino acid based chemical substance (Daniels *et al.,* 2005).

The lycaneid larvae also possess an eversible pair of tentacle organs on the eighth abdominal segment, innervated by a small bipolar sensory cell that secrete a volatile compound functioning as a signal to ants when a caterpillar is being attacked. This gland secretions mimic ant alarm pheromones and communicate the distress situation to the attendant ants (Gnatzy *et al.,* 2017).

Acoustic Signalling

The acoustic signalling in Lepidoptera is mainly concerned with mating traits and defensive behaviour. However, in case of lycaenid caterpillar, sound production play a critical role in interceding the association with ants. The acoustic organ in caterpillars located at the inter-segmental region of segments 4–5, 5–6, or 6–7 working through file-and-scraper mechanism. Besides, a vibratory papillae on the distal edge of the prothorax with concentric grooves is also noticed in some Riodininae larva. The caterpillar oscillates the body parts to create low amplitude calls that travels through the substrate and receiving these substrate borne vibrations may elicit an investigative response in ants.

In addition to these mechanisms, the larva associated facultatively with the ants possesses a thicker cuticle than that of obligate ant associates as an additional defense mechanism (Dupont, 2012).

Examples of ant- Lepidoptera interactions

Several examples of ant-lepidopteran association mediated through chemical and acoustic signalling are observed in the ecosystem. The association with *Aricoris propitia* (Lepidoptera: Riodinidae) and fire ants (*Solenopsis saevissima)* are arbitrated through both type of signalling and all larval stages are tended by ants. The fourth instar stage of this caterpillar exhibited a peculiar behaviour as it devour the host plant during night and rest during the day time inside an underground shelter constructed and guarded by ants (Kaminski and Filho, 2012).

The chemical secretions of lycaenid only act as nutritive rewards but also as manipulative drugs that modify the behaviour of ants. The secretions from dorsal nectary organ of *Arhapala japonica* larva alter the locomotory activities of their tending ants, *Pristomyrmex punctatus* workers. The attending ants fed on these secretions recorded with a lower level of dopamine level in the brain that may result in the manipulation of ant behaviour (Hojo *et al.,* 2015). Likewise, the tentacle organ secretion of the caterpillar *Shirozua jonasi* contains dendrolasin that mimic alarm pheromones of the attendant ants.

In the ecological perspectives, obligate ant associates are more vulnerable to extinction, as they are more prone to invasive ants, habitat destruction and climate changes. As per IUCN statistics, more than 70% of threatened species of Lycaneidae and Riodinidae are ant associates that highlight the importance of ant- Lepidoptera interactions in the ecosystem.

REFERENCES

AntWeb, 2022. *Ants of All Antweb* [On-line]. Available: https://www.antweb.org/project.dona me =allantwebants. [25.Sept.2022].

Daniels, H., Gottsberger, G. and Fiedler, K. 2005. Nutrient composition of larval nectar secretions from three species of myrmecophilous butterflies. *Journal of Chemical Ecol*ogy 31(1): 2805-2821.

Dupont, S. 2012. Structural evolution and diversity of the caterpillar trunk. PhD thesis, University of Copenhagen, 250p.

Gnatzy, W., Jatho, M., Kleinteich, T., Gorb, S. N. and Hustert, R. 2017. The eversible tentacle organs of *Polyommatus* caterpillars (Lepidoptera, Lycaenidae): Morphology, fine structure, sensory supply and functional aspects. *Arthropod structure and Development* 46(6):788-804.

Helms, K. R. 2013: Mutualisms between ants (Hymenoptera: Formicidae) and honeydew-producing insects: Are they important in ant invasions. *Myrmecological News.* 18: 61-71.

Hojo, M. K., Pierce, N. E. and Tsuji, K. 2015. Lycaenid caterpillar secretions manipulate attendant ant behavior. *Current Biology* 25(17): 2260-2264.

Kaminski, L. A. and Filho, F. S. C. 2012. Life History of *Aricoris propitia* (Lepidoptera: Riodinidae) - A myrmecophilous butterfly obligately associated with fire Ants. *Psyche: A Journal of Entomology* 23(1):178-183.

Pierce, N. E., Braby, M. F., Heath, A., Lohman, D. J., Mathew, J., Rand, D. B. and Travassos, M. A. 2002. The ecology and evolution of ant association in the Lycaenidae (Lepidoptera). *Annual Review of Entomology*. 47(1): 733-771.

Pierce, N. E. and Dankowicz, E. 2022. Behavioral, ecological and evolutionary mechanisms underlying caterpillar-ant symbioses. *Current Opinion in Insect Science*, p.100898.

Schultheiss, P., Nooten, S.S., Wang, R., Wong, M.K., Brassard, F. and Guénard, B. 2022. The abundance, biomass, and distribution of ants on Earth. *Proceedings of the National Academy of Sciences*, 119(40), p.e2201550119.

MS Received 05 October 2022
MS Accepted 10 December 2022

DOI 10.55278/JMUN7289

Puddling: Butterflies sourcing moisture and nutrients from wet soil and dung

Athira G. Menon and Haseena Bhaskar
Department of Agricultural Entomology,
College of Agriculture, Kerala Agricultural University, Thrissur-680656, Kerala, India
***Corresponding author: athiragmenon94@gmail*.com**

The aggregation of insects on wet soil or dung to obtain moisture and nutrients is termed puddling. It is a type of supplementary feeding targeted at accumulating specific micronutrients (Larsen, 1991). Although puddling is most common in butterflies (Lepidoptera), a few insects belonging to the orders Orthoptera, Hemiptera, Hymenoptera, Diptera and Blattodea also exhibit this behaviour. Among butterflies, Skippers, Blues and coppers, Yellows, and Swallow tails are the predominant puddlers. The puddling sites of butterflies include mud, rotting fruit, bird dropping, dung, and carrion (Rima *et al.*, 2016).

Figure 1: Butterflies puddling on soil surface
(Source:https://soilsmatter.wordpress.com/2020/07/15/what-type-of-insects-live-in-soil/

Figure 2: Butterfly drinking from the tears of a turtle
(Source:https://en.wikipedia.org/wiki/Mud-puddling

Figure 3: Butterfly feeding on bird excreta
(Source:https://www.wildwanderer.com/mud-puddling/

Figure 4: Butterfly feeding on carcass
(Source:https://www.reddit.com/r/oddlyterrifying/comments/l2uib6/butterflies_eating_a_carcass/

Though puddling aims at acquiring water and nutrients, it also has a significant role in achieving reproductive success as well as excretion of excess nutrients in butterflies. Major nutrients that butterflies derive while puddling are sodium and protein, which are vital for many physiological functions (Beck *et al.,* 1999). Sodium derived from puddling has been shown to act as nuptial gift in a few lepidopteran species. Mitra *et al.* (2016) studied the effects of sodium puddling on male mating success, courtship and flight behaviour in the pipevine swallowtail butterfly, *Battus philenor* (L.). The sodium consumption increased the success of mating in males and the males took more time to complete aerial courtship manoeuvre. Insects feed on carrion and bird excrement and utilize proteins present in them. In females, the absorbed proteins help in the development of egg yolk. Since proteins are a natural source of nitrogen, it improves the growth of flight muscles which in turn enhance the male competitive ability.

The stimulants for puddling in Lepidoptera are the genotype, age and mating status of the individual, as well as visual and olfactory cues from the substrate. The participants of puddling are usually the young males, as they need to sustain high activity levels to fly around and locate receptive females. According to Otis *et al*. (2006) pierids and papilionids mainly depend on visual cues to discover puddling sources, whereas nymphalids, hesperiids and lycaenids rely on olfactory cues.

Major factors affecting puddling are the age and mating status of a species, nutrient status, competitive abilities, environmental factors and pollution. According to Boggs and Jackson (1991), young males had high activity levels and reproductive success when compared to the older males. The males which puddled for a longer period of time was preferred by females for mating. A study conducted by Ankola *et al.* (2020) revealed that temperature played a significant role in the regulation of puddling activity in *Papilio polytes* Linn. The puddling rate was highest at temperatures ranging from 26°C to 28°C, and males puddled longer at lower temperatures. Environmental pollution can be a major threat to puddling in insects. Puliyancholai, a famous tourist destination near Trichy was well known for its butterfly puddling for years. Accumulation of plastic pollutants in the area has started to pose a serious threat to the ecological system resulting in reduced number of butterflies and their puddling behaviour (Times of India, 2016).

There are various costs and risks associated with puddling. Puddling is an energy-expensive process where individuals have to locate their substrate and imbibe the nutrients. Butterflies get intoxicated on whatever they have been puddling on and become oblivious to their surroundings. This makes them very vulnerable to predatory or parasitic attacks as they are sedentary and exposed. The digestive system of insects that use carrion or dung as puddling site needs additional mechanisms for neutralizing microbes and their toxic products.

The knowledge on puddling behaviour of butterflies can be utilized for conservation of endangered butterfly species and also for mass rearing them in conservatories. Basumatary *et al.* (2015) demonstrated that the mud puddling locations of butterflies might be one of the important sites for palynological studies. Pollen data from the mud puddling locations may also be helpful to trace the migration pattern of butterflies and to provide the past climatic interpretation in a region.

Even though puddling appears to be a dirty behaviour of butterflies, it is an alternative strategy for obtaining scarce nutrients and achieving reproductive success in them. Knowledge on this behaviour provides deep insight into the ecology and behaviour of butterflies.

References

Ankola, K., Aiswarya, D., Anusha, R., Vaishnavi, N., and Supriya, V. K. 2020. Ecological significance of puddling as a behavioural phenomenon in the life history of butterfly *Papilio polytes* Linn. (Lepidoptera: Papilionidae). *J. Asia Pac. Entomol.* [e-journal]. Available: https://doi.org/ 10.1016/j.aspen.2020.10.014 [28 Oct. 2020].

Basumatary, S. K., Dhananjoy, N., and Brahma, M. 2015. A comparative palynological study on butterfly mud puddling localities and surface forest samples: a case study from northeast India. *Palynology* 41(1): 1-12.

Beck, J., Eva, M., and Konrad, F. 1999. Mud-puddling behaviour in tropical butterflies: in search of proteins or minerals *Oecologia* 119: 140-148.

Boggs, C. L. and Jackson, L. A. 1991. Mud puddling by butterflies is not a simple matter. *Ecol. Entomol.* 16: 123-127.

Larsen, T. B. 1991. *The Butterflies of Kenya and Their Natural History*. Oxford University Press, Oxford, 490p.

Mitra, C., Edgar, R., Goggy, D., and Daniel, P. 2016. Effects of sodium puddling on male mating success, courtship and flight in a swallowtail butterfly. *Anim. Behav.* 114: 203-210.

Otis, G. W., Locke, B., McKenzie, N. G., Cheung, D., MacLeod, E., Careless, P., and Kwoon, A. 2006. Local enhancement in mud-puddling swallowtail butterflies (*Battus philenor* and *Papilio glaucus*). *J. Insect Behav.* 19(6): 685-698.

Rima, N., Meme, A., and Hossain, M. 2016. Puddling of butterflies in Jahangirnagar University campus and the bank of Bangshi River, Savar, Bangladesh. *J. Biol. Sci.* 5(1): 57-70.

MS Received 06 October 2022

MS Accepted 18 December 2022

DOI 10.55278/JMUN7289

Infestation of *Tarucus indica* Evans (Lycaenidae: Lepidoptera) on apple ber, *Ziziphus mauritiana* Lam.

C.M. Rafee[1] and M K Chandaragi[2]
[1]*University of Agricultural Sciences, Dharwad-580005, Karnataka*
[2]*Cotton Research Station, Sardarkrushinagar Dantiwada Agricultural University, Talod-383 215*
Corresponding author:mallu3731@gmail.com

Ber, *Ziziphus mauritiana* Lamarck also called as desert apple belongs to family Rhamnaceae. Fresh fruits contain protein, fat, fiber, carbohydrates, reducing sugars and non-reducing sugars. Major constituents are triterpenes and triterpene saponins. The dried fruits are used as anodyne, anticancer, pectoral, refrigerant, sedative, stomachache, styptic and tonic (Palejkar *et al*, 2012). It is rich source of ascorbic acid (70–165 mg per 100 g) and a good source of total phenolics (172 to 328.6 mg GAE per 100 g) and essential minerals such as calcium, phosphorus and iron (Koley *et al*., 2016). The crop is gaining popularity among the growers because it thrives well under adverse climatic condition and gives good return. The avoidable loss is more due to insect pests. Lakra and Bhatti (1985) reported that as many as 130 species of insect pests on ber in India, but only few species have attained the status of the pest and cause considerable damage. Jothi and Tandon (1995); Patil and Patil (1996); Kavitha *et al*., (2002); Balikai (1999); Haldhar *et al*., 2016 and Karuppaiah *et al*., 2010 recorded seveal insect-pests and non insect pests on ber in Karnataka, Andra Pradesh and Rajasthan

Apart from several important insect pests causing damage to ber, one such insect pest that feeds on ber leaf is *Tarucus indica* Evans (Lycaenidae: Lepidoptera). The infestation of this larva was noticed in farmer field ber plantation at Chikkamannapura village, Koppal district of Karnataka, India during 2020. The damage on two year old ber tree found to be 45 per cent. The larvae found feeding on sprouting tender shoots, leaves as well as flower buds (Fig.1). Infested ber leaves look characteristic whitish long streaks due to chlorophyll feeding (Fig 2). It was interesting to note that larvae were associated with black ants due to sugary secretion from the larval anus (Fig 3).

Acknowledgements:

Authors are thankful to Dr. P. R. Shashank, Scientist, Division of Entomology, ICAR-IARI, Pusa Campus, New Delhi-110 012 for identification of pest species.

Figure 1. Larva of *Tarucus indica* Evans

Figure 2. Leaf infested by larva

Figure 3. Infested leaves along with Ants

References

Balikai, R. A. 1999. Pest scenariao of ber (*Zizyphus mauritiana* Lamarck) in Karnataka. *Pest Manage. Hort. Ecosystem*, **5(1)**:67-69.

Haldhar, S. M., Deshwal,H. L., Jat, G. C., Berwal, M. K. and Singh, D, 2016. Pest scenario of ber (*Ziziphus mauritiana* Lam.) in arid regions of Rajasthan: a review. *Journal of Agriculture and Ecology*, **1**: 10-21

Jothi, B. D. and Tandon, P. L. 1995, Present status of insect pests of ber in Karnataka. *Curr. Res*. **24(9)**:153-155

Karuppaiah, V., More, T.A., Sivalingam, P.N., Hanif Khan and Bagle B.G. 2010. Prevailing insect pests of Ber (*Ziziphus mauritiana* LamK) and their natural enmines in hot arid ecosystem. *Haryana J. Hortic.Sci.*,**39(3&4)** : 214-216

Kavitha, Z., Savithri, P. and Vijayaragavan, C. 2002. Insect pests of ber, *Ziziphus jujube* in Tirupati region. *Insect Environment*,**7(4)**:157-158.

Koley, T. K., Kaur, C., Nagal, S., Walia, S., Jaggi, S. 2016, Antioxidant activity and phenolic content in genotypes of Indian jujube (*Zizyphus mauritiana* Lamk.). *Arabian Journal of Chemistry*, **9**, S1044-S1052.

Lakra, R. K. and Bhatti, D. S. 1985. In: Third National Workshop on Arid Zone

Fruit Research, Rahuri, Maharashtra, India.

Palejkar, C. J., Palejkar, J. H., Patel, A. J. and Patel, M.A. 2012, Plant review on *Ziziphus mauritiana. International Journal of Universal Pharmacy and Life Sciences*, **2(2)**: 202-210

Patil, P. and Patil, B.V. 1996, Insect pests of ber in North Karnataka. *South Indian Horticulture* **44(3/4):**113.

MS Received 01 October 2022

MS Accepted 08 December 2022

DOI 10.55278/EBBK8340

Insect Biomimetics

Sunny Maanju* and Preeti Sharma
Department of Entomology, CCS Haryana Agricultural University, Hisar – 125004 (Haryana), India
****Corresponding author: sunnymaanju97@gmail.com***

Biomimetics also known as Biomimicry, is the study and use of structural and functional aspects of living organisms as templates to create materials, substances or products by reverse engineering techniques. Insects have the required potential to act as models owing to their diversity and unique adaptations. There are many practical examples of insect biomimicry around us used in our everyday life without even being noticed. Honey comb design is used to make clothes more flexible. The stable tripod stands were inspired by the structure and position of legs. The principle of pterostigma in the insect wings helped the aeroplane manufacturers to reduce the fluttering of the plane wings and make the flight more stable. The concise folding of earwig (*Forficula auricularia*) hindwings inspired engineers to make foldable solar plates and other electronic devices which occupy large space. Termite's humongous mounds helped us to understand and improve the natural ventilation system of huge skyscrapers. Butterfly wing structure when studied closely at nano structure level unraveled its self-cleansing property which have been pragmatically applied in manufacturing of self-cleaning window glass. Migros chain of supermarket in Switzerland uses ant inspired software to decide each day the order and route with which their trucks will deliver goods to the network of retail stores in order to shorten the route lengths by up to 20% thereby reducing carbon dioxide emissions and cutting cost.

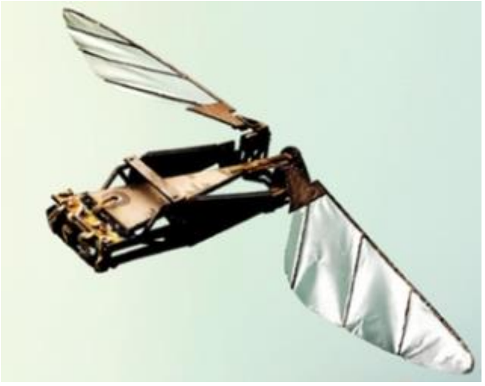
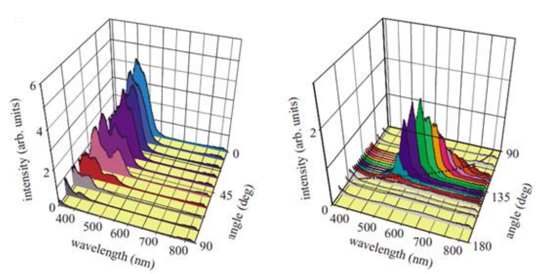


Figure 1: A Robobee Prototype (Wood *et al.*, 2013)

Harvard's Robobee project (Wood *et al.*, 2013) ended up as the smallest ever man-made device (Fig. 1) based on an insect that have managed to achieve flight. In spite of being in a prototype phase, its latest versions are not just capable of flying but stick to surfaces, swim in water and even move in and out of water. In future it could be used for search and rescue operations, survey and surveillance and even as artificial pollinators.

A team of designers from Fraunhofer has come up with a camera based upon the compound eyes of insect that can reduce the size of the camera lens to just 2 mm compared to a normal one of 5 mm. They have been calling it as facet VISION, made up of 135 tiny lenses which captures individual images and later combine them together to create the final picture. This mechanism is present in compound eyes of most insects and such inspirations will bring down the bulk of micro-electronics dimensions and size with better contrast and higher resolution images. Another break-through in the tyre industry, that is Honeycomb tyres have imparted resilience to military vehicles for travelling in some of the nasty uneven terrains. They don't need to be filled with air, can support large weight and are puncture free but most importantly they are bullet & bomb proof. The only disadvantage of this technology is that the ride offered by them is uncomfortable. People may tolerate the bumpers of honeycomb tyres but the aichmophobia of people who are scared of sharp objects like needles is on another level. But even if they aren't phobic, injecting a needle can be a horrible experience at times. This may be due to the procedure followed but also because of the size of needles. To tackle this, researchers from Japan have taken inspiration from the mosquito's highly serrated proboscis used in piercing and injecting saliva as well as sucking blood. The piercing is with such precision along with such small proboscis that it doesn't even comes in contact with the nerves at times and hence we sometimes don't even feel the blood sucking by mosquitoes. Even if they come in contact, it only incites a sub-threshold stimulus which is incapable of producing any nerve impulse due to lack of depolarisation. So, the bite remains relatively pain-free. Japanese engineers have used this knowledge to manufacture just 1 mm long needles with a diameter of 0.1 mm, which is only a fraction of the regular needle size typically used for treatments and thus capable of delivering pain-free injection.

Figure 2: The structural blue colours of the Blue Morpho Butterfly, *Morpho peleides* (Source: laughingsquid.com)



(a) (b)

Figure 3: Single-scale angle- and wavelength-resolved experiment on a scale of *Morpho sulkowskyi* under normal incidence (0°) in (a) reflection and (b) transmission directions. (Kinoshita *et al.*, 2002).

The fascinating colours of some butterfly wings (e.g., Morpho butterfly, *Morpho* sp.) are not due to any pigment but as a result of prism like nanoscale structure of the scales present on the wings and are called structural colours (Fig. 2) produced as a result of a phenomenon called optical interference which causes an iridescence (Kinoshita *et al.*, 2002). This splits the white light into its various colours depending on the angle at which the light is incidence on the wing surface so the actual colour may vary with viewing angle (Fig. 3). Mirasol screens and IMod displays of Qualcomm company are inspired by the butterfly wing structure to produce an "always on" effect without draining energy for backlighting (Rai and Mishra, 2021). Since it uses sunlight rather than screen brightness, colours intensify outdoors unlike old screens that are washed away in daylight. And reduces the colour automatically in dark to act as night mode which doesn't stress out user's eyes. Mirasol technology also uses 10 times less energy since it doesn't use much backlight to operate and hence increase the battery efficiency. Although, spiders are totally different from insects, they too can be useful for inspiring us. UV-reflecting strands of spider-webs inspired us to make UV light reflecting glass for installing in humongous glass skyscrapers. This saves the bees, birds and other insects which can detect UV light reflection, from crashing into the glass buildings.

Figure 4: The Namib Desert beetle collecting water droplets from the air (Source: namibdesrtbeetle.weebly.com)

The Dew Bank designed by Kitae Pak, which collects and stores condensation was inspired by the Namib Desert Darkling Beetle, *Onymacris unguicularis* (Tenebrionidae: Coleoptera) who's hydrophobic (repels water) body is covered with hydrophilic bumps (about twice the thickness of a human hair). The fog/water droplets stick to these water loving bumps when the beetle raises its abdomen tip on the slope of a sand-dune (desert) facing the incoming cloud of fog. The water droplet due to the sloped posture, run down his back and into his mouth (Fig. 4). The Dew Bank is made up of stainless steel to avoid rusting and its beetle-back-shaped dome collects condensed fog and runs it into a circular reservoir (Seth, 2010) for later consumption (Fig. 5). This could provide an estimated one glass water per day for survival of Namib Desert (Southern Africa) people (Stewart, 2010). The Australian scientists has succeeded in manufacturing a near perfect rubber with 98% level of resiliency by studying resilin, an elastic protein found in joints of fleas which can jump 100 times their body length and other insects at various places including wings. This rubber could be used to improve everything from the efficiency of heart valves to the fragility of sports shoes. Hence, there are more learnings than you think in the world of insects. We should see the world from their perspectives and problems to find out the unique and effective solutions which they use to survive this cruel dynamic world.

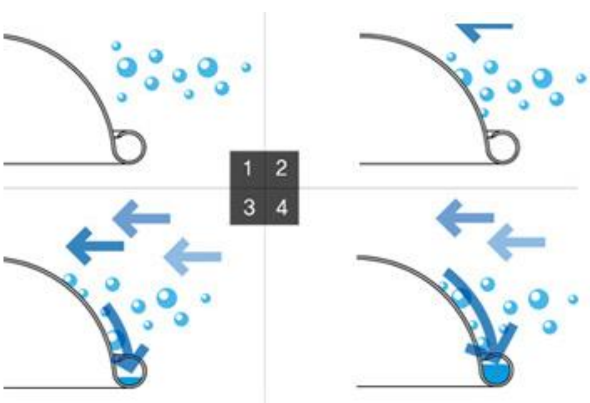


Figure 5: Mechanism employed by the Dew Bank Bottle inspired by the Namib Desert beetle (Seth, 2010).

References

Kinoshita, S., Yoshioka, S. and Kawagoe, K. 2002. Mechanisms of structural colour in the Morpho butterfly: cooperation of regularity and irregularity in an iridescent scale. *Proceedings of the Royal Society of London. Series B: Biological Sciences*, **269(1499):** 1417-1421.

Rai, S. and Mishra, G. 2021. Techno Insects. *Science Reporter*, **58(2):** 20-23.

Seth, R. 2010. Beetle Juice Inspired. Retrieved from https://www.yankodesign.com/2010/07/05/beetle-juice-inspired/

Stewart, L. 2010. Beetle-inspired bottle harvests drinking water from thin air. *InHabitat: Design*, 7 July 2010.

Wood, R., Nagpal, R. and Wei, G. Y. 2013. Flight of the Robobees. *Scientific American*, **308(3):** 60-65.

MS Received 10 October 2022

MS Accepted 15 December 2022

Short Notes

Which fly is this? *Silbomia asiatica* Crosskey, 1965 or different species?

Rushikesh R. Sankpal
Department of Biotechnology, MES's Abasaheb Garware College (Autonomous), Pune 411004
****Corresponding author: rushisankpal@gmail.com***

Insects play a major role in ecosystem functioning. In general, the abundance and biodiversity of insects are declining (Dar *et al*., 2021) and insect monitoring programs are playing a crucial role in understanding the same (William, 2019). On 26th May, 2020 (05.23 PM), I was pursuing my hobby photography of insects with camera make: One Plus, model: HD1901 at A/P- Tatyasaheb Kore Nagar, Warananagar, Kolhapur District, Maharashtra, India (16°52'04.2"N; 74°13'03.2"E). I observed a fly with interfrontal orange-yellow area, blackish legs, densely silvery-white postorbits, metallic green-blue thorax, metallic greenish blue abdomen and dark brown to infuscate wings.

The photographs of the fly as shown in figure 1-A, 1-B, 1-C. It was found resting on the tree trunk of an *Albizia lebbeck* (L.) Benth, (figure 2-A). The fly was photographed in the resting position heading downwards at the height of 0.96 m from the ground, and the girth (stem diameter) at this height was 2.44 m. Based on external appearance, the unidentified fly is morphologically similar to *Silbomyia asiatica* Crosskey, 1965 (British Museum, London, Natural History, 1965; Natural History Museum Data Portal, 2022). As the specimen was neither collected nor studied in detail, further taxonomic studies based on morphology and molecular biology are needed to answer which fly is this?

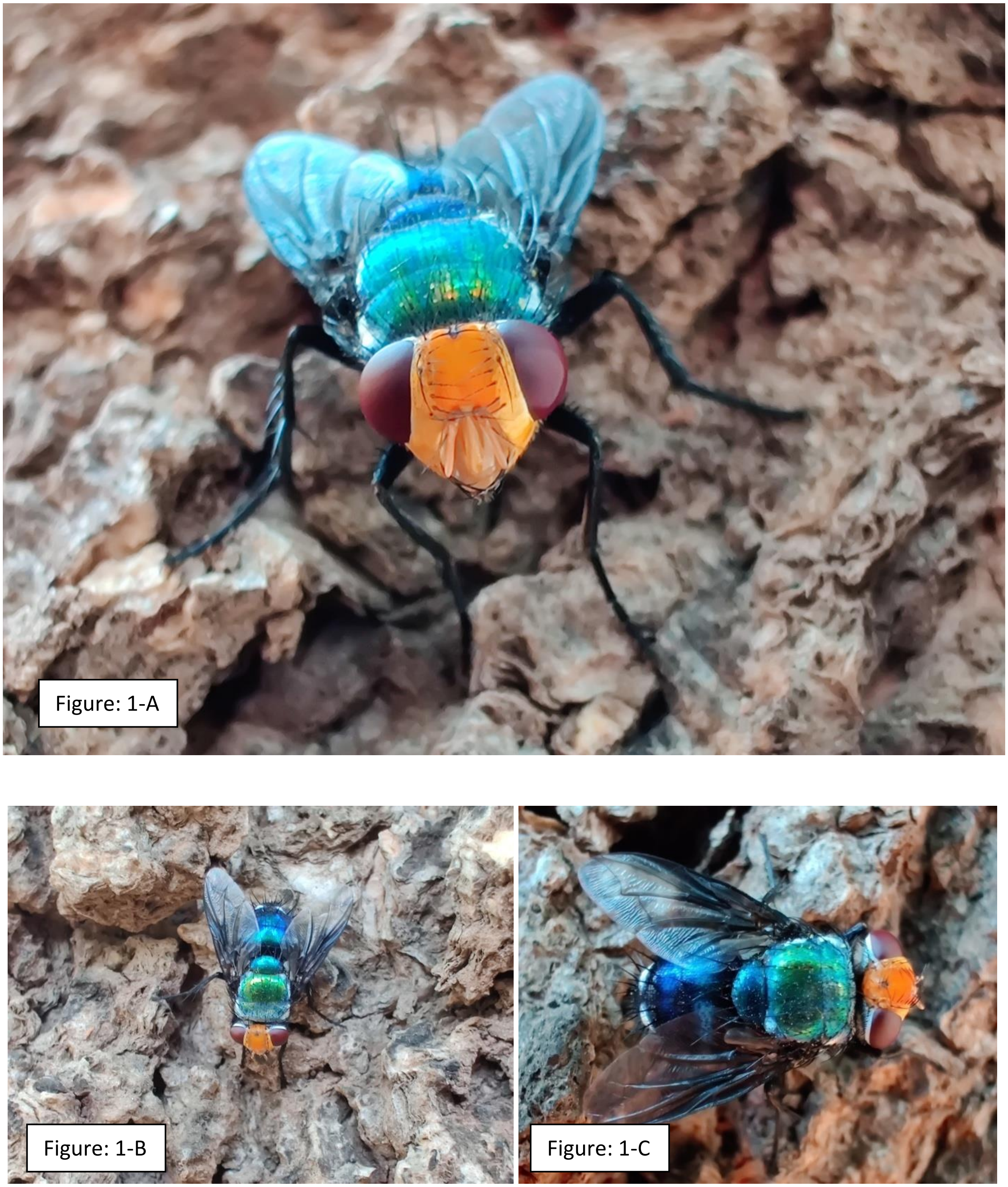


Figure 1: A) The fly with interfrontal orange-yellow area and blackish legs, B) The fly resting on the tree trunk heading downwards, C) The fly with postorbits: densely silvery-white, thorax: metallic green-blue, wings: dark brown infuscate, abdomen: metallic greenish blue

Figure 2: A) Frontal view of *Albizia lebbeck* (L.) Benth

Since a fly with such a description was not reported earlier from the study location and data are scarcely available, it was important to record and publish as an observatory document. It also adds to the knowledge of spatio-temporal distribution and ecology of the species.

References:

British Museum (London). Natural History, 1965, Bulletin of the British Museum (Natural History) Entomology, Vol XVI, 1965, pp 80-81 https://www.biodiversitylibrary.org/item/19409#page/94/mode/1up and https://www.biodiversitylibrary.org/item/19409#page/95/mode/1up, Retrieved: 26 July 2022

Dar, S.A., Ansari, M.J., Al Naggar, Y., Hassan, S., Nighat, S., Zehra, S.B., Rashid, R., Hassan, M. and Hussain, B., 2021. Causes and Reasons of Insect Decline and the Way Forward. In Global Decline of Insects. IntechOpen.

Natural History Museum Data Portal, NHMUK012810593, Permanent URL for the most up to date record data: https://data.nhm.ac.uk/object/9b422c76-577b-4e97-b5bc-49814d01e5be Retrieved: 09 Aug 2022

William E. Kunin, 2019. "Robust evidence of declines in insect abundance and biodiversity," Nature, Nature, vol. 574 (7780), pages 641-642, October.

INSECT LENS

Citrus woolly whitefly, Aleurothrixus floccosus (Aleyrodidae: Hemiptera) – nymphs

The flower like (with white mealy growth) are the nymphs of the Citrus woolly whitefly. Whiteflies are known to excrete the sugar rich and sticky excretions called honeydew, observed as droplets. Once these insects pierce the plant phloem with their stylets (needle like mouthparts), the fluid from the phloem flows into the insect at higher pressure. The insect partially digests them and excretes the sogars as honeydew.

Normally we see many ants always moving around plant sap sucking insects. They feed on this honeydew and in turn protect the sucking insects from predatory insects. Such a symbiotic relationship where one organism provides food to the others is referred at trophobiosis. Honeydew also gets spread widely in the infested plants and they form the substrate for growth of black sooty mould fungus (a collection of Ascomycete fungi).

Author: *Sevgan Subramanian, ICIPE, Nairobi, Kenya*

Location: *Temple Court Apartments, Wambugu Road, Nairobi, Kenya (October, 2022)*

Email: *ssubramania@icipe.org*

Mating pair of fruit fly, Dacus persicus on Calotropis procera fruit

Dacus persicus is a highly destructive monophagous insect pest of Calotropis. It is native to India, Sri Lanka, Iran, Pakistan and Iraq. Gravid D. persicus females lay eggs inside developing Calotropis fruits by penetrating the skin of fruit with its ovipositor. The number of D. persicus eggs in a Calotropis fruit is positively correlated with the fruit size. D. persicus larva completely feed on seeds and influence Calotropis reproduction.

Author: *D. N. Nagaraj,* Project Head (Entomologist) Ento Proteins Pvt. Ltd., Mangalore, India
Location: *Bengaluru, Karnataka*

Email:nasoteya@yahoo.co.in

Eublemma dimidials (Erebidae: Lepidoptera)

Caterpillar of Eublemma dimidialsis a minor pest on various crop plants of family fabaceae including mung beans (Vigna radiata) and cow peas (Vigna unguiculata). They attack plants during flowering to pod formation stage. Caterpillar bore into pods and feeds on seeds.

Author: *D. N. Nagaraj,* Project Head (Entomologist) Ento Proteins Pvt. Ltd., Mangalore, India
Location: *Bengaluru, Karnataka*

Email:nasoteya@yahoo.co.in

Green leaf mimic Katydid, Aegimia elongate Rehn, J. A. G., 1903

Aegimia elongata is a mid-sized leaf-mimicking, green katydid. Aegimia is related to the almost perfect petiole-like appearance and its use in crypsis 'the insects remain motionless during the day, with the head pressed against the substrate (usually branches of trees and shrubs), making them difficult to detect for predators'.

Author: *P.L. Tandon*
Location: *R T Nagar, Bengaluru, Karnataka*

Ligurian leafhopper, Eupteryx sp. (Cicadellidae: Hemiptera)

The Ligurian leafhopper, Eupteryx is a sap-feeding insect native to the Mediterranean basin around the Ligurian Sea, including parts of Italy, France, and islands. This range expansion may have been facilitated by commercial transportation of host plants in the mint family (Lamiaceae).Some of the species belonging to Eupteryx genus are pest of Rosemary and other aromatic plants of the sage plant.

Author: *Sevgan Subramanian, ICIPE, Kenya*

Location: *Temple Court Apartment, Wambugu Road, Nairobi.*

Email:*ssubramania@icipe.org*

The cucurbit bug, Coridius janus (Dinidoridae: Hemiptera)

Janus is the Roman God of beginning. Coridius janus also known as the red pumpkin bug which feeds by sucking on the sap on soft parts of plants especially in the cucurbit family and causes damage.

Author: *D. N. Nagaraj,* Project Head (Entomologist) Ento Proteins Pvt. Ltd., Mangalore, India
Location: *Bengaluru, Karnataka*

Email:*nasoteya@yahoo.co.in*

Encyrtid parasitoid, Anagyrus pseudococci (Encyrtidae: Hymenoptera)

Anagyrus pseudococci capable of developing on a variety of mealybug species viz., Planococcus spp. and Pseudococcus spp. A. pseudococci the most common commercial parasitoid reared for mealybug control. It is a solitary, internal parasitoid of size 1.5 – 2 mm and lays one egg per host with the larva developing inside the host's body.

Author: *Sevgan Subramanian, ICIPE, Nairobi, Kenya*
Location: *Temple Court Apartment, Wambugu Road, Parklands, Nairobi (September, 2022)*
Email:*ssubramania@icipe.org*

Citrus aphid, Toxoptera sp. (Aphididae: Hemiptera) viviparous reproduction

The brown citrus aphid is one of the world's most serious pests of citrus and also efficient transmitter of citrus tristeza closterovirus (CTV). One of the most devastating citrus crop losses ever reported followed the introduction of brown citrus aphid into Brazil and Argentina:

***Author**: Sevgan Subramanian, ICIPE, Nairobi, Kenya*

***Location:** Temple Court Apartment, Wambugu Road, Parklands, Nairobi (September, 2022)*

***Email:**ssubramania@icipe.org*

Plasterer bee or Polyester bee, Hylaeus sp. (Colletidae: Hymenoptera)

The common name of the family comes from the unique way its members plaster and smoothen their nest hive cells with their oral secretions and the secretion dries out to a cellophane-like layer. Most insects live in aggregations with exception of very few as solitary bees. They carry pollen in their oesophagus – crop (gut) to their nest to feed their developing larvae.

Author: *Sevgan Subramanian, ICIPE, Nairobi, Kenya*

Location: *International Centre of Insect Physiology and Ecology (ICIPE), Nairobi, Kenya (October, 2022)*

Email:ssubramania@icipe.org

The six-spot ground beetle grubs (Anthia sexguttata, Carabidae: Coleoptera)

Anthia sexguttata is common in the scrub forests of southern India. Tiger beetles can be very fast-running and in fact it is said that they are one of the fastest animals in the world for their size. Some scientists have estimated that if tiger beetles were proportionately the same size as people, they would be able to run at 300 miles per hour!

Author: *T.V.K. Singh*
Location: India

Diglyphus isaea (Eulophidae: Hymenoptera) parasitizing Liriomyza huidobrensis infesting kale.

Diglyphus isaea is a small, black, non-stinging wasp that searches out leaf miners on which lays its egg and kills the leaf miner larvae. The emerging larvae use the dead miner as food. Leaves with short or dead-ended mines often are the indication for the presence of D. isaea.

Author: *Sevgan Subramanian, ICIPE, Nairobi, Kenya*
Location: *International Centre of Insect Physiology and Ecology (ICIPE), Nairobi, Kenya*
Email:*ssubramania@icipe.org*

Common club tail (Gomphus vulgatissimus) feasting on pantala

The common club tail dragonfly is a medium-sized, yellow and black insect. They get their names from their tail, which becomes wider at the tip like a club. They are attracted to clean, slow-moving rivers and creeks where the soil is relatively sandy, and it's these waters that they need to breed and lay eggs.

***Author**: Chitra Shankar, Principal Scientist (*Entomology*), ICAR-Indian Institute of Rice Research, Hyderabad*

***Location:** Hyderabad*

Thick-legged hoverfly, Syritta sp. (Syrphidaeae: Diptera) visiting avocado flowers for nectar

Syritta sp. is fast and nimble fliers and their larvae are found in wet, rotting organic matter such as garden compost, manure and silage. The adult Syritta flies are pollinators for variety of flowering plants.

Author: *Sevgan Subramanian, ICIPE, Nairobi, Kenya*
Location: *International Centre of Insect Physiology and Ecology (ICIPE), Nairobi, Kenya*
Email:*ssubramania@icipe.org*

Predatory fungal gnats, Truplaya sp. (Keroplatidae: Diptera).

This was relatively a large sized fungus gnat. Maggots of species belonging to this family are both fungus feeders and predators of small invertebrates.

Author: *Sevgan Subramanian, ICIPE, Nairobi, Kenya*
Location: *International Centre of Insect Physiology and Ecology (ICIPE), Nairobi, Kenya*
Email:*ssubramania@icipe.org*

Liriomyza sp. (Liriomyzidae: Diptera)

They are a pair of Liriomyzid leaf miners. In Kenya, L. trifoli, L. sativae and L. huidobrensis are the commonly observed invasive leaf miners affecting crops like potato, tomato, cabbage and kale.

Author: *Sevgan Subramanian, ICIPE, Nairobi, Kenya*
Location: *International Centre of Insect Physiology and Ecology (ICIPE), Nairobi, Kenya*
Email:*ssubramania@icipe.org*

***Zonopterus consanguineus* (Cerambycidae: Coleoptera)**

Zonopterus consanguineus is a species of beetle in the family Cerambycidae. It is brightly coloured with orange bands on black and the elytra sometimes shows a bluish tint at the apex.

Author: *D. N. Nagaraj,* Project Head (Entomologist) Ento Proteins Pvt. Ltd., Mangalore, India
Location: *Bengaluru, Karnataka*

_Email:_nasoteya@yahoo.co.in

Black mealy bug Predator, Exochomus nigromaculatus (Coccinellidae: Coleoptera)

Despite their name 'Black Mealy Bug Predator', they will also feast on aphids, soft scale and cochineal insects.

Author: *Sevgan Subramanian, ICIPE, Nairobi, Kenya*

Location: *International Centre of Insect Physiology and Ecology (ICIPE), Nairobi, Kenya*

Email: *ssubramania@icipe.org*

Congregation of Cuckoo Wasp (Chrysidae: Hymenoptera)

The term "cuckoo wasp" refers to the cuckoo-like way in which wasps lay eggs in the nests of unrelated host species. They are generally kleptoparasites, laying their eggs in host nests, where their larvae consume the host egg or larva while it is still young, and also the the food provided by the host for its own juvenile.

Author: *Sevgan Subramanian, ICIPE, Nairobi, Kenya*

Location: *International Centre of Insect Physiology and Ecology (ICIPE), Nairobi, Kenya*

Email: *ssubramania@icipe.org*

Tephritinae, (Tephritidae: Diptera).

Flower visitor to Avocado.

Author: *Sevgan Subramanian, ICIPE, Nairobi, Kenya*
Location: *Temple Court Apartment, Wambugu Road, Parklands, Nairobi (October, 2022)*
Email:*ssubramania@icipe.org*

Bark Mantis, Humberttiella sp. (Liturgusidae: Mantodea)

Bark mantis highly adapted in mimicry and camouflage. They are natural biocontrol agent against many pests.

Author: *D. N. Nagaraj,* Project Head (Entomologist) Ento Proteins Pvt. Ltd., Mangalore, India
Location: *Bengaluru, Karnataka*

Email:nasoteya@yahoo.co.in

Author: *Niraj Mani Chourasia, Asst. Manager, Amgoorie Tea Garden*

Location: *Nonaipara Tea Garden Udalgiri District, Assam – 784523*

Email: *niraj.tnau@gmail.com*

(*Identification help needed from readers!*)

Author: *Niraj Mani Chourasia, Asst. Manager, Amgoorie Tea Garden*

Location: *Nonaipara Tea Garden Udalgiri District, Assam – 784523*

Email: *niraj.tnau@gmail.com*

(*Identification help needed from readers!*)

Tailed Jay, Graphium agamemnon (Papilionidae: Lepidoptera)

Tailed Jays belong to the family of Swallowtails because they have tailed hindwings. They are fast, restless and flutter while feeding. Most of them are found in the gardens and urban green spaces due to their food plant false ashoka (Polyalthia longifolia) which is an ornamental tree.

Author: *Ruchita.Naidu.D, Msc Zoology, Christ (Deemed to be University), Bangalore, India*

Location: *Shaniwar Wada, Pune, Maharashtra, India*

Email: *naiduruchita2000@gmail.com*

Common evening brown, Melanitis leda (Nymphalidae: Lepidoptera)

They are Brushfooted butterflies. Their fore legs are covered with long and dense scales which form a brush like appearance. They are a common species of butterflies which fly during the dusk. Their caterpillars feed on grass whereas most of the adults feed on nectar.

Author: *Ruchita Naidu.D, Msc Zoology, Christ (Deemed to be University), Bangalore, India*

Location: *Shaniwar Wada, Pune, Maharashtra, India*

Email: *naiduruchita2000@gmail.com*

We sincerely acknowledge the Lens contributions from Dr. D N Nagaraj, Dr. Sevgan Subramanian (Sourced from WhatsApp), Dr. Chitra Shankar, Dr. P.L. Tandon and Ruchita Naidu. We have included pictures of Dr. Niraj Mani Chourasia of eggs, pupae, etc for its sheer aesthetic value. We will be grateful if readers can suggest identity.

Insect Environmentalist awardee 2022 for excellence in Insect Photography

- Dr D N Nagaraj

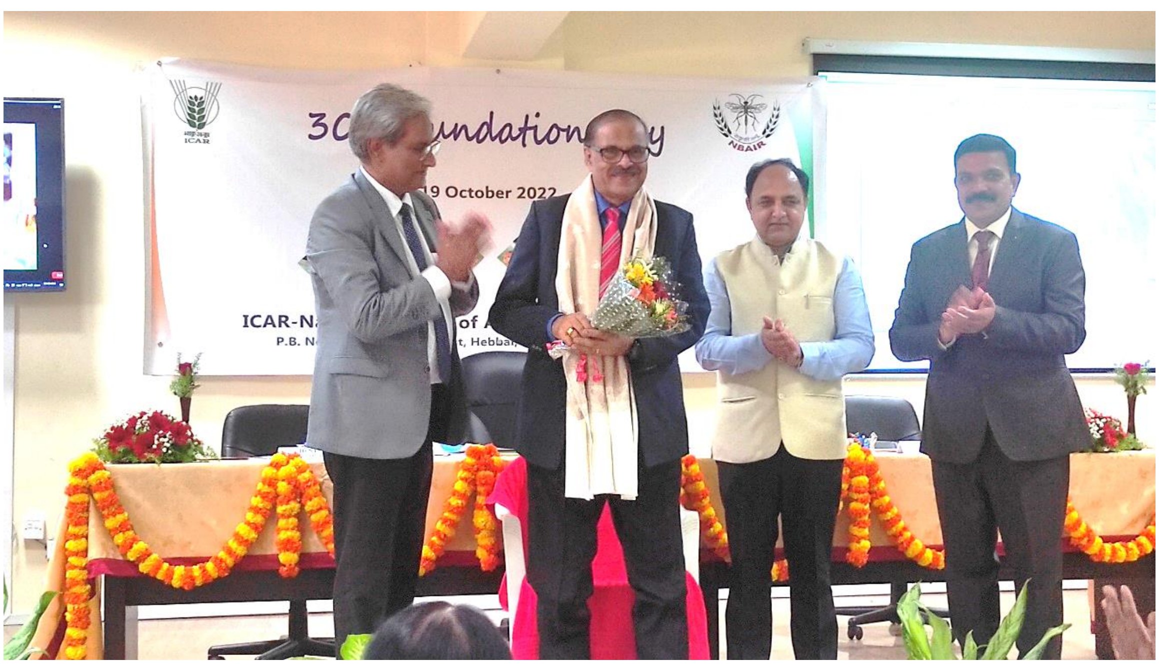
Insect Environment Extension

Insect Environment team at EBSCO CABI MEET, with Neil MacDonald, CABI UK, Shaji, Vice President EBSCO, Tirumala Rao, CABI New Delhi.

Insect Environment team with Dr. Krushnamegh Kunte, National Centre for Biological Sciences (NCBS)

Insect Environment team at Regional and National level, National Children's Science Congress (NCSC), a programme of National Council for Science and Technology Communication (NCSTC), Department of Science and Technology, Government of India.

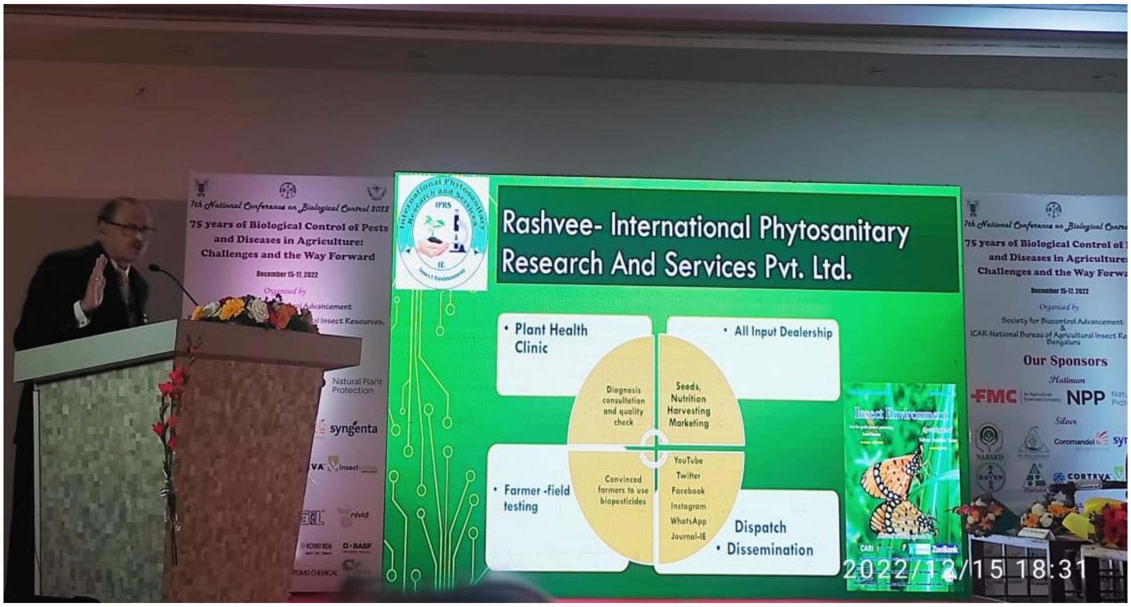
Insect Environment team with Dr. Vasanthraj David &
Dr. Stephen Devanesan, General Secretary, FIA & Bee Expert



Dr. Abraham Verghese felicitated by DDG Crop Science ICAR, ADG Plant Protection ICAR, Director NBAIR on 30th Foundation Day, ICAR -NBAIR

Appraising the extension activities of IE and R-IPRS to DDG Crop Science ICAR, ADG Plant Protection ICAR, during their visit to biocontrol control workshop

Insect Environment team with Dr. Sanjay Arya Secretary, CIBRC, DPPQS, Faridabad at National Conference on Biological Control, Bengaluru, Karnataka, India



Lead talk by Dr. Abraham Verghese on Agri Startup at National Conference on Biological Control, Bengaluru, Karnataka, India

Farmer's day celebration by Insect Environment and AVIAN Trust at Channarayapattana, Bengaluru rural, Karnataka, India

Newspaper coverage of our extension activities and award ceremony

हिन्दुस्थान समाचार Hindusthan Samachar

28 Dec 2022, 19:41 HRS IST

NATIONAL REGIONAL OTHER SUBSCRIPTION LOGIN HPS LOGIN

Insect Environmentalist Awards Presented

20 Dec 2022 16:57:34

Bengaluru, 20 December (H.S): As part of the silver jubilee celebration, the Insect Environment organized an essay and photo contest in which 121 participants participated including officials and students. Of these 45 became eligible for the Insect Environmentalist Awards.

These awards were distributed here by Dr J.P Singh, the Plant Protection Advisor, Government of India, to all the participants who came from diverse geographical regions like different parts of the country including contestants from Kuwait.

A special award was also given to Dr J.P Singh, Plant Protection Advisor, Dr. S.N. Sushil, Director ICAR-National Bureau of Agricultural Insect Resources, Bengaluru, Dr D.K. Nagaraju, Deputy Director, Regional Plant Quarantine Station, Directorate of Plant Protection Quarantine and storage and Dr Priti Khalkho, a Women Entrepreneur.

Many school students participated and awareness of insect conservation was spread.

മാവ് കർഷകർക്കായി കൊല്ലങ്കോട് നടത്തിയ സെമിനാർ കെ. ബാബു എം.എൽ.എ ഉദ്ഘാടനം ചെയ്യുന്നു

മാവ് കൃഷി: കീടനിയന്ത്രണത്തിൽ ഏകീകൃത കൃഷിരീതി വേണം

കൊല്ലങ്കോട്: മാവ് കർഷകർക്കിടയിൽ ഏകീകൃത കൃഷിരീതിയുണ്ടായാൽ കീടനിയന്ത്രണം വിജയകരമാകുമെന്ന് കാർഷിക ശാസ്ത്രജ്ഞനും ഐ.ഐ.എച്ച്.ആർ മുൻ ഡയറക്ടറുമായ ഡോ. എബ്രഹാം വർഗീസ് പറഞ്ഞു. കൊല്ലങ്കോട് അഗ്രികൾച്ചറൽ ഇംപ്രൂവ്മെൻറ് സഹകരണ സംഘവും പെരുമാട്ടി അഗ്രോ സർവിസ് സെൻററും ചേർന്ന് കൊല്ലങ്കോട് നടത്തിയ 'മാവ് കൃഷിയിലെ പ്രശ്നങ്ങളും പ്രതിസന്ധികളും പരിഹാരമാർഗങ്ങളും' സെമിനാറിൽ സംസാരിക്കുകയായിരുന്നു അദ്ദേഹം.

നിരന്തരമായ കീടനാശിനി പ്രയോഗം മിത്രകീടങ്ങളെ ഇല്ലാതാക്കി മാവിനെ നശിപ്പിക്കും. ഉൽപാദനം വർധിപ്പിക്കാനുള്ള കൾട്ടാർ എന്ന ഹോർമോൺ ഉപയോഗം നിരോധിച്ചിട്ടുണ്ട്.

പൂക്കളിൽ പൊടികുമിൾ രോഗം, ഇലപ്പേൻ, തുള്ളൻ എന്നിവക്ക് എല്ലാ മാവിൻ തോട്ടങ്ങളിലും ഏകീകരണ കൃഷിരീതി വേണമെന്ന് ഡോ. രാഘവേന്ദ്ര പറഞ്ഞു. മാവിൽ പൂക്കൾ വരുംമുമ്പ് പൊൻഗാമിയ ലിക്വുഡ് സോപ്പ് ലായനിയിൽ ബി വേറില്ല ബസിയാന അഞ്ച് മില്ലി മെറ്റാ റൈസിയത്തിൽ കലർത്തി ഉപയോഗിക്കാമെന്ന് കീടരോഗ നിർണയ വിദഗ്ധൻ ഡോ. കെ.ഡി. പ്രതാപൻ പറഞ്ഞു. പൂക്കുന്ന സമയത്ത് പുഴുക്കളെ കണ്ടെത്തിയാൽ ജൈവ നിയന്ത്രണ സംവിധാനമാണ് ആവശ്യമെന്ന് വെള്ളായനി കാർഷിക കോളജിലെ ഡോ. ടി. സന്തോഷ് കുമാർ പറഞ്ഞു.

സെമിനാർ കെ. ബാബു എം.എൽ.എ ഉദ്ഘാടനം ചെയ്തു. പെരുവെമ്പ് കൃഷി ഓഫീസർ ടി.ടി. അരുൺ, മുൻ ഡെപ്യൂട്ടി ഡയറക്ടർ എം. മുകുന്ദനുണ്ണി എന്നിവർ വിവിധ വിഷയങ്ങളിൽ സംസാരിച്ചു. പഞ്ചായത്ത് പ്രസിഡൻറ് കെ. സത്യപാൽ അധ്യക്ഷനായി. ശാസ്ത്രജ്ഞ സംഘം പെരുമാട്ടി, മുതലമട പഞ്ചായത്തുകളിലെ മാവിൻ തോട്ടങ്ങൾ സന്ദർശിച്ചാണ് മടങ്ങിയത്.

വോളിബാൾ

ಉದಯವಾಣಿ 1/3

ರೈತರಿಗೆ ದ್ರಾಕ್ಷಿ ಬೆಳೆ ವರದಾನ

ಪಟ್ಟಣದಲ್ಲಿ ರೈತರಿಗೆ ದ್ರಾಕ್ಷಿ ಸಮಗ್ರ ಸಸ್ಯ ಸಂರಕ್ಷಣೆ ಕಾರ್ಯಾಗಾರ ನಡೆಯಿತು.

ವಿಜಯಪುರ: ಬಯಲುಸೀಮೆ ಭಾಗದ ರೈತರ ಪಾಲಿಗೆ ದ್ರಾಕ್ಷಿ ಬೆಳೆ ವರದಾನವಾಗಿದ್ದು, ವಾಣಿಜ್ಯ ಬೆಳೆಯಾಗಿ ಮಾರ್ಪಟ್ಟಿದೆ. ಈ ಬೆಳೆ ರೈತರು ಹೆಚ್ಚಾಗಿ ತಿಳಿದುಕೊಳ್ಳಬೇಕಿದೆ ಎಂದು ಹೆಸರುಘಟ್ಟದ ಭಾರತೀಯ ತೋಟಗಾರಿಕಾ ಸಂಶೋಧನಾ ಸಂಸ್ಥೆ ವಿಜ್ಞಾನಿ ಡಾ. ಜಿ. ಎಸ್.ಪ್ರಕಾಶ್ ಹೇಳಿದರು.

ಪಟ್ಟಣದಲ್ಲಿ ರೈತರಿಗೆ ಆಯೋಜಿಸಿದ್ದ ದ್ರಾಕ್ಷಿ ಸಮಗ್ರ ಸಸ್ಯ ಸಂರಕ್ಷಣೆ ಕಾರ್ಯಾಗಾರದಲ್ಲಿ ಮಾತನಾಡಿದ ಅವರು, ದ್ರಾಕ್ಷಿ ಬೆಳೆಗೆ ರಾಸಾಯನಿಕ ಗೊಬ್ಬರ ಬಳಕೆ ಮಾಡದೆ ಸಾಧ್ಯವಾದಷ್ಟು ಸಾವಯುವ ಗೊಬ್ಬರಗಳ ಬಳಕೆ ಮಾಡಬೇಕು. ಮಣ್ಣಿನಲ್ಲಿ ಕರಗುವ ಪೋಷಕಾಂಶ ಗೊಬ್ಬರಕ್ಕಿಂತ ನೀರಿನಲ್ಲಿ ಸುಲಭವಾಗಿ ಕರಗುವ ಗೊಬ್ಬರಗಳನ್ನು ಹನಿ ನೀರಾವರಿ ಮೂಲಕ ನೀಡಬೇಕು. ಇದರಿಂದ ಗಿಡಗಳು ಹೆಚ್ಚು ಬಲಿಷ್ಠವಾಗಿ ಬೆಳೆಯುತ್ತವೆ. ಜತೆಗೆ ಫಸಲು ಕೂಡಾ ಉತ್ತಮವಾಗಿ ಬರುತ್ತದೆ. ಇದರಿಂದ ಹೆಚ್ಚು ಲಾಭಗಳಿಸಬಹುದು ಎಂದರು.

ಕೀಟಶಾಸ್ತ್ರ ವಿಭಾಗದ ಮಾಜಿ ನಿರ್ದೇಶಕ ಡಾ. ಅಬ್ರಹಾಂ ವರ್ಗೀಸ್, ಸಿಎಲ್ ಮ್ಯಾನೇಜ್ ಮೆಂಟ್ ಮತ್ತು ಟ್ರೇಡಿಂಗ್ ಇಂಡಿಯಾ ಸಂಸ್ಥೆಯ ವ್ಯವಸ್ಥಾಪಕ ಎಸ್. ಪುರುಷೋತ್ತಮ್, ಶ್ರೀನಿಧಿ ಆಗ್ರೋ ಕೆಮಿಕಲ್ಸ್ ಮುಖ್ಯಸ್ಥೆ ಡಾ.ರಶ್ಮಿ, ರಾಘವೇಂದ್ರ, ಡಾ. ರಾಜೇಶ್, ರೈತ ಭಾರತೀಯ ಕಿಸಾನ್ ಸಂಘದ ಅಧ್ಯಕ್ಷ ನಾಗರಾಜಯ್ಯ, ಚಂದ್ರೇಗೌಡ, ಬೈರೇಗೌಡ, ನಂದಕುಮಾರ್, ರಾಜಣ್ಣ, ಪ್ರದೀಪ್, ಅಪ್ಪಸ್ವಾಮಿ ಇದ್ದರು.

ರಾಷ್ಟ್ರೀಯ ರಾಜ್ಯ ಅಂತಾರಾಷ್ಟ್ರೀಯ ಮುಖ್ಯ ಸುದ್ದಿ ಕ್ರೀಡೆಗಳು ಅಪರಾಧ/ಕಾನೂನು ಮನರಂಜನೆ ಇತರೆ

ಕೀಟ ಸಂರಕ್ಷಣೆಯ ಜಾಗೃತಿ,ಕೀಟ ಪರಿಸರವಾದಿ ಪ್ರಶಸ್ತಿ ಪ್ರಧಾನ

20 Dec 2022 20:30:05

Insect Environmentalist Awards
17th December 2022

ಬೆಂಗಳೂರು,20 ಡಿಸೆಂಬರ್(ಹಿ.ಸ):

ಆ್ಯಂಕರ್ :

ರಜತ ಮಹೋತ್ಸವದ ಅಂಗವಾಗಿ, ಕೀಟ ಪರಿಸರವು ಪ್ರಬಂಧ ಮತ್ತು ಛಾಯಾಚಿತ್ರ ಸ್ಪರ್ಧೆಯನ್ನು ಆಯೋಜಿಸಿತು, ಇದರಲ್ಲಿ ಅಧಿಕಾರಿಗಳು ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಗಳು ಸೇರಿದಂತೆ 121 ಸ್ಪರ್ಧಿಗಳು ಭಾಗವಹಿಸಿದ್ದರು. ಇವರಲ್ಲಿ ೪೫ ಮಂದಿ ಕೀಟ ಪರಿಸರವಾದಿ ಪ್ರಶಸ್ತಿಗಳಿಗೆ ಅರ್ಹರಾದರು.

ಈ ಪ್ರಶಸ್ತಿಗಳನ್ನು ಭಾರತ ಸರ್ಕಾರದ ಸಸ್ಯ ಸಂರಕ್ಷಣಾ ಸಲಹೆಗಾರ ಡಾ. ಜೆ.ಪಿ. ಸಿಂಗ್ ಅವರು ಕುವೈತ್ ನ ಸ್ಪರ್ಧಿಗಳು ಸೇರಿದಂತೆ ದೇಶದ ವಿವಿಧ ಭಾಗಗಳಂತಹ ವಿವಿಧ ಭೌಗೋಳಿಕ ಪ್ರದೇಶಗಳಿಂದ ಬಂದ ಎಲ್ಲಾ ಸ್ಪರ್ಧಿಗಳಿಗೆ ಇಲ್ಲಿ ವಿತರಿಸಿದರು.

ಸಸ್ಯ ಸಂರಕ್ಷಣಾ ಸಲಹೆಗಾರ ಡಾ.ಜೆ.ಪಿ.ಸಿಂಗ್, ಬೆಂಗಳೂರಿನ ಐಸಿಎಆರ್-ನ್ಯಾಷನಲ್ ಬ್ಯೂರೋ ಆಫ್ ಅಗ್ರಿಕಲ್ಚರಲ್ ಇನ್ಸೆಕ್ಟ್

Dr. Abraham Verghese as a resource person at "Conservation Biocontrol Training" for Assistant professors at Department of Entomology, Tamil Nadu Agricultural University, Tamil Nadu, India