Volume 25 (2) June 2022

ISSN 0975-1963

Insect Environment

Not-for-profit journal promoting Insect Science

Quarterly journal

Silver Jubilee Year

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
International Phytosanitary Research & Services (IPRS)

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

Editorial Board

***Cover Page: *Apoderus tranquebaricus* (Attelabidae) identified by Dr. Chitra N, Professor, Department of Entomology, Tamil Nadu Agricultural University.**
Photo by: Dr. Sevgan Subramanian,
Principle Scientist, International Centre of Insect Physiology and Ecology, Kenya

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 and ZooBank, ensuring global coverage.

Editorial processing fee per article for each author (Note all authors have to pay): India: Students Rs. 300, Others Rs. 400, Overseas 10 USD for each author, DOI charges per article Rs. 300.

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 related to Insect Environment to *einsectenvironment@gmail.com*

Disclaimer: The contents, style, language, plagiarism, data/tables, figures, photographs, line-drawings, references, mention of any products if any, etc., are the sole responsibility of the authors. We encourage downloading and printing of the articles for academic, teaching & extension purposes. However, authors and IE should be acknowledged.

Contents

Volume 25 (2) June 2022

IE Blog Contents

Sl. No.	Author/Authors	Date	Title of the blog
1	Abraham Verghese, Rashmi M. A	10-04-2022	First issue of silver jubilee year
2	Abraham Verghese	15-04-2022	The story of Insect Environment: Post Card to Web-posts
3	Abraham Verghese	24-04-2022	Conserving the blue banded bee, *Amegilla zonata*
4	Deepak. S	01-05-2022	3D imaging artificial compound eyes: Inspired by Insects
5	Abraham Verghese	22-05-2022	Insects Sustain Biodiversity
6	Abraham Verghese	29-05-2022	Where are the crows in the city?
7	Abraham Verghese	03-06-2022	The new mango borer: alert of 2016 is RED ALERT today!
8	Deepak. S	12-06-2022	Scarabaeus sacer: ‘KHEPRI’ god of ancient Egypt

Editorial

Insect Environment (IE) has been experiencing phenomenal growth in the last two years. The drivers are our authors and the myriad well-wishers in India and around the globe. Our research articles have been touching millions of viewers or rather viewers are making hits into our articles; thanks to CABI (UK), DOI and Research Gate. Many authors message me that interest in their papers from far flung corners of the globe, indeed, made them feel elated, while we felt, our labours were not in vain!

We were the first to whistle-alert *Thrips parvispinous* on chillies in South India through our blogs followed with a couple of articles (IE 24 (4), 2021). Talking of our blogs they have been short ento-thrillers, and every Monday blogs are auto-sent to a few thousands, around the world.

Nobody ever thought of giving amateur insect pictures a chance to see the light of the day. 'Big' journals would accept photographs, relevant to a paper that too with a lot of editorial fuss and sometimes as I have myself experienced, pretence to quality! At IE we make a difference- if an insect picture tells a story by itself or its *oikos* or has aesthetics (all insects, however drab are beautiful to us) we publish it. I am dazed, that android/iphone mobiles nearly capture insects with clarity and presentability, almost matching professional cameras! No wonder, mobile pixels and soft digitization have unfortunately shrunk the genre of camerapersons! But IE is lucky to still have a repertory of professional entomologist-photographers of the likes of Dr. D. N. Nagaraj, Dr. Sevgan Subramanian and many more, who frame excellent pictures to the last setae and bristle!. IE would have been poorer but for these "lens-persons," whose watchful eyes, rarely miss a fly! I am also happy to appreciate the efforts of Dr Thirupam Reddy from Jharkhand. His picture on gynandromorphy of tassar silk moth in this issue is mention-worthy.

Once more I reiterate IE is all about capturing the natural history of insects and their environment in words, data and pictures. This phase hopefully- the post-pandemic- is seeing revival of physical meetings. IE would be happy to collaborate in publicity, if poster-pictures are given well on time. It is always 'fun' to attend conferences/seminars in India, as the 'Indianness' and pluralism injected into such meets, deliver not only scientific discussions, but also unforgettable camaraderie, local cuisines and art-shows.

This was certainly not evident in many international meets I attended round the world. There are excellent discussions (business-style), paid water (!) especially in Europe, and future networking with peers take place only if they have something to gain.

Indians go beyond that (for we are large-hearted!) in generating hospitality and friendship.

In 2012, I attended the 'grand' entomological Congress in South Korea. The gathering was large with nine concurrent sessions. Even 10% of the participants could not be met in four days. Big registration fee, but no lunch or tea! We had to buy them. One of the Indian participants quipped, "Many donors, no food!" For us in India, food also decides the output of such meets! And it should be so always! (Ah: I am an indulgent foodie!) One exception has been Thailand. I have attended three international meets here, and all the time my sensuous enjoyment of Thai food has been a hallmark memory.

IE has always been favouring short research notes and observations of scientific value, and to capture important in-betweens of research, which many so called 'standard' journals loathe to publish. But articles of longer versions, mini-reviews, and exceptional reports of a group of Insecta have started streaming into IE websites, that our Editorial felt that IE should evolve to give readers a fair share of well written, qualitative, and discursive writing. I am sure commercial Meleponiculture by Stephen Devanesen will stimulate hiving of stingless bee, *Tetragonella* for pollination services in polyhouses. Those who adopt /recommend this please do give credit to his team from Kerala Agricultural University and ICAR. Likewise Aparna *et al's.*, Erebid moths of Lonavala and Bakra *et al's.*, ants of Sunderbans are very useful documentations of longer versions. All articles, finally accepted are notable and useful. I may point out the Butterfly Identification App (BIA) of Ramadevi *et al.* as a useful addendum to native libraries of schools and colleges. Articles/reviews on hormesis, immune priming, insect navigations, etc are useful reading and seminar topics for post graduate students.

We have more than 80 blogs in our websites which hardly lose their topicality as insects exhibit marvellous relevance in wider space and longer temporals.

IE has a unique professional refereeing systems. Our experiences tell us many "peer" reviewers are not up to the mark in gauging the spirit and philosophy of research contributions of authors, so tend to go by physical data in the guise of pretence to some standard! This is often found defeating creativity and stymieing originality in authors. So, our reviewers are mature scientifically empathetic subject-specialists, who goad especially youngsters into higher echelons of research. Many top-notch directors and scientists, vice chancellors and professors have all been once (and still are)

IE authors. So, it is a pleasant worthwhile experience to be an author in IE! So be our contributors, either as articles, blogs or pictures, as these behove well to a splendid career especially for youngsters in future.

So, welcome all, amateurs to professionals, to be part of insect information dissemination for a better entomological tomorrow!

My special thanks to Dr Romeno Faleiro, FAO Consultant, for hand-holding us through the entire editorial process. Not the least, my special gratitude to IE's anchor-person, Dr M A Rashmi for her multi-tasking-coordinating to get each issue in the web-light!

Dr. Abraham Verghese
Editor-in-Chief

Research articles

DOI: 10.55278/OYTG4218

Need for surveillance in case of the invasive thrips, *Thrips parvispinus* (Karny) on chilli (*Capsicum annuum*) (Including IPM recommendations)

Rashmi, M.A[1], Abraham Verghese[3] and Sireesha, K[2]

[1]Regional Plant Quarantine Station, Directorate of Plant Protection Quarantine & Storage, Bengaluru 560024 India

[2] Dr. YSR Horticultural University, Horticultural Research Station, Lam, Guntur, Andhra Pradesh522002 India

[3]Former Director ICAR-NBAIR, Former Head Entomology ICAR-IIHR, 560089 Bengaluru India

Corresponding author: rashmigowda.ento@gmail.com

The objective of this article is to sensitize all chilli growers and stakeholders n the light of the recent outbreak of the invasive thrips, *Thrips parvispinus* (Karny) on chilli (*Capsicum annuum*) in Andhra Pradesh, Telangana and Karnataka in 2021 (Sireesha *et al*., 2021, Anitha *et al*., 2021 and Nagaraju *et al*., 2021). There is an urgent need for a coordinated surveillance across the country in all the chilli growing areas.

Ever since Mound and Collins (2020) reported the presence of the South-East Asian thrips, *Thrips parvispinus* (Karny) (Thysanoptera: Thripidae) on *Gardenia* plants in Greece, the fear of it traversing through the Indian sub-continent was not ruled out. Basically, a species of SE Asia with regional distribution starting from Thailand, Malaysia to New Guinea and northern Australia, its introduction to Greece was mainly through flowers of *Gardenia* sp. from Indonesia (Johari *et al.*, 2014). Though a serious pest on chilli, it has also been reported on, papaya (Hawaii) beans and solanaceous crops like chilli, potato, brinja (Murai *et al.*, 2009). In India, the alarm bells were rung when Tyagi *et al*. (2015) recorded *T. parvispinus* on papaya in Bengaluru, Karnataka. Subsequently, Rachana *et al.* (2018) and Roselin *et al.* (2021) reported *T. parvispinus* in 2018 on ornamental, *Dahlia rosea*, from Karnataka, India. These two Indian reports amply confirmed that *T. parvispinus* has come to stay and would infest economically important crops, especially chilli (Figs 1 & 2).

The earliest incidence of *T. parvispinus* was noticed in major chilli growing mandals of Andhra Pradesh *ie.* Chilakaluripeta and Prathipadu (16.09N 80.16E and 16.16N 80.22E) during January 2021, when chilli crop was at harvesting stage and subsequently in other major chilli growing mandals (Sireesha *et al*, 2021). The infestation peaked in the next crop between November and December 2021 (K. Sireesha *et al*., 2021, Anitha *et al*., 2021 and Nagaraju *et al*., 2021). Andhra Pradesh is the largest producer of chilli and contributes 38%, whereas Guntur alone contributes 15 %

of total production in India[6]. In Guntur district. chilli is cultivated in an area of 1,06,656 ha. Here the loss is estimated at 12% of the cropped area (uprooted) and about 50% yield loss on an average (Sireesha *et al.*, 2021).

As chilli is an important domestic and export market crop that is grown extensively as mono-crop in Andhra Pradesh, Telangana and Karnataka together comprising >70% area of the country strict surveillance is 2022 is advocated during the future seasons, using visual and trap catch documentation and additionally in all chilli growing areas.

The risk of *T. parvispinus* potentially able to spread and infest crops in neighbouring chilli growing states in India and in neighboring countries like Sri Lanka, Nepal, Bhutan and Myanmar, cannot be ruled out. An added threat is to capsicums grown in greenhouses, on which too it has been reported (Tan *et al.*, 2015). So, networked surveillance to forewarn farmers and exporters, to lower risk of loss is a high priority.

Integrated control advisory for thrips complex in chilli

1. Seed treatment with Imidacloprid WS@ 12 gm/Kg
2. Drenching liquid Arka Microbial Consortium (AMC) @ 5ml/litre in seed beds and prior to transplanting in main field (This is a product of ICAR-IIHR, Bangalore)
3. Add neem cake @200Kg/acre at transplanting along the rows of the plants
4. Spray Rashvee liquid herbal volatile soap @ 3 ml/litre, 2 weeks after transplanting or neem soap (IIHR) 5-10gms /litre
5. After two weeks of above, spray Rashvee liquid herbal volatile soap @ 3ml/litre or pongamia soap (IIHR) @ 5-10gm/litre
6. Spray vegetable special (IIHR), one month after transplanting @5gm/litre (This can be repeated before flowering).
7. Erect 50 blue sticky traps/acre one month after transplanting
8. If thrips become serious, spray Fipronil 5SC @ 1.5ml/litre
9. Spray delivery should be rotated from below to top, to ensure spray droplets also falling on underside of the leaves
10. After fruit set, if needed spray safer biopesticides as indicated above
11. mbination of Entomopathogenic Nematode+ Beauveria + Metarhizium + Verticillium has shown good results in reducing adults by infecting prepupae and pupae
12. If a second insecticidal spray is required (under expert advice only) Emamectin Benzoate 5% WG @0.4gm/lit or Spinosad @0.3 ml/litre may be given
13. Try to intercrop - for every 20 rows of chillies, one row of tomato.

14. Growing tall maize crops or Sesbania along the borders will reduce immigrating adult population

Acknowledgements. We thank IPRS for helping in the study. Our thanks to the Plant Protection Advisor for encouragement. We thank Dr. R. R. Rachana, of ICAR-National Bureau of Agricultural Insect Resources (NBAIR) for identification of the thrips.

Fig. 1: *Thrips parvispinus* adults on chilli flower

Fig. 2: Chilli crop highly infested with invasive thrips

Reference

Mound, L. A. & Collins, D.W. 2000, A South East Asian pest species newly recorded from Europe: *Thrips parvispinus* (Thysanoptera: Thripidae), its confused identity and potential quarantine significance. *Eur. J. Entomol.*, 97, 197–200.

Johari, A., Herlinda, S., Pujiastuti, Y., Irsan, C. & Sartiami, D., 2014, Morphological and genetic variation of *Thrips parvispinus* (Thysanoptera: Thripidae) in chilli plantation (*Caspicum annuum* L.) in the lowland and highland of Jambi Province, Indonesia. *AJBIO*., 2, 17-21.

Tyagi, K., Kumar, V., Singha, D. & Chakraborty, R., 2015, Morphological and DNA barcoding evidence for invasive pest thrips, *Thrips parvispinus* (Thripidae: Thysanoptera), newly recorded from India. *J. Insect Sci.*, 15(1), 105.

Rachana, R.R., Roselin, P. & Varatharajan, R., 2018, Report of invasive thrips species, *Thrips parvispinus* (Karny) (Thripidae: Thysanoptera) on *Dahlia rosea* (Asteraceae) in Karnataka. *Pest manage. hortic. ecsyst.*, 24(2), 187–188.

Tan, J. L., Chuanooi P. A and Khoo, G, 2016, Thrips on eggplant, chilli and bell pepper in cameron highlands, Malaysia. *Serangga*, 21(1), 71-85.

Spice Board, 2022, http://www.indianspices.com/spice board.

Roselin, P., Kuldeep Sharma. & Rachana, R.R. (2021). Diversity of floral thrips from Western Ghats of Karnataka. *Indian j. entomol.,* 83(3), 407–410.

K. Sireesha, B. V. L. Prasanna, T. Vijaya Lakshmi and R.V.S.K. Reddy, 2021, Outbreak of invasive thrips species *Thrips parvispinus* in chilli growing areas of Andhra Pradesh. *Insect Envt*., 24 (4), 514-519.

D. Anitha Kumari, K. Bhasker and V. Suresh, 2021, A new invasive chilli thrips (*Thrips parvispinus*) in Telangana State. *Insect Envt*., 24 (4).520-522.

Nagaraju, D. K., Uppar, V., Ranjith, M., Sriharsha, Ramesh, G., Verma, O, P., Prakash, R., 2021, Occurrence of *Thrips parvispinus* (Karny) (Thripidae: Thysanoptera) in major chilli growing areas of Karnataka. *Insect Envt*., 24 (4).523-532.

Murai, T., Watanabe, H., Toriumi, W., Adati, T. and Okajima, S. 2009. Damage to vegetable crops by *Thrips parvispinus* Karny (Thysanoptera: Thripidae) and preliminary studies on biology and control. *J. Insect Sci.,* 10: 166.

MS Received 28 April 2022
MS Accepted 13 May 2022

DOI: 10.55278/GIRU6255

Association of the elusive Fulgorid bug, *Pyrops delesserti* Guérin-Méneville, 1840 (Hemiptera: Fulgoromorpha: Fulgoridae) with pithraj tree *Aphanamixis polystachya* (Meliaceae): an observation from Kerala

Gavas Ragesh [1]*, Tom Cherian[2], Milu Mathew[2] and D.K. Nagaraju[2]
[1] ICAR-AICRP on Fruits, Banana Research Station, Kerala Agricultural University, Kannara (P.O), Thrissur- 680652, Kerala, India*
[2] Central Integrated Pest Management Centre, Directorate of Plant Protection, Quarantine & Storage, Block A, First Floor, Kendriya Bhavan, Kakkanad, Kochi – 682037, Kerala,India
* ***Corresponding author: gavas.ragesh@kau.in***

Introduction

Laternflies, the spectacularly coloured large planthoppers belong to the family Fulgoridae Latreille, 1807 (Hemiptera Linnaeus, 1758, Fulgoromorpha Evans, 1946) and has about 774 species in 142 genera according to the FLOW database (Fulgoromorpha Lists On the Web – Bourgoin, 2022). Mostly distributed in the wet tropics of the globe, these true bugs have caught the attention and imagination of scientists, and bug enthusiasts (Constant & Pham, 2022).

The genus *Pyrops* Spinola, 1839 a member of the family Fulgoridae is set apart from other Fulgoromorphs by the presence of their typical elongated, upward curving cephalic process (Constant, 2015) and has nearly 70 species described so far (Constant & Pham, 2022). It is widely distributed in South East Asia, from Sri Lanka to the Himalayas (north India, south China), eastwards to Taiwan and Vietnam, and southwards to Sulawesi and neighbouring islands through Indonesia and the Philippines (Constant, 2015).

In India, three *Pyrops* species are currently recorded from the Andaman and Nicobar archipelago *viz*., *Pyrops andamanensis* (Distant, 1880), *P. rogersi* (Distant, 1906) and *P. azureus* (Constant & Mohan, 2017). *Pyrops delessertii* (Guérin Méneville, 1840), the fourth one is recorded from southern India (Constant & Mohan, 2017).

Dearth of information on their biology, natural history and host plant association still remains poorly documented except for a few species (Constant & Pham, 2022; Bourgoin, 2022). Hence efforts were taken to shed some light into sightings of these beautiful bugs especially *Pyrops delessertii* in Kerala during 2020-2022.

Materials and methods

Purposive surveys were carried out into areas where presences of rare or elusive fulgorid insects were reported by the farmers or officials of the Department of Agriculture and Farmers welfare in the Idukki district of Kerala state, south India. Efforts were taken to visually identify and confirm the specimens/reports through the photographs given by the farmers or with the information gleaned from the conversations with them to remove misinformation. Live insects were located and their activities were continuously observed and documented without hampering their natural activities. After a reasonable period ranging from few weeks to months of observation, couple of specimens was collected for confirmation of species identity with the help of an expert or available literature. The specimens were pinned and dried for preservation for further studies. Meticulous recording of insect behavior and host plant association were done. Pictures were taken with a Canon EOS 700 D camera with Canon Macro 100 mm lens and Canon EFS 50-250mm zoom lens.

Results and discussion

Heightened attention and media frenzy generated around the invasion of desert locust (*Schistocerca gregaria*) into Indian subcontinent and the emergence of large masses of coffee locust (*Aularches miliaris*) with bright warning colours in the state of Kerala, drove many to report unique insects that they saw. In one such incidence, a farmer confusing the aggregation of brightly colored lanternflies on a tree in his mixed cropping system, as swarms of adult coffee locust took the drastic steps of killing them. On receipt of the information and the picture of the insect through WhatsApp, quick purposive surveys were conducted to the locality (Nariyampara, Idukki district; 9.7424° N, 77.0939° E).

Adult lanternflies were observed in groups of 3-9 individuals per group. They were observed to remain still at the same spot for more than 3 hours if undisturbed. They were later identified as *Pyrops delesserti* Guérin-Méneville, 1840. Most of the vivid earlier records pertaining to these bugs were made under the name *Fulgora delesserti* especially on their morphology, morphometrics etc (Distant, 1906, Delessert, 1843 and Atkinson, 1885). This species was recorded from Western Ghats of southern India with specific reference on Nilgiris-Malabar, Karwar and Trivandrum (Distant, 1906) and mostly prefers riverine forests (Delessert, 1843).

We could not collect or record any nymphal stages of the insect. In adult insects, cephalic process and head is greenish or brownish with white mottling. Thorax is brown with red bands at the base of the neck. Forewings/tegmina are black with reticulate venation with numerous ochraceous spots arranged in three transverse bands at the basal half with apical one more scattered. The hind wings are bluish green with a broad black border along the margin.

The wild trees on which congregations of *Pyrops delesserti* were observed was locally known as *Chemmaram* in vernacular (Malayalam) language. Commonly called as pithraj tree (*Aphanamixis polystachya*), these evergreen trees grow to 20 m height having reddish-brown bark mottled with green. It is widely used for therapeutic uses (Mishra, 2014) and is native to SAARC countries especially India. Even though genus *Pyrops* is well represented by many large specimens with brilliant colours globally, the specimens are hard to collect for their timid nature and long flight on slight disturbance. *Pyrops delessertii* was no exception to this behaviour, which made the documentation of their activities more difficult. The adult lanternflies when disturbed flew away from the host tree to large distances, but returned to the same tree after a gap of 20- 50 minutes. It is curious to note that the bugs dutifully returned to the same tree which stood in the middle of large assorted group of trees. This strongly points to the close affinity of the bugs to *Aphanamixis polystachya*.

Even though excretions of honey dew by the fulgorids and consequent trophobiosis with gecko and cockroaches was already recorded with *Pyrops whiteheadi* and *P. intricatus* (Constant, 2015), we could observe only opportunistic attendance by ants in the case of *P. delessertii*.

Further dedicated surveys and observations are to be made to record various nymphal stages, host plants, trophobiosis associations and life cycle of this beautiful bug.

Acknowledgement

Authors sincerely thank Dr. Yeshwanth H. M. of Department of Entomology, University of Agricultural Sciences, Bengaluru for confirming the species identity and Dr. Jérôme Constant of Royal Belgian Institute of Natural Sciences, Brussels, Belgium for his constant support, affable nature and sharing valuable literature on the lanternflies, and for his immense contribution to the understanding these elusive natural beauties.

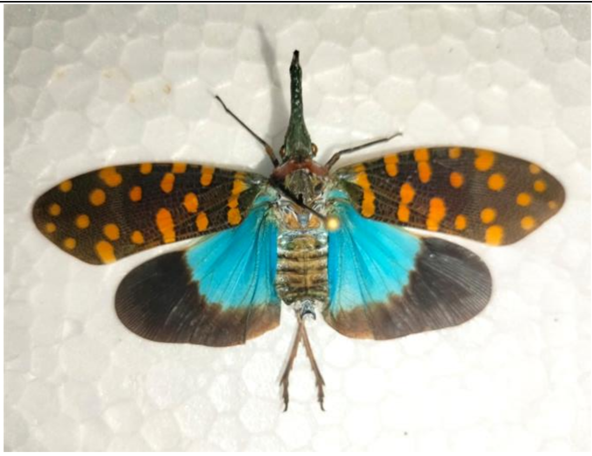


Fig 1: *Pyrops delessertii* Habitus, dorsal view

Fig 2: *Pyrops delessertii* Habitus, ventral view

Fig 3: *Pyrops delessertii* on *Aphanamixis polystachya*

Fig 4: *Pyrops delessertii* aggregation *Aphanamixis polystachya*

References

Abhay Prakash Mishra, Sarla Saklani, Subhash Chandra, Abhishek Mathur, Luigi Milella, Priyanka Tiwari. 2014. *Aphanamixis polystachya* (wall.) Parker, phytochemistry, pharmacological properties and medicinal uses: an overview. World Journal of Pharmacy and Pharmaceutical Sciences. 3: 2242–2252.

Atkinson, E.T. (1885). "Notes on Indian Rhynchota. No 4". Journal of the Asiatic Society of Bengal: 127–158.

Bourgoin T. 2022. FLOW (Fulgoromorpha Lists on The Web): a world knowledge base dedicated to Fulgoromorpha. Available from http://hemiptera-databases.org/flow/ [accessed 12 June, 2022]

Constant J. 2015. Review of the effusus group of the Lanternfly genus *Pyrops* Spinola, 1839, with one new species and notes on trophobiosis (Hemiptera: Fulgoromorpha: Fulgoridae). European Journal of Taxonomy 128: 1–23.

Constant J. & Mohan A.V. 2017. "The lanternflies from Andaman and Nicobar: one new *Pyrops* species, new records and illustrated key to the species (Hemiptera: Fulgoromorpha: Fulgoridae)". Belgian Journal of Entomology. 49: 1–24.

Constant J. & Pham H.T. 2022. The Lantern fly genus *Pyrops* in Vietnam: A new species from Central Vietnam, taxonomic changes, checklist, identifi cation key (Hemiptera: Fulgoromorpha: Fulgoridae). European Journal of Taxonomy 813: 123–154. https://doi.org/10.5852/ejt.2022.813.1741

Delessert A. (1843). *Souvenirs d´un voyage dans l´Inde exécuté de 1834 à 1839*. Paris: Bétrune et Plon for Fortin, Masson et Cie & Langlois et Leclerq. p. 66.

Distant, W.L. (1906). Fauna of British India, including Ceylon and Burma. Rhynchota. Volume 3. London: Taylor and Francis. pp. 189–190.

Spinola M .1839. Essai sur les Fulgorelles, sous-tribu de la tribu des Cicadaires, ordre des Rhyngotes. Annales de la Société Entomologique de France. Paris 8: 133-337 [231]

MS Received 26 April 2022
MS Accepted 10 June 2022

DOI: 10.55278/URCL8831

Exotic storage pests intercepted in raw cashew nuts shipments imported into India and cost of salvaging the intercepted material

D. K. Nagaraju*, D. Iyyanar, Maharaj Singh, T. Prema Ranjitham, N. Kasturi, B. Esakkirani, Om Prakash Verma and Ravi Prakash
Directorate of Plant Protection Quarantine and Storage, NH-IV, Faridabad 121 001, India.
Corresponding author: dkn.raju@gov.in

India is the largest producer, processor and exporter of cashew kernels. India consumes nearly 32% of cashew produced in the world. Cashew ranks high among the Agri-horticultural commodities exported from India, thereby earning foreign exchange to the tune Rs. 4000 crores per annum. Cashew is grown in Kerala, Karnataka, Goa and Maharashtra along the West coast, and Tamil Nadu, Andhra Pradesh, Orissa and West Bengal along the East coast. Cashew is also being cultivated in Chattisgarh, North Eastern states like Assam, Manipur, Tripura, Meghalaya and Nagaland and Andaman and Nicobar Islands to limited extent.

In India, nearly 14 lakh tones of cashew nuts are processed as against annual production of 7 lakh tones. To bridge the gap, India imports raw cashew nuts from different countries. The Indian cashew industry is almost export-oriented; more than 3900 processing units are functioning in India under the organized and unorganized sector. These processing units provide sustainable employment opportunities to 1.5 million people in processing and agrarian sector, especially women thereby contributing substantiality to the rural economy. The raw material availability is the major challenge for cashew processing units. The domestic production of cashew nut meets half of the demand by cashew processing units, while the remaining is met through imports. Over 15 African and Asian countries exported raw cashew to India were cleared from Plant Quarantine Station, Tuticorin, Tamil Nadu alone. The present study records the storage pests intercepted in the raw cashew nuts imported from different countries.

The Plant Quarantine (Regulation of Import into India) Order 2003 issued under Destructive Insects & Pests Act, 1914 (Act 2 of 1914), Government of India regulates the import of all agricultural commodities into India. Imported raw cashew shipments were inspected as per provisions of Plant Quarantine Order. Ship loads of raw cashew nuts are being imported either in bulk or in gunny bags in shipping containers. Consignments in containers were inspected by partially opening the door and examined for flying insects. The outside of gunny bags were examined for any crawling insects. The bags were opened and the interior of the gunny bags were examined. The random samples drawn were spread on a white sheet and examined for insect infestation. The insects thus intercepted were collected in 70% ethanol for identification. The specimens were sent to the National Bureau of Agricultural Insect Resources (NBAIR), Bangalore for identification.

The raw cashew nuts imported from different countries were intercepted with four species of storage pests namely, *Ahasvesus advena* (Waltl.) (Coleoptera: Silvanidae), *Cryptolestes ferrugineus* (Stephens) (Coleoptera: Cucujidae), *Ephestia cautella* (Walker) (Lepidoptera: Pyralidae) and *Carpophilus* sp. (Coleoptera: Nitidulidae) (Fig. 1).

Shipments from Madagascar and Mozambique were free of *A. advena;* those of Cote d Ivoire, Madagascar, Tanzania and Togo were free of *Carpophilus* sp. and shipments from Burkina Faso were free of *C. ferrugineus. Ephestia cautella* infestation was found in shipments of all the 15 countries. Of the insects intercepted, *A. advena* was not known to occur in India, with *C. ferrugineus* having limited distribution.

During 2018–2020, 8,600 shipments of raw cashew nuts weighing 864,055 MT were imported from 15 countries. More than 80% of the shipments were imported from seven countries namely Benin, Burkina Faso, Cote d Ivoire, Ghana, Guinea, Guinea Bissau and Senegal. Of the total shipments imported, 370 shipments were intercepted with at least one storage insect and the extent of interception ranged a minimum of 0.67 to a maximum of 10% (Table 1).

Intercepted shipments were observed to be infested by multiples species of insects. Shipments from Madagascar were intercepted with only two species of insects, those from Togo, Tanzania, Mozambique, Burkina Faso were infested by three species. All the four species of storage insects intercepted were found in shipments from Senegal, Nigeria, Mali, Indonesia, Guinea, Ghana, Gambia, Cote d Ivoire and Benin (Fig. 2).

The intercepted raw cashew nuts were recommended for fumigation with methyl bromide @ 32 g/m^3 for 24 hours at Normal Atmospheric Pressure (NAP) (PQ Order 2003). In India, fumigations are being carried out by the Pest Control Operators (PCOs) accredited by the Directorate of Plant Protection Quarantine and Storage as per the guidelines issued under National Standard for Phytosanitary Measures (NSPM) – 12 (DPPQS, 2022). The shipments are re-inspected after 24 hours of fumigation and released for use, if found free of live infestation.

Such interceptions and subsequent fumigations add to the cost of the imported shipments and become expensive to the consumers. The approximate market rate of fumigating a 20’ container is Rs. 1500/-. At this rate, importers altogether might have spent approximately Rs. 28,09,500/- (Twenty-Eight Lakhs Nine Thousand and Five Hundred) towards treating the infested raw cashew nuts. Such consignments are re-inspected after 24 hours of fumigation to check for pest freedom, which is additional man power and cost. The cost is exclusive of container retention charges. In addition, the infested material has to be on hold for at least 24 hours, which has the cascading effect on the processing industries. Above all, methyl bromide is an Ozone depleting substance, use of which has been restricted except for Plant Quarantine purposes. Interception of insects in the imported shipments leads to use of methyl bromide on the Indian shores, which adds to the cost of imported shipments and environmental pollution (Table 2).

Under India's ambitious "One District One Product (ODOP)" program seven districts of four states namely Andhra Pradesh (Srikakulam), Assam (South Salmora), Chhttisgarh (Kondgaon), Meghalaya (West Garo Hills), Tamil Nadu (Ariyalur, Cuddalore and Pudukottai) are identified for processing of raw cashew nuts. The imported shipments are moved within country to different processing industries located in different states. Intercepted insects are storage pests and exotic, which contaminate the storage products in these processing industries ultimately leading to output of processed products.

Ahasverus advena is found in Angola, Ethiopia, Lesotho, Malawi and Nigeria. Bangladesh, Indonesia, Malaysia, Philippines, Singapore and Sri Lanka in Asia. Widespread in Bangladesh and Sri Lanka. This species occurs on a wide variety of food stuffs, including grains, cereal products, oil seeds and their products, dried fruit, and spices. *Cryptolestes ferrugineus* found in Chad, Egypt, Ethiopia, Kenya, Namibia, Nigeria, Somalia, Sudan, Zimbabwe. Bangaldesh, India (Andhra Pradesh and Haryana), Japan, Saudi Arabia, Singpore, South Korea, Sri Lanka, Taiwan, Turkey, Vietnam. Their original native habitat was probably under the bark of trees and shrubs but they have adapted to commodities in storage including wheat, barley, flour, peanuts, sorghum, oilseeds, cassava root, dried fruits, chillies (CABI, 2022). *Carpophilus*, also known as driedfruit beetles, are a worldwide pest of fruits, both pre- and post-harvest, and grains. Driedfruit beetles attack a wide variety of hosts including stone fruit, persimmons, fallen citrus, apples and figs. Adult carpophilus can cause feeding damage on ripening stone fruit and is a vector of the fungal disease brown rot. Most commercial feeding damage is done to ripening stone fruit. Stone fruit can be attacked on the tree, beetles burrow into the fruit, particularly near the stem end suture line. They also enter through splits and mechanical damage. In other fruits such as citrus, apples and figs, only fallen fruit is attacked (DPIRD, 2022).

Interception of large number of exotic storage insects in the imported shipments indicates the poor crop management and storage conditions in the country of origin, failure of plant quarantine inspections carried out by the NPPOs of exporting countries, and fumigation failure, if carried out. Such instances have to be promptly brought to the notice of the exporting countries as per international norms and plant quarantine inspectors at the point of entry should always be alert while inspecting such consignments. The intercepted insects are biosecurity risk to India. Therefore, all imported shipments intercepted with storage pests were fumigated using Methyl Bromide @ 32 g/ m3 for 24 hrs at Normal Atmospheric Pressure (NAP). The treated shipments were re-inspected prior to release to ensure they were free of live infestation. The non-compliances were notified to the trading partners on each interception as per the guidelines in the ISPM-13.

Acknowledgements

The authors are thankful to Dr. K. Sreedevi, Principal Scientist, National Bureau of Agricultural Insect Resources (NBAIR), Bangalore for identification of insects. We also thank the Plant Protection Advisor, Directorate of Plant Protection, Quarantine and Storage, Faridabad for facility and encouragement. The support extended by staff of PQS, Tuticorin is duly acknowledged.

Table 1. Raw Cashew nuts imported and intercepted with storage insects during 2018–2020.

Country	Import		Interception	
	# Shipments	Quantity (MT)	# Shipments*	Quantity (MT)
Benin	594	46,050	36 (6.06)	3,484
Burkina Faso	460	33,287	15 (3.26)	1,288
Cote d Ivoire	1,664	196,227	70 (4.21)	7,357
Gambia	236	16,416	18 (7.63)	1,274
Ghana	2,013	190,080	56 (2.78)	4,123
Guinea	677	60,346	47 (6.94)	5,566
Guinea Bissau	813	127,258	37 (4.55)	3,056
Indonesia	223	18,581	3 (1.35)	710
Madagascar	30	1,483	3 (10)	260
Mali	9	571	5 (55.56)	275
Mozambique	167	21,432	9 (5.39)	1,393
Nigeria	909	60,950	50 (5.50)	3,532
Senegal	306	34,561	17 (5.56)	1,908
Tanzania	297	44,385	2 (0.67)	865
Togo	202	12,428	2 (0.99)	2,364
	8,600	**8,64,055**	**370**	**37,455**

* Figures in parenthesis are percentages

Table 2. Cost of salvaging the infested material

Infested Raw Cashew	# 20' Containers (@ 20 MT/Container)#	MBR used @ 32 g/m^3 (Volume of one 20' Container is 33 CuM)*	Amount spent on fumigation (Rs. 1500/20' Container)**
37,455 MT	1873 No.	2019 kg.	Rs. 28, 09, 500/-

Note: Values are indicative for the purpose of calculating approximate cost of salvaging the infested material. # Each 20' container can hold 16-20 MT of raw cashew nuts and raw cashew nuts imported in shiploads is also converted to container volume for ease of calculation. *Actual volume increases based on the sheeting skill of the fumigation operator. ** PCO's approximate market cost of fumigating a 20' container is Rs. 1500.

Raw cashew nuts in gunny bags in containers

Visual examination

Drawal of primary samples

Live beetles crawling on bags

Ahasversus advena (Waltl.)
(Coleoptera: Silvanidae)

Carpophilus sp. (Coleoptera: Nitidulidae)

Cryptolestes ferrugineus (Stephens) (Coleoptera: Laemophloeidae).

Ephestia sp. (Lepidoptera: Pyralidae).

Fig. 1. Inspection and intercepted insects on raw cashew nuts imported from different countries.

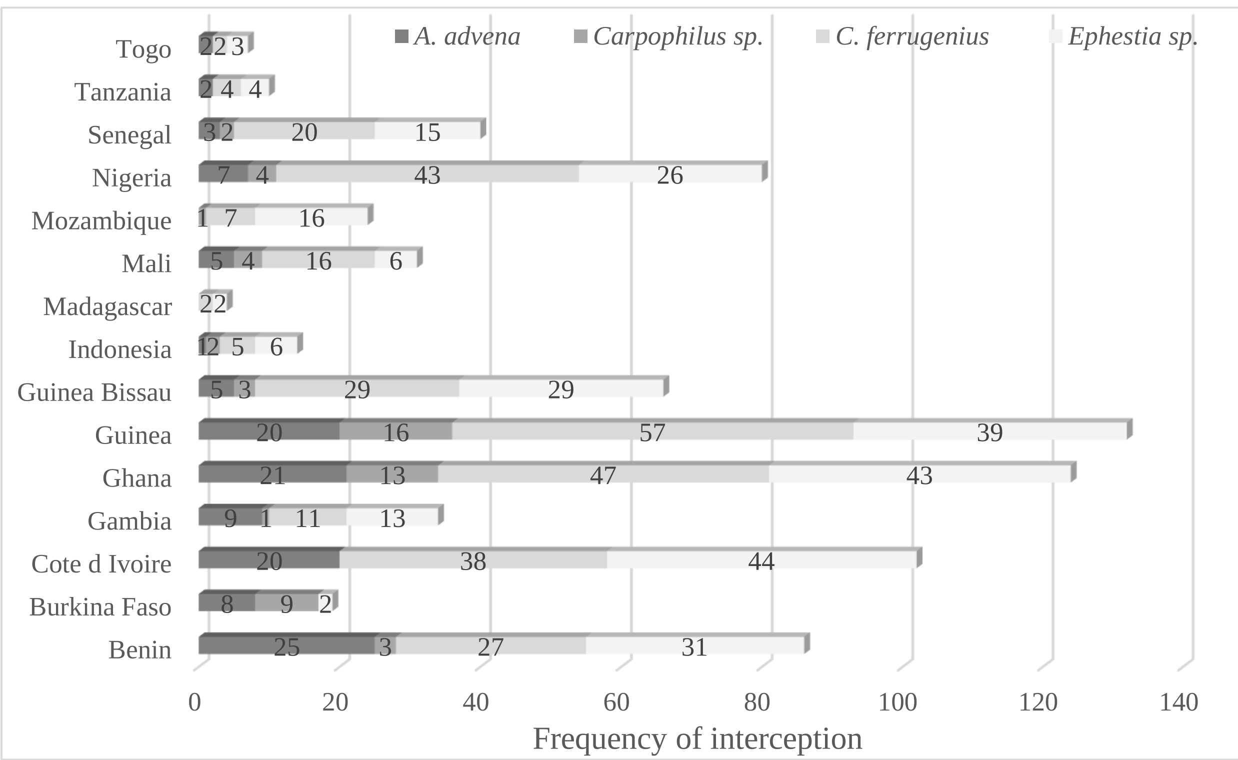


Fig. 2. Frequency of storage pests intercepted in raw cashew nuts.

References

CABI 2022. https://www.cabi.org. (Accessed 24 May 2022).

DPIRD (Department of Primary Industries and Regional Development), 2022. https://www.agric.wa.gov.au/citrus/dried-fruit-beetle-carpophilus-pest-stone-fruit. (Accessed 24 May 2022).

Directorate of Plant Protection, Quarantine & Storage (DPPQ&S). 2022. https://plantquarantineindia.nic.in (Accessed 30 May 2022).

ICAR-DCR 2015. Insects pests of cashew and their management, ICAR-Directorate of Cashew Research, ICAR-DCR Technical Bulletin No. 2. pp. 70.

Plant Quarantine (Regulation of Import into India) Order 2003 and its amendments. *The Gazette of India* Part II; Section-3; Sub-section (ii) published by the Ministry of Agriculture and Farmers Welfare (Department of Agriculture and Farmers Welfare) Notification, New Delhi dated 18th November, 2003.

MS Received 16 April 2022
MS Accepted 01 June 2022

DOI: 10.55278/JXFA9798

Heavy incidence and damage by *Rastrococcus mangiferae* (Green) Ferris in mango

S. Kowsika*, R. Divya, N. Dilipsundar and N. Chitra
Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore- 641 003, Tamil Nadu, India
Corresponding author: kowsikaentomology@gmail.com

Mango (*Mangifera indica* L.) the 'King of Fruits' is an important fruit crop in tropical and subtropical countries of the world. Mango is vulnerable to a variety of pests including insects, mites, pathogens and vertebrates. Mango originated from Indo-Burma region and is cultivated in India, China, Thailand, Mexico, Pakistan, Philippines, Indonesia, Brazil, Nigeria and Egypt. India contributes about 50% of the world's mango production with 2.5 million hectares with an annual production of 18.0 million tons (Reddy *et al.*, 2018). Insect pests pose a valid threat to sustainable cultivation of mangoes. An elaborate compilation of insect pests in mango indicates around 400 species of insect pests from different parts of the world (de Laroussilhe 1980; Tandon and Verghese 1985; Veeresh 1989; Pena *et al.* 1998). Among the insects sucking pests (leafhoppers, mealybugs, scales, thrips) and mites form a larger group causing huge yield loss. Sucking insects with shorter life cycles and ability to reproduce asexually result in their huge abundance. Further, frequent outbreaks owing to climatic variation pose serious challenge through both direct and indirect losses (Jayanthi *et al.*, 2014).

Approximately 20 species of mealybugs are reported to infest mango. Among them, *Drosicha mangiferae* (Green), *D. stebbingi* (Green), and *Rastrococcus iceryoides* (Green), are considered to be serious pests and are more frequently reported. They are widely distributed in India, Nepal, Bhutan, China, Pakistan and Bangladesh. *R. iceryoides* is also reported from Malaysia (Tandon and Verghese 1985). Under genus *Rastrococcus* of the 22 species described, three species, *R. invadens* Williams, *R. iceryoides* (Green) and *R. mangiferae* (Green) are documented in mango from India (Narasimham and Chacko, 1988 and 1991).

A survey was conducted in February, 2022 at Tamil Nadu Agricultural University (TNAU) orchard (11.005567 N, 76.930086 E). Fifty to sixty years old trees were observed with heavy infestation of the ornate mealybug species completely covering the foliage. Population densities of the mealybug were noted to be significantly higher in the mango trees on the abaxial leaf surface; approximately 10 to 15 numbers/cm^2 was observed. Infestation was severe on older leaves later shift towards young tender leaves was noticed. Appearance of sooty mold on leaves and parasitized mealybug cadavers with exit holes were also observed.

Externally adults were observed to be oval in shape with dorsum pale yellow and with thick white mealy coating. Stout cottony tassels are seen on the margin, increasing in length from anterior to posterior end. Both immatures and adult were present with 30 prominent wax tassels.

The collected specimens were slide mounted based on the protocol given by Bahder *et al.,* (2015) with slight modifications and observed under phase contrast microscope LEICA DM750. Based on the following characters: antennae slender with 9 segments, circulus oval shaped situated in middle of third abdominal segment, posterior pair of ostioles, anal ring situated a short distance from apex of abdomen, cerarii numbering 15 pairs, each on a more or less round to oval sclerotized base, larger in area than anal ring, trilocular disc pores being present in a ventral marginal zone on thorax, the specimen was identified to be *R. mangiferae* which was in concurrence with the key to species of *Rastrococcus* provided by Williams, 1989.

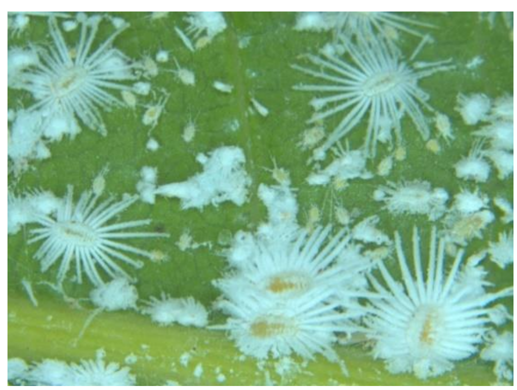
The incidence of *R. mangiferae* was reported from Coimbatore India by Ramakrishna Ayyar on mango in 1914. Narasimham and Chako (1988) have reported this species to be more common in southern India than *R. invadens*. If left unnoticed this pest may lead to significant loss in size and weight of fresh mangoes and become a growing threat to mango orchards.

Rastrococcus mangiferae **found on the abaxial leaf surface**

Female

Male

Parasitized



Unparasitized

Rastrococcus mangiferae **(Green) Ferris 1954**

References

Bahder, B.W., Bollinger, M.L., Sudarshana, M.R. and Zalom F.G. 2015. Preparation of Mealybugs (Hemiptera: Pseudococcidae) for Genetic Characterization and Morphological Examination. *J. Insect Sci.,* **15**(1): 104.

de Laroussilhe F. 1980. Le Manguier. G.P. Masoneuve and Larose, Paris.

Ferris, G.F. 1954. Report upon scale insects collected in China (Homoptera; Coccoidea). Part V. *Microentomology,* **19:** 51-66.

Jayanthi, P.D.K., Verghese, A., Arthikruba, A., Sowmya, B.R. and Bhatt, R.M. 2014. Emerging pests of mango under changing climate scenario. Technical bulletin no. 18. Indian Institute of Hortricultural Research, Bengaluru.

Narasimham, A.U. and Chacko, M.J. 1988. *Rastrococcus* spp. (Hemiptera: Pseudococcidae) and their natural enemies in India as potential biocontrol agents for *R. invadens* Williams. *Bulletin of Entomological Research*, **78**:703-708.

Narasimham, A.U. and Chacko M.J. 1991. The distribution of some Rastrococcus spp. (Homoptera: Pseudococcidae) on mango in India. *Bulletin of Entomological Research,* **81:** 445-448.

Pena, J.E., Mohyuddin, A.I. and Wysoki, M. 1998. A review of the pest management situation in mango agroecosystems. *Phytoparasitica*, **26**: 129–148.

Reddy, P.V.R., Gundappa, Chakravarthy, A.K. 2018. Pests of mango. In: Omkar (ed) Pests and their management. Springer, Singapore.

Tandon, P.L. and Verghese, A. 1985. World list of insect, mite and other pests of mango. Technical document. Indian Insistute of Horticultural Research, Bengaluru, p 5.

Veeresh, G.K. 1989. Pest problems in mango - world situation. *Acta Hortic.*, **231**: 551–565.

Williams, D.J. 1989. The mealybug genus *Rastrococcus* Ferris (Hemiptera: Pseudococcidae). *Systematic Entomol,* **14** (4): 433–486.

MS Received 28 April 2022
MS Accepted 13 May 2022

DOI: 10.55278/EGNF4485

Monitoring of major insect pests, correlation and yield loss in pearl millet

R.P. Juneja*, G. M. Parmar, R.J. Chaudhari and K. D. Mungra
Main Pearl Millet Research Station, Junagadh Agricultural Univeristy, Jamnagar-361006, Gujarat.
Corresponding author: rajkumarjuneja19@gmail.com

Abstract

Investigations were carried out at Main Pearl Millet Research Station, Junagadh Agricultural University, Jamnagar (Gujarat) during *kharif* 2021 revealed that shoot fly, *Atherigona soccata,* stem borer, *Chilo partellus*, and ear head worm, *Helicoverpa armigera* were the major insect-pests in pearl millet. Significant correlation was found of shoot fly, stem borerand *Helicoverpa armigera* with different weather parameters. There was a considerable loss in yield due to insect-pest complex in pearl millet.

Key Word: Shoot fly, stem borer, *Helicoverpa armigera*, correlation, yield loss.

Introduction

In India, pearl millet, *Pennisetum typhoides* (Burm.) or *bajra* is grown in Rajasthan, Maharashtra, Gujarat, Uttar Pradesh, Andhra Pradesh, Haryana, Tamil Nadu and Karnataka (Prem Kishore and Solomon, 1989). It occupies an area of 6.93 million ha with an average production of 8.61 million tones and productivity of 1243 kg/ha (Anonymous, 2020). Pearl millet is generally preferred in low rainfall areas and on light soils. This crop has wide spectrum adaptability in respect of rainfall, temperature and soil. It is generally believed that pearl millet either grown as mono crop or mixed crop or in relay cropping system has hardly had any serious problems. However, perusal of literature on insect pest of this crop gives quite a different picture. Twenty six insects and two non-insect pests were found feeding on pearl millet (Balikai, 2010). Out of these, shoot fly, *Atherigona soccata,* stem borer, *Chilo partellus* Swinhoe and ear head worm, *Helicoverpa armigera* are comparatively more serious pests attacking the crop. The need to study the effect of different weather parameters on insect-pest incidence has also arised in present situation of climate change. Hence, study was under taken.

Material and methods

The experiment was taken during *kharif* 2021 at Pearl Millet Research Station, Junagadh Agricultural University, Jamnagar (Latitude:22.46816, Longitude:70.02855, Altitude:64 ft). Sowing of released pearl millet variety (GHB 558) was done over an area of 200 m^2 which was kept free from insecticidal application during crop season. During, *kharif*-2021, monsoon commenced in the third week of June. Total rainfall *i.e.* 800 mm was received in 28 rainy days. Sowing for entomological trials was done on 20th July, 2021. After sowing there was long dry spell and hence irrigation was given. All the agronomical package of practices was followed from time to time. Incidence (%) and population of various insect pests observed during the crop period was recorded at weekly interval from 20 randomly selected plants seven days after germination (DAG) of the crop till maturity. The presence of bio agents was also recorded simultaneously. Weather data was also recorded on weekly basis (Meteorological Standard Weather Week) for correlation. The correlation of major insect pest was worked out. Simultaneously, one treated plot was maintained and kept insect-pest free by taking recommended package of practices for insect pest management to get the information for losses. The following treatments were adopted for treated plot.

1. Seed treatment imidacloprid 600 FS @ 8.75 ml/kg seed was given for protection against shoot fly, stem borer & white grub at early crop stage. For later stage crop protection (Shoot fly & stem borer) foliar spray of fipronil 5 SC @ 0.01%, at 35 days after germination of the crop was given.
2. Spray of Novaluron 10 EC 0.01%, at ear head stage at pest appearance of the *Helicoverpa armigera* was given.
3. For leaf binder, grass hopper, grey weevil and hairy cater pillar spray of neem seed kernel extract 5% was done.

Results and discussion

(A) Insect-pest incidence:

Shoot fly: The initiation of shoot fly incidence was found in 31st SWW (5.0%). The highest shoot fly incidence (25.0%) was observed during 40th SWW. The average incidence was 13.18% during the crop period. Stem borer: The initiation of stem borer was found from 32nd SSW (5.0%). However, its incidence was found highest (25.0%) during 36th week with an average incidence of 12.73% during the crop period. The overall range of other insect pests *viz.* White grub (0.0-10.0%), leaf roller (0.85-2.50 damage score), grass hopper (0.0-5.0%), grey weevil (0.0-1.85 damage score), hairy cater pillar (0.0-10.0/20 ear heads), chaffer beetles (0.0-7.0/20 ear heads), blister beetle (0.0-6.0/20 ear heads), *Helicoverpa* (0.0-12.0 larvae/20 ear heads). The incidence of fall army worm was not observed during the study period. The natural enemy lady bird beetle population initiated during 32nd SWW (2 adults/20 plants) and was observed till the end of the season ranging from 0.0 to 25.0 adults/ 20 plants. The average population was 11.73 adults/20 plants. C*hrysopa* population was population initiated during 33rd SWW (1 adult/20 plants) and was observed till 36th SWW i.e. during med crop stage. The overall range was 0.0 to 2.0/ 20 plants with an average of 0.55 adults/20 plants, table-1.0.

(B) Correlation

The correlation of shoot fly with temperature minimum (-0.671*) was found negatively significant and highly and negatively significant with wind speed (-0.832**). The correlation of stem borer was again negatively significant with temperature minimum (-0.629*) and highly and negatively significant with wind speed (-0.809**). As far as *Helicoverpa armigera* was concerned its correlation was found negatively significant with wind speed (-0.608*) and negatively highly significant with evaporation rate (-0.725**), table 1.1. Raghvani *et al.*, 2008 reported that none of the weather parameters showed significant correlation with incidence of shoot fly. However, maximum temperature and difference of minimum and maximum temperature exhibited negative correlations with stem borer. While significant positive association of minimum temperature was observed with larval population of *Helicoverpa* and correlation with rainy days was found significantly negative.

(C) Losses

The treated plot recorded 2343 kg/ha grain and 4566 kg/ha fodder yield (Table-1.2). The losses in grain and fodder yield were 16.41% and 20.01%, respectively. Prem Kishore, 1996 reported that, shoot fly causes 23.3 to 36.5 percent grain losses and 37.5 per cent fodder loss. Whereas, borers indicated losses varied from 20 to 60 per cent. Juneja and Raghvani (2000) reported that on an average 10 to 15 per cent reduction in yield was observed due to *Helicoverpa armigera*.

Conclusions

The above study on monitoring of major insect pests in pearl millet during *kharif* 2021 revealed that there is huge difference in the intensity of different insec -pests. These insec -pests are collectively responsible for loss in yield. Moreover, weather played an important role in the pest incidence.

Ackoweldgements

The authors are thankful to the Directorate of Research and Dean Post Graduate studies and honorable Vice Chancellor, Junagadh Agricultural University, Junagadh for providing necessary facilities to conduct this experiment. Thanks are also due to The Project Coordinator, AICRP on Pearl millet, Agricultural Research Station, Mandore-Jodhpur-342 304 (Rajasthan).

Table-1.0: Incidence/population of insect-pests and natural enemies in pearl millet during *kharif*,2021

No.	SWW	Date of Observation	Days After Germi. nation	Shoot fly % incidene	Stem borer % incidece	White grub % Inci.	leaf roller damage score (0-10)	Grass hopper % damage	FAW % damage	Mean Grey weevil damage score (0-10)	Hairy cater pillar /20 pl.	Blister beetles/ 20 EH	Chaffer beetle 20 / EH	Helicoverpa larvae/ 20 EH	Lady bird beetle/ 20 pl.	Chrysopa/ 20 pl.
1	30	26.07.21	7 DAG	0.00	0.00	0.00	0.85	0.00	0.00	0.00	0	0	0	0	0	0
2	31	02.08.21	14 DAG	5.00	0.00	0.00	1.00	0.00	0.00	0.00	0	0	0	0	0	0
3	32	09.08.21	21 DAG	5.00	5.00	5.00	1.10	5.00	0.00	0.40	0	0	0	0	2	0
4	33	16.08.21	28 DAG	10.00	10.00	10.00	1.45	5.00	0.00	0.60	0	0	0	0	5	1
5	34	23.08.21	35 DAG	15.00	15.00	10.00	1.62	5.00	0.00	0.80	0	0	0	0	10	1
6	35	30.08.21	42 DAG	20.00	20.00	10.00	1.80	5.00	0.00	0.85	0	0	0	0	12	2
7	36	06.09.21	49 DAG	10.00	25.00	10.00	1.95	5.00	0.00	1.00	0	0	0	0	15	1
8	37	13.09.21	56 DAG	15.00	10.00	10.00	2.10	5.00	0.00	1.20	4	3	0	0	18	1
9	38	20.09.21	63 DAG	20.00	15.00	10.00	2.20	0.00	0.00	1.65	7	5	4	5	20	0
10	39	27.09.21	70 DAG	20.00	20.00	10.00	2.25	0.00	0.00	1.75	8	5	6	8	22	0
11	40	04.10.21	77 DAG	25.00	20.00	10.00	2.50	0.00	0.00	1.85	10	6.00	7	12	25	0.00
			Mean	**13.18**	**12.73**	**7.73**	**1.71**	**2.73**	**0.00**	**0.92**	**2.64**	**1.73**	**1.55**	**2.27**	**11.73**	**0.55**
N.B.: Date of sowing: 20.07.2021, Harvesting: 15.10.2021, Variety: GHB 558																

Table-1.1: Correlation of major insect-pests of pearl millet with different weather parameters

No.	SWW	Date of Observation	Days After Germi. nation	Temp. C Maxi.	Temp. C Mini.	R.H. Morn.	R.H. Even.	Wind speed km/hr	BSS (hrs)	Eo (mm)	Rainfall (mm)	Rainy Days
1	30	26.07.21	7 DAG	32.0	27.1	93	76	15.2	1.4	5.6	30.0	2
2	31	02.08.21	14 DAG	32.1	26.5	85	67	16.2	1.6	5.6	4.5	1
3	32	09.08.21	21 DAG	33.0	25.8	85	66	9.3	5.8	6.6	0.5	0
4	33	16.08.21	28 DAG	33.0	25.4	84	65	10.1	7.0	6.8	0.0	0
5	34	23.08.21	35 DAG	32.7	25.9	86	65	9.8	6.1	6.9	2.0	0
6	35	30.08.21	42 DAG	33.1	25.5	89	72	8.0	5.0	7.2	68.5	2
7	36	06.09.21	49 DAG	31.4	25.6	93	83	8.2	2.7	5.4	91.0	4
8	37	13.09.21	56 DAG	30.3	24.8	95	83	7.2	1.1	4.7	204.0	5
9	38	20.09.21	63 DAG	32.5	26.1	91	76	7.8	6.5	4.8	6.5	1
10	39	27.09.21	70 DAG	31.4	24.8	94	86	4.9	3.3	4.2	244.0	4
11	40	04.10.20	77 DAG	32.6	25.2	90	73	5.1	8.1	4.1	7.0	1
		Correlation	Shoot fly%	0.027^{NS}	**-0.671***	0.258^{NS}	0.276^{NS}	**-0.832****	0.512^{NS}	-0.372^{NS}	0.280^{NS}	0.153^{NS}
			Stem Borer%	-0.051^{NS}	**-0.629***	0.349^{NS}	0.437^{NS}	**-0.809****	0.360^{NS}	-0.205^{NS}	0.334^{NS}	0.335^{NS}
			Helicoverpa /5 EH	0.003^{NS}	-0.384^{NS}	0.287^{NS}	0.305^{NS}	**-0.608***	0.437^{NS}	**-0.725****	0.157^{NS}	0.047^{NS}

Table-1.2: Yield losses in grain & fodder due to insect-pest complex in pearl millet.

Parameters	Yield kg/ha in treated plot	Yield kg/ha in Un-treated plot	% losses
1. Grain	2343	1959	16.41
2. Fodder	4566	3652	20.01

References

Anonymous. (2020). Pearl Millet News Letter, ICAR-All *India Coordinated Pearl millet Research Project on Pearl millet*, Jodhpur, Rajasthan**.**

Balikai, R.A. (2010). *International Journal of Plant Protection*. 2 (2):189-190.

Juneja, R. P. and Raghvani, K. L. (2000). Feeding behavior of *Helicoverpa armigera* (Hubner) and its damage in pearl millet. *Insect Environment*, **6** (3): 141-142.

Prem Kishore (1996). *Journal of Entomological Research*. 20(4):287-293.

Prem Kishore and S. Solomon (1989). Seeds and Farms, **15** (7 & 8): 23-28.

Raghvani, K.L., Juneja, R.P., Ghelani, Y. H., Parmar, G.M., and Dangaria, C.J. (2008). *Indian Journal of Applied Entomology*, **22** (1):458-50.

MS Received 06 May 2022
MS Accepted 18 May 2022

DOI: 10.55278/DQCS5854

Butterfly Identification App (BIA): A mobile application for identification and monitoring of butterflies in the state of Karnataka

O.K. Remadevi*, J. Cruz Antony, Jane Maria D Souza and K.H. Vinaya Kumar
Centre for Climate Change, Environmental Management and Policy Research Institute (EMPRI), Bengaluru 560 078, Karnataka, India.
Corresponding author: okremadevi@gmail.com

Abstract

Butterflies attract the attention of everyone, but it is difficult to identify and know their names instantly. Even for the students and researchers, identifying them in the field itself necessitates capturing and referring field guides. A novel mobile application known as Butterfly Identification App (BIA) has been developed by Environmental Management and Policy Research Institute EMPRI, Bengaluru, India to identify butterflies in the field. It is a colour-based identification application, which can be used by anyone having an android mobile phone. It is not necessary to capture the butterflies but photos taken can be compared with the photos in the colour based groups in the BIA database. The identification of all butterflies reported from Karnataka is possible through the BIA. The usage of this by proficient taxonomists, students and environmentalists can contribute to the monitoring and conservation of butterfly species in their localities. Pilot studies conducted in six green spaces in Bengaluru (12.9716° N, 77.5946° E) with GPS locations (Lalbhag: 12.9487,77.5887; Cubbon Park: 12.9798,77.5968; Doresanipalya: 12.8971,77.5905; IISc: 13.0173,77.5712; GKVK: 13.0808,77.5677; Bannerghatta: 12.785,77.5745) using the BIA is presented in the paper.

Keywords: Android mobile, Butterfly Identification App, EMPRI.

Introduction

According to Ghazoul (2002), about 19,238 species of butterflies have been documented from all over the world, which includes 1501 species from India (Kunte *et al.*, 1999). Ashish *et al.*, (2007) have reported 332 species from the Western Ghats. In Karnataka, about 323 species of butterflies have been recorded (Remadevi *et al.*, 2020) and around 140 species are found in Bengaluru alone (Yates, 1933; Remadevi et al., 2018). Climate change and environmental degradation are indicated by butterflies. Butterflies react faster to ecological changes than birds and vascular plants (Thomas *et al*. 2004). They are important components in the food chain of birds, reptiles, spiders and predatory insects. They help in pollinating many economically important crops. The crucial information on the ecology of a particular region is provided by a faunistic survey of butterflies based on their occurrence and characteristics (Ghazoul, 2002). In general, monitoring butterfly populations are considered an essential means of evaluating change in the ecosystem and also the state of habitation for biodiversity (Paul and Sultana, 2020). Van Swaay *et al*., (2012) stated that these trends contribute as an indicator of biodiversity status and to interpret the environmental change. Butterflies act as best bio-indicators for effect on climate change (Ghazanfar, et al., 2016). Since butterflies are one of the most eye-catching insects with various colour patterns, the identity of a butterfly could be mistaken.

Utilizing Information and Communication Technologies (ICT) in agriculture and economy can boost production in the shortest and fastest way (Nitin *et al.*, 2020). Smart phone technology helps in field for delivery of information. In contrast to printed publications, the information conveyed through the mobile application can be augmented, restructured, updated, and corrected repeatedly. For extension professionals in turf grass management, the development of application and the delivery of information through this technology present an invaluable, fast, accurate, new resource and delivery of information (McCullough *et al*., 2011).

Identification of butterflies using mobile applications is being practiced in many countries. Fox *et al*., (2015) through the scheme "Butterflies for the New Millennium (BNM)" which runs in partnership with the Biological Records Centre (part of the UK Centre for Ecology & Hydrology) surveys butterfly distributions across the UK. The BNM scheme uses smart mobile technology to aid and strengthen the recording of butterfly distribution. A free mobile app named "iRecord Butterflies" was developed and more than 10,000 users have started using this app since the launch of the app in 2014. Using the app, a butterfly surveyor/recorder can log and submit sightings as a single process and also make use of the built-in GPS facility in their mobile phone to automatically generate high-resolution grid references for their records. The app also acts as a simple identification guide to help new surveyors/recorders and guides them through the process of submitting butterfly records.

Andre Poremski (2019) developed a mobile app named "Leps" which is funded privately by Public Good Projects, United States. Leps was developed using image recognition technology to identify butterflies and moths (Lepidoptera) which is achievable with a photo, date and location of the species observed. The app uses a machine learning framework named "Fieldguide" to help identify the butterflies and moth. The "Butterfly Id" is a paid mobile app developed by Sunbird Images, Germany. This app is used to identify butterfly species very easily with available butterfly records created by professional ecologists. This app also provides information about the anatomy, ecology and taxonomy of the butterflies. To aid in fast identification of the species, this app provides information about every butterfly's hind and forewings.

Shubhalaxmi *et al.* (2016) have developed a butterfly mobile app under the U.S. State Department's International Exchange Alumni programme. The mobile app characterizes 50 common Indian butterfly species with their images, common and scientific name, host plants and other related facts. Theivaprakasham Hari (2019) has developed an app called "Butterfly Vision" which helps in the identification of nearly 300 butterflies from the Western Ghats region. This app uses a machine learning technique to help identify butterflies in the field. This app was developed to exclusively engage school kids to identify butterflies and thus helps in the documentation of butterfly fauna with the adoption of technology. This app is linked with the website https://butterflyvision.in/ which also provides facility to upload the captured butterfly images and in return helps to identify the butterfly with similarity index using percentage.

The Nature Web's "Indian Butterflies" app is an offline mobile app which provides butterfly information along with the butterfly's regional names viz., Assamese, Bengali, Marathi, Malayalam and Tamil. "Indian Butterflies" app is easy to use as a field guide by providing information such as habitat, host plant, wingspan, sexual differences, etc. This app is linked with http://www.indiabutterflies.com which acts as the butterfly repository. It also allows creating checklists of the on-field observations and can be further exported into CSV file.

1. Materials and Methods

Thus, BIA has been developed to identify the butterflies based on their major colour in the wings. This mobile app can be used for the continuous monitoring of butterflies in specific areas with the involvement of naturalists, officials from the forest department, eco clubs, school children etc.

1.1 Butterfly Identification Mobile Application (BIA)

For monitoring the diversity and the impact of climate change on butterflies in Karnataka, an android mobile app (BIA - butterfly identification app) was developed. BIA is extremely simple to use and. it can be downloaded into any android mobile and the information such as GPS of the location, name of the area, date and time along with the identified butterfly information reaches the BIA dashboard through the internet transfer protocols. The minimum requirement for the operating system to download the BIA is Android 5 Lollipop. BIA allows taking pictures of butterfly resting with open or closed wings in field conditions. BIA app would help in identifying nearly 300 butterfly species of Karnataka. In BIA, the butterflies of Karnataka, a state in south India are classified based on their major colours like white, blue, yellow, orange, brown and black. Photo taken can be zoomed in and out and matched with details and image of the butterflies that are available in the BIA database, for identification. If the identification is confirmed, by pressing the SUBMIT button the information collected will be submitted to the database. In case the captured butterfly is not present in any of the colour code available, then the identification can be submitted as UNIDENTIFIED. Later this category will be checked and processed by the resource persons available at EMPRI to identify or add the new species into the BIA database.

1.1.1 Steps involved in using BIA app

1) Open the app and press the “Start” button
2) Notice the butterfly in the field and take photos of open / closed wings of a butterfly. Press the “Skip” button if the second photo cannot be taken
3) To acquire only the image of butterfly, crop the background
4) Notice the major colour in butterfly wings and press a similar colour button
5) Butterflies photos with chosen colour will be displayed below
6) Scroll, compare and match with the butterfly photo taken and the butterfly photo available from the database
7) Tap and zoom the photos to notice the wing patterns and read about wings description
8) After verifying the identification, press the SELECT button
9) Identified butterfly details will be displayed for further verification
10) Finally, press the SUBMIT button to send the identified butterfly data

1.2 BIA Dashboard

The identified/unidentified information about the butterflies sent from BIA such as the butterfly name and photos along with the geographical information fetched using the mobile phone’s GPS system are transferred to the dashboard available at Karnataka State Climate Change Strategic Knowledge Portal (KSCCSKP) Link - http://skcccempri.karnataka.gov.in. The portal was developed under the Department of Science and Technology, DST-SPLICE funded project. The main objective of KSCCSKP is to disseminate information on climate change and related activities in the state of Karnataka. The dashboard is developed on the basis of 2-tier architecture using Laravel PHP and MYSQL software application. The dashboard displays various reports on identified butterflies based on the family, region and year-wise using pie charts and displays the butterfly name (scientific and common name) and geographical information. Fig.-2 represents the flow diagram of the complete butterfly identification process.

2. Results and discussion

The BIA app is intended for documenting the diversity in different seasons and has particularly been developed to be simple to use. A training workshop was conducted on how to use BIA android application to eco-club school teachers as a part of NGC activity at EMPRI on 2nd Feb 2019 and a pilot testing using BIA for the identification of butterflies at EMPRI campus was organized. As an outcome, 55 records were received until June 2019. Further, a presentation was provided to Karnataka districts teachers from eco-club schools through SATCOM (Satellite communication) and after that 42 records were received until October 2019. A pilot test study using BIA was made during winter seasons in 2019 and 2020 (October, November, December and January) in the 6 green spaces of Bangalore and a total of 69 species were recorded in different regions.

Fig. 1 depicts the total butterfly species found in different survey areas Doresanipalya has the highest number of species found with 22 per cent (69 species) followed by Bannerghatta with 21 per cent (68 species). IISc has 19 per cent (59 species) and GKVK has 18 per cent (58 species) of butterfly species. Lalbagh has the second least butterfly species with 12 per cent (39 species) and least is Cubbon Park with 8 per cent (26 species) of butterfly species.

Fig. 2 depicts butterfly families found in different survey regions. Nymphalidae is found to be dominant in all the study areas with 25 species in Doresanipalya and Bannerghatta and 9 species in Cubbon Park which is least among other areas. Lycaenidae is found to be second most dominant with 18 species in Doresanipalya and 17 species in Bannerghatta and least in Cubbon Park with 6 species. Pieridae and Papilionidae are moderate with 15 species in Bannerghatta and 8 species in Doresanipalya, GKVK and IISc respectively. Riodinidae is the least in Doresanipalya and Bannerghatta with one species whereas it is not found in the other four study areas. Hesperiidae is second least with 7 species in Doresanipalya and 4 species in Lalbagh and GKVK.

Conclusions

Over the past centuries, many researchers have significantly contributed to the field of butterfly diversity and ecology within the various ecosystems in India. Monitoring diversity in different geographical locations, integrating more than the conventional hotspots, makes it quite feasible to identify changes over an extensive range of habitations. This might provide an enhanced knowledge of the species associations in various vegetation categories. The phenological changes in plants due to climatic variability and changes in different areas is reflected in the diversity of butterflies in the area. A mobile application "Butterfly Identification Application (BIA)" is developed by EMPRI to achieve the dual purpose of helping butterfly field identification effortlessly and receiving the butterfly diversity information for further studies of butterfly ecology in Karnataka in relation to climatic and environmental changes. BIA helps in easy identification of butterflies by anyone from anywhere in Karnataka. Currently, the app helps in the identification of 323 butterfly species reported from Karnataka. BIA can be downloaded in any Android mobile and the information such as GPS of the location, name of the area, date and time along with the identified butterfly information reaches the BIA dashboard through the internet transfer protocols. The BIA dashboard is developed using Laravel PHP and MYSQL for database and has linked to both EMPRI website and the Karnataka State Climate Change Strategic Knowledge Portal (KSCCSKP). This BIA dashboard developed for processing the butterfly data is hosted in Karnataka State Data centre (KSDC) and shall be accessible to everyone interested to know the butterfly information of the state. The link to the BIA dashboard is https://bmpempri.karnataka.gov.in/.

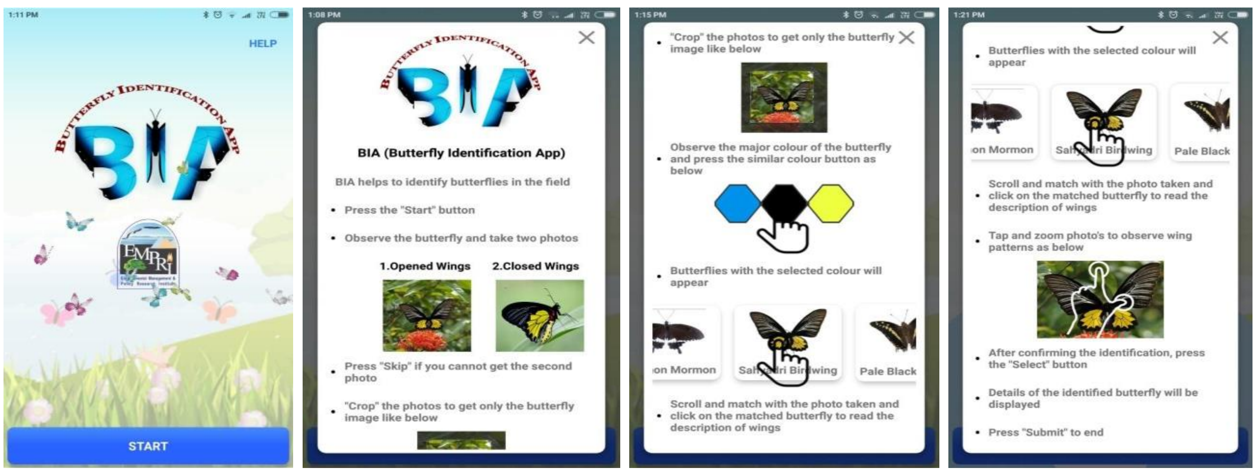


Fig. 1: Butterfly Identification Application screenshots

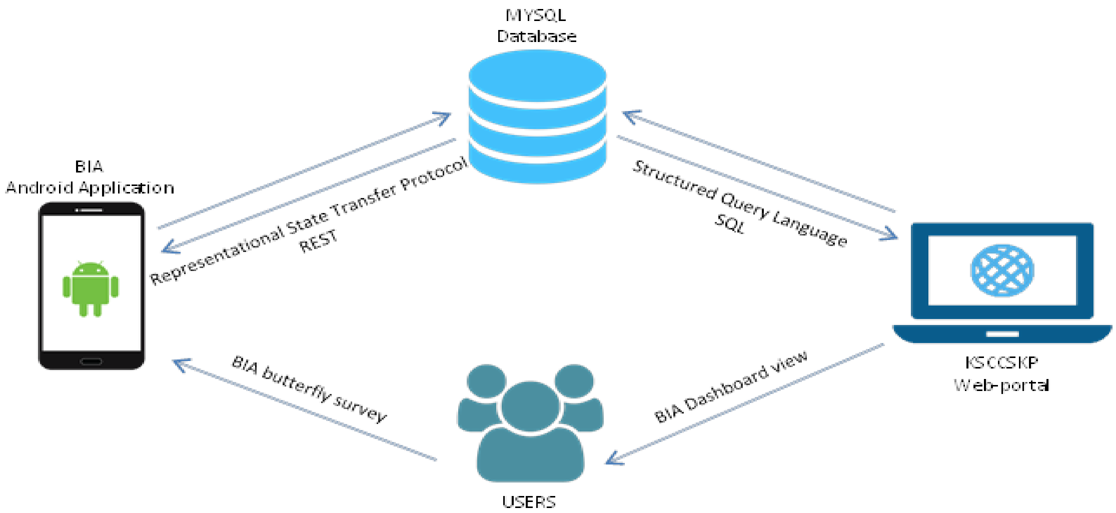


Fig. 2: Flow diagram of Butterfly Identification Application

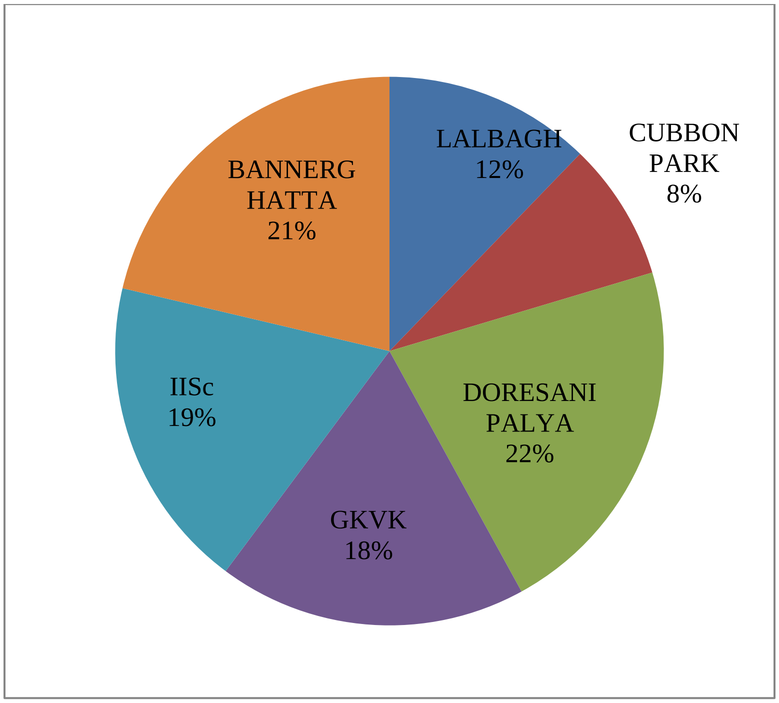


Fig. 3: Butterfly species recorded by BIA in survey areas

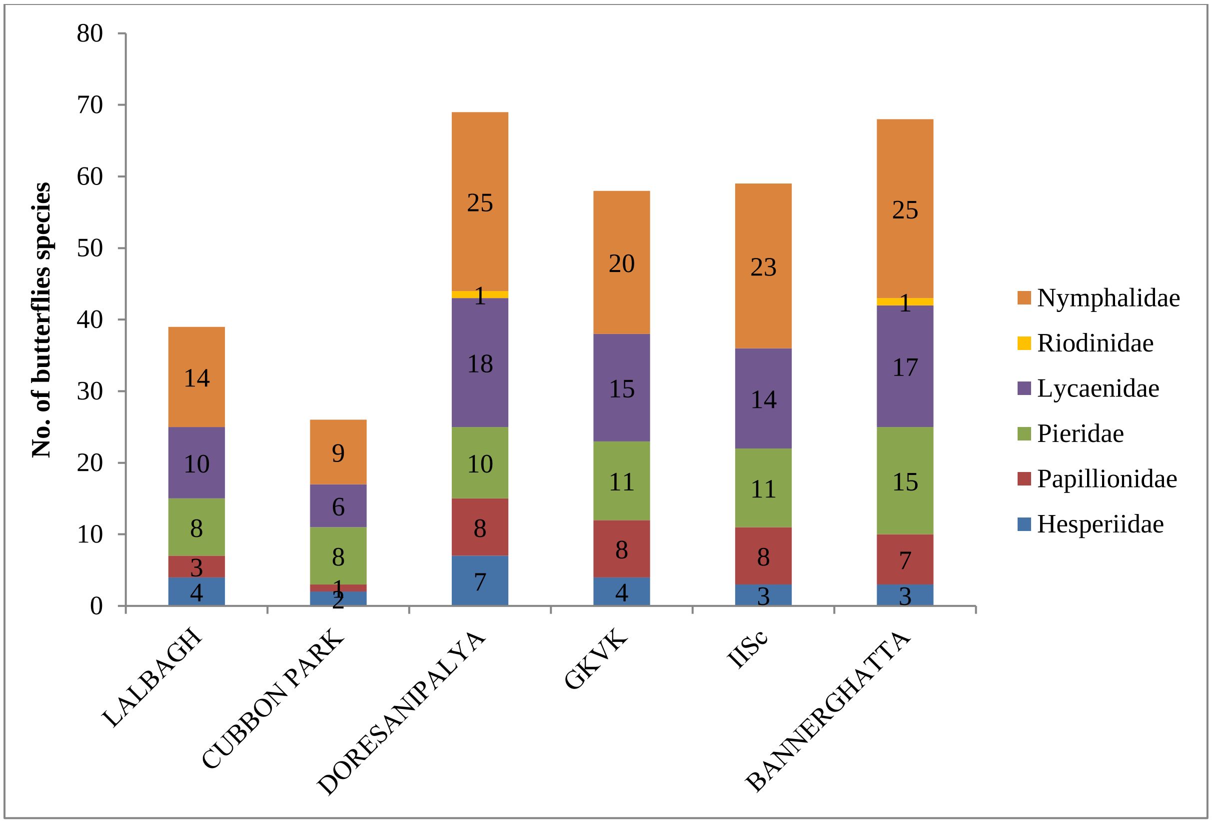


Fig. 4 Butterfly family-wise distribution in different areas

References

André Poremski., 2019. Getting started with Field guide: An introduction to Field guide website & mobile apps,; https://medium.com/@andrporemski/getting-started-with-fieldguide-c967d364e258.

Borges, R.M., Gowda, V. and Zacharias, M., 2003. Butterfly pollination and high-contrast visual signals in a low-density distylous plant. *Oecologia*, **136:** 571-573; https://doi.org/10.1007/s00442-003-1336-y.

Fox, R., Brereton, T.M., Asher, J., August, T.A., Botham, M.S., Bourn, N.A.D., Cruickshanks, K.L., Bulman, C.R., Ellis, S., Harrower, C.A., Middlebrook, I., Noble, D.G., Powney, G.D., Randle, Z., Warren, M.S. and Roy, D.B., The State of the UK's Butterflies 2015. Butterfly Conservation and the Centre for Ecology & Hydrology, Wareham, Dorset.

Ghazanfar, M., Malik, M.F., Hussain, M., Iqbal, R. and Younas, M., 2016. Butterflies and their contribution in ecosystem: A review. *Journal of*

Entomology and Zoology Studies, 4(2): 115-118.

Ghazoul, J., 2002. Impact of logging on the richness and diversity of forest butterflies in a tropical dry forest in Thailand. *Biodiversity and Conservation*, **11:** 521-541; https://doi.org/10.1023/A:1014812701423.

Kunte, K., Joglekar, A., Utkarsh, G. and Padmanabhan, P., 1999. Patterns of butterfly, bird and tree diversity in the Western Ghats. *Current Science*, **77(4):** 577-586.

McCullough, P.E., Waltz, Jr. F.C., Hudson, W. and Martinez-Espinoza, A.D., 2011. Turfgrass management at your fingertips: information delivered through "smart" phone technology. *Journal of Extension*., **49(3):** 1-6.

Nitin K.S., Loc H.C. and Chakravarthy A.K., 2020. Use of Mobile Apps and Software Systems for Retrieving and Disseminating Information on Pest and Disease Management. In *Innovative Pest Management Approaches for the 21st Century* (ed. Chakravarthy, A), Springer, Singapore, pp. 103-117.

Ohwaki, A., Tanabe, S. and Nakamura, K., 2007. Butterfly assemblages in a traditional agricultural landscape: importance of secondary forests for conserving diversity, life history specialists and endemics. *Biodiversity and Conservation*, **16:**1521-1539; https://doi.org/10.1007/s10531-006-9042-9.

Paul, M. and Sultana, A., 2020. Studies on butterfly (Insecta: Lepidoptera) diversity across different urban landscapes of Delhi, India. *Current Science*, **118(5):** 819-827.

Prajapati, R.C., 2010. Biodiversity of Karnataka: At a glance. Karnataka Biodiversity Board, Forest, Ecology and Environment Department, Government of Karnataka, Bengaluru, India, pp. 96.

Remadevi, O.K., Sooraj, S., Chaturved, S., Vinaya Kumar, K.H and Ritu Kakkar. 2018. Bengaluru Butterflies: A Field Guide. Excel India Publishers, New Delhi, p. 70. ISBN: 978-93-86724-52-6.

Remadevi, O. K., Vinaya Kumar, K. H., Kakkar, R. and Singh, R. K. 2020. Karnataka Butterflies: a Field Guide. Excel India Publishers, New Delhi, p. 130. ISBN 978-93-89947- 16-8.

Shubhalaxmi, V., Kehimkar, I., Das, S., Whittier, D.B., Gupta, A. and Richhariya, A., 2016. Mobile Apps for Recording Climate Change: A Case Study of Mobile Learning through

Citizen Science in Four Urban Secondary Schools in India. In Proceedings of the 7th Conference of Learning International Networks Consortium (LINC), Massachusetts Institute of Technology (MIT), Cambridge, MA, USA,

Thomas, J.A., Telfer, M.G., Roy, D.B., Preston, C.D., Greenwood, J.J.D., Asher, J., Fox, R., Clarke, R.T. and Lawton, J.H., 2004. Comparative losses of British butterflies, birds, and plants and the global extinction crisis. *Science*, **303(5665):** 1879-1881; https://doi.org/10.1126/science.1095046.

Tiple, A.D., Khurad, A.M. and Dennis, R.L.H., 2007. Butterfly diversity in relation to a human-impact gradient on an Indian university campus. *Nota Lepidopterologica*, **30(1),** 179-188.

Van Swaay, C.A.M., Brereton, T., Kirkland, P. and Warren, M., 2012. Manual for Butterfly Monitoring. Report VS2012.010, De Vlinderstichting/ Dutch Butterfly Conservation, Butterfly Conservation UK & Butterfly Conservation Europe, Wageningen, pp. 12.

Yates, J.A., 1933. The butterflies of Bangalore and Neighbourhood. *Journal of the Bombay Natural History Society*, **36**: 450-459.

MS Received 25 April 2022
MS Accepted 14 May 2022

DOI: 10.55278/QWMQ8437

A note on the biology, host plants and distriutional record of Goa's state butterfly- *Idea malabarica*

Channabasava Veershetty and R. Maruthadurai
Crop Science Section,
ICAR – Central Coastal Agricultural Research Institute, Ella Old Goa – 403 402
****Corresponding author**: **basava6959@gmail.com***

Abstract

The Malabar tree nymph butterfly, *Idea malabarica* (Moore, 1877) (Nymphalidae: Lepidoptera) was declared as state butterfly of Goa at the fifth Goa bird festival – December 2021 by Government of Goa. This butterfly is familiar for its captivating black and white wing pattern and unique gliding flight hence it is also known "Paperkite". *Idea malabarica* is endemic to the moist evergreen forests of Western Ghats and is categorized as "near threatened" species by International Union for Conservation of Nature (IUCN). It undergoes complete metamorphosis with six week of life period. Five instar larval phase feeds mainly on *Aganosma cymosa*, a species of Apocynaceae family. Losses of habitat and climate change are the major concerns to be dealt for the conservation of butterflies, which are indicators of healthy ecosystem and healthy environment.

Keywords: Malabar tree nymph, Butterfly, Western Ghats, IUCN, climate change

Introduction

Idea malabarica, the Malabar tree nymph is one of the largest milkweed butterfly confined to wet evergreen forests of Indian peninsula. This attractive butterfly is in current news of India because the state government of Goa (India) has declared Malabar tree nymph butterfly as their state butterfly on December 2021. Goa, a tiny state of India with rich biodiversity of different flora and fauna is sandwiched between the Arabian Sea and Western Ghats. Though being the smallest state of the country, Goa has endowed with 215 species of butterflies (Gaude and Janarthanam, 2015). The steps like, the state butterfly status will encourage in developing conservation measures of Malabar tree nymph butterfly in this region as it falls under the "Near Threatened" category of International Union for Conservation of Nature (IUCN). This review article emphasizes on the classification, biology, habit, habitat, host plants and importance of Malabar tree nymph butterfly *I. malabarica*. These studies would be helpful in developing broad approaches for conservation of *I. malabarica* and other butterfly diversity.

Scientific classification of Malabar tree nymph butterfly

Kingdom:	Animalia
Phylum:	Arthropoda
Class:	Insecta
Order:	Lepidoptera
Family:	Nymphalidae
Genus:	*Idea*
Species:	*malabarica*
Binomial name:	*Idea malabarica* (Moore, 1877)

Biology

Malabar tree nymph butterfly experiences a holometabolous life cycle consisting of four stages: egg, larva, pupa and adult. The butterflies of genus *Idea* takes around six weeks to complete their life cycle (Cabras et al., 2015).

Egg: Adult butterfly lays oval shaped, white creamy or translucent eggs singly on under surface of the host plant leaves (Figure 1). The cream-colored eggs turn pinkish on the 4th and 5th day when they are about to hatch (Cabras *et al*., 2015). The maximum egg duration may vary according to the season and climatic condition (Evans, 1932).

Larva: The caterpillar (Figure 2) is stout and smooth which undergoes five instars (Instars I, II, III, IV, V) of developmental stages. After hatching, the neonate larva starts feeding on empty egg shell and epidermis of the host plant leaves. Later instars feed rigorously on the different parts of the host plant and grow bigger in size. The morphological characters of fully grown matured caterpillar are black body with white stripes and red spots on its lateral side. One can see varying number of long black spikes/horn like structures protruding on the dorsal surface of the body, which are used for protection against predators. Before entering into the pupal stage, the last larval instar stops feeding, becomes lethargic and shrinks in its body size (Pre-pupal stage). Usually, the butterflies of genus *Idea* take around three weeks to complete the larval period (Kumar, 2005; Cabras *et al.*, 2015).

Pupa: The pupal form is known as "Chrysalis" which is initially golden colour ornamented with black shiny spots over its surface (Figure 3). Later from 8th day onwards black pigmentation starts to appear on the surface and on 14th day, a day before adult emergence it turns black. On the under surface of leaves the chrysalis suspends free from the anal hook or cremaster without any silken girdle (Cabras *et al.*, 2015)**.**

Adult: Malabar tree nymph appears as a white butterfly with black markings and the wingspan measures generally about 120-154 mm (Figure 4). The upper sides of both the wings are semitransparent white with powdery black scales. These have long black antennae with rounded clubs at the end, head and thorax spotted and streaked with black and abdomen is white, with broad dusky black streak above (Moore, 1890; Thomas, 1905; Varshney and Smetacek 2015).

Habit

Malabar tree nymph butterfly is slow and week flier with flapping movement of wings. A gliding flight is common habit of the genus *Idea* so these are also called as "Paperkite". They can be seen often gliding above the forest tree canopy but infrequently move lower down in forest openings (Evans, 1932).

Habitat and distribution

Idea malabarica have specific habitat requirements depending upon their feeding and reproduction needs. It is endemic to the wet evergreen forests with heavy rainfall areas which include Western Ghats stretches of Maharashtra, Goa, Karnataka and Kerala (Bringham, 1905; Manoj and Sharma, 2013). Also found in few parts of Tamil Nadu bordering to Kerala state (Arun, 2003; Dunstan and Raj, 2005; Alagumurugan *et al.,* 2011). In Goa it is found mainly in the areas of swamp vegetation of Ajobachi Tali, Bibtyan, Nirankarachi Rai and Mharinginichi Rai in Sattari and Bhati, and Savari in Sanguem (Gaude and Janarthanam, 2015). Numerical abundance study by Rao *et al.,* 2021 at Rivona near the foothills of Western Ghats - Goa reported Malabar tree nymph under "Very Rare" status with 0.026 relative abundance.

Host Plants

The larva of *Idea malabarica* mainly feed on the species of Apocynaceae *Aganosma cymosa* (Wynter-Blyth 1957; Kunte, 2000) and according to few recent reports the medicinal plants *Parsonsia spiralis* and *P. alboflavescens* (Apocynaceae) are also considered as larval host plants of *I. malabarica* (Susanth 2005; Aishwarya and Revanna, 2018).

Conclusion

By declaring, Goa's "State butterfly' status to the Malabar tree nymph butterfly, endemic to Western Ghats is recognized as biodiversity indicator of this region. Butterflies are important component of rich biodiversity, have been on planet around for at least 50 million years and these have special aesthetic, educational, scientific, ecosystem and economic value. Butterflies are widely used as model organism by ecologists to study the impact of habitat loss and fragmentation, and climate change because these are indicators of a healthy environment and healthy ecosystems. In the present global scenario, loss of wildlife habitat in a large scale and unpredictable shifting of climate and weather patterns in response to pollution of the atmosphere are the major issues related to decreasing trend of wildlife including butterflies. In this case, a broad and scientific approach for butterfly conservation is necessary. Butterfly distribution and population status assessment, diagnosing the driving factors causing decline trend of the species, identifying effective species recovery solutions and application of long-term sustainable solutions are the stepping factors for butterfly conservation. By gaining Goa's "State butterfly' status, the Malabar tree nymph butterfly endemic to Western Ghats is recognized as biodiversity indicator of this region.

Figure 1. Egg

(Source: Vinayraj, Wikimedia)

Figure 2. Larva

(Source: Ashok Senagupta, Wikimedia)

Figure 3. Pupa

(Source: Ashok Senagupta, Wikimedia)

Figure 4. Adult butterfly

(Source: Ajith Unnikrishnan, Wikimedia)

References

Aishwarya, B and Revanna, R. 2018. Rare and endemic medicinal plant, *Parsonsia alboflavescens* (Dennst.) Mabb. and malabar tree nymph butterfly, Idea malabarica in Western Ghats of Karnataka. J Pharmacogn Phytochem. **7**: 201-203.

Bingham, C.T. 1905. Fauna of British India Butterflies. **1**: 4.

Cabras, A., Calimutan, M. and Mohagan, A. 2015. Development of Idea leuconoe Erichson 1834 (Lepidoptera: Nymphalidae) reared on Parsonia sp. leaves. University of Mindanao International Multiresearch Journal. **1**: 137-142.

Evans, W.H. 1932. The Identification of Indian Butterflies (2nd ed.). Mumbai, India: Bombay Natural History Society.

Gaude, K. and Janarthanam, M. K. 2015. The butterfly (insecta: Lepidoptera) diversity of four sacred groves of Goa, India. Journal of Threatened Taxa. **7**: 7927-7932.

Kumar, C.S. 2005. Malabar Tree Nymph bnhs note published. Journal of the Bombay Natural History Society. **102**: 354-355.

Kunte, K. 2000. Butterflies of Peninsular India. Universities Press (Hyderabad) and Indian Academy of Sciences (Bangalore). First fascicle from "India: A Lifescape", series editor: Madhav Gadgil.

Moore, F. 1890–1892. Lepidoptera Indica. Vol. I. London: Lovell Reeve and Co. **1**: 18–22.

Rao, K.R., Shreya, N., Nutan, P., Glamy, R., Arya, N. and Akshata, N. 2021. Assessment of butterfly (Lepidoptera: Rhopalocera) Diversity and Relative Abundance in Rivona Near the Foothills of Western Ghats-Goa. Journal of Himalayan Ecol. Sustain. Dev. **16**: 69-85.

Varshney, R.K. and Smetacek, P. 2015. A Synoptic Catalogue of the Butterflies of India. New Delhi: Butterfly Research Centre, Bhimtal & Indinov Publishing, New Delhi. 151. doi:10.13140/RG.2.1.3966.2164. ISBN 978-81-929826-4-9.

Wynter-Blyth, M.A. 1957. Butterflies of the Indian Region. Bombay Natural History Society, Mumbai.

MS Received 29 April 2022
MS Accepted 12 May 2022

DOI: 10.55278/KZRY1465

Efficacy of entomopathogenic fungi against chrysanthemum aphid, *Macrosiphoniella sanborni* (Gillette)

Surani Pratikkumar M., Abhishek Shukla [*] and Mangali Ashwini
Department of Entomology, N.M. College of Agriculture
Navsari Agricultural University, Navsari-396450, Gujarat, INDIA
Corresponding author: abhishekshukla@nau.in (corresponding author)

Abstract

An experiment was carried out to evaluate different entomopathogenic fungi against chrysanthemum aphid, *Macrosiphoniella sanborni* (Gillette) under laboratory conditions at Biocontrol Laboratory, N.M. College of Agriculture, Navsari Agricultural University, Navsari during 2019-20 and 2021-21. The pooled mean corrected percent mortality revealed that among all the entomopathogenic fungi tested at 4g/L, *Verticillium lecanii* was found superior over the rest of the treatments by recording highest percent mortality (53.66%) of aphids, *M. sanborni* and it was followed by *Metarhizium anisopliae* and *Beauveria bassiana* with 36.84 and 32.61 percent mortality, respectively. The lowest per cent mortality of aphid was recorded by *Nomuraea rileyi* (25.55%). The chemical check, Dimethoate 30 EC at 1ml/L recorded highest percent mortality of aphids (77.82 %) among all the treatments.

Keywords: Chrysanthemum aphid, *Macrosiphoniella sanborni*, Entomopathogenic fungi

Introduction

Chrysanthemums (*Dendranthema grandiflora* Tzvelev), sometimes called mums or chrysanths, are flowering plants of the genus Chrysanthemum of the family Asteraceae. Countless horticultural varieties and cultivars of this flower exist. Presently, 2000 varieties are grown around the world and in India, about 1000 varieties are grown (Datta and Bhattacharjee, 2001). As many as seven insect pests are reported damaging this crop right from germination to harvesting of the crop. The important insect pests attacking Chrysanthemum are aphid, *Macrosiphoniella sanborni* (Gillette); thrips, *Haplothrips ramakrishnae* Krishna; Chrysanthemum caterpillar, *Diacrisia oblique* Walker; grub, *Holotrichia* spp. and leafminer, *Pytomyza syngenesiae* (Hardy). The Chrysanthemum aphid, *M. sanborni* is a widespread pest on cultivated Chrysanthemum throughout the world. It is a holocyclic species of East Asian origin (Heie, 1995). It feeds mainly on young leaves and developing flower buds and could become very abundant on them. In case of high infestation, the aphid causes significant damage which results in deformation and disturbance of flower development and it also acts as a vector to vein mottle and virus B

(Blackman and Eastop, 1984; Chan *et al.*, 1991). All these factors together become hereby significant and responsible for economic damage to the Chrysanthemum by decreasing the beauty and value of cut flowers (Zahedi, 1999). Pal and Sarkar (2009) reported *M. sanborni* as the major sucking pest of Chrysanthemum in hilly regions of West Bengal area by conducting field surveys. Considering the importance of Chrysanthemum aphid, the eco-friendly management and the growing demand for Chrysanthemum in South Gujarat, the present study was taken up to study the efficacy of various entomopathogenic fungi against the Chrysanthemum aphid under laboratory conditions.

Materials and methods

The laboratory experiment on efficacy of various entomopathogenic fungi against Chrysanthemum aphid, *M. sanborni* were carried out in Biocontrol Laboratory, N. M. College of Agriculture, Navsari Agricultural University, Navsari (20.925ºN, 72.908ºE) following Completely Randomized Design with six treatments and four repetitions during the year 2019-20 and 2020-21. The treatments included four entomopathogenic fungi *viz*., *Nomuraea rileyi* (1×10^8 cfu/g), *Beauveria bassiana* (1×10^8 cfu/g), *Lecanicillium* (*Verticillium*) *lecanii* (1×10^8 cfu/g) and *Metarhizium anisopliae* (1×10^8 cfu/g) along with chemical check Dimethoate 30 EC (1ml/L) and untreated control. The treatments were imposed by dipping the healthy Chrysanthemum leaves for five minutes in conidial solution of each treatment. The treated leaves were allowed to dry under ceiling fan. Twentyfive aphids were released on each treated leaf to study the mortality. After 15 minutes of exposure, the aphids on treated chrysanthemum leaves were transferred to fresh leaves. The mortality of chrysanthemum aphid were recorded at 3rd, 5th, 7th, 10th and 14th days after treatment. The turgidity of leaves was maintained by using standard technique (?). At an interval of 24 hrs., each leaf (*i.e.*, untreated) was changed with new fresh leaf in same Petri dish. The data obtained on cumulative dead chrysanthemum aphid counts were summed up and utilized for calculation of percent corrected mortality. The data of cumulative dead aphids were converted into arcsine transformation and analyzed statistically by using completely randomized design. The percent corrected mortality was worked out through utilizing the formula suggested by Henderson and Tilton (1955).

Results and discussion

The results on the efficacy of entomopathogenic fungi against chrysanthemum aphid, *M. sanborni* during the years 2019-20 and 2020-21 were presented in Table 1. The mean corrected percent mortality of 3, 5, 7, 10, 14 DAT (Days after Treatment) revealed that among all the entomopathogenic fungi, the highest mortality was recorded for *V. lecanii* with 52.93 per cent during 2019-20 and 54.40 per cent mortality during 2020-21. The next most effective treatment was *M.*

anisopliae with 35.51 per cent during 2019-20 and 38.17 percent mortality during 2020-21 which was on par with *B. bassiana* with 31.5 per cent mortality during 2019-20 and 33.72 percent during 2020-21. The lowest per cent mortality of aphid was recorded for *N. rileyi* with 25.11 and 26.00 per cent mortality during 2019-20 and 2020-21, respectively. However, chemical check Dimethoate 30 EC recorded 77.65 (2019-20) and 77.99 per cent mortality of aphid, *M. sanborni.*

The overall pooled data on corrected percent mortality of aphid, *M. sanborni* are presented in Table 1. The mean data of 3, 5, 7, 10 and 14 DAT revealed that among all the entomopathogenic fungi, the treatment of *V. lecanii* at proved to be the most effective with highest per cent mortality (53.66%), the next effective treatment was *M. anisopliae* at (36.84%) which was at par with *B. bassiana* at *i.e.* 32.61 per cent mortality. The lowest per cent mortality of aphid was recorded in the treatment with *N. rileyi* (25.55%). Among all the treatments, chemical check Dimethoate 30 EC recorded highest per cent mortality of aphid, *M. sanborni* (77.82%). The results of present study are in agreement with those obtained by Saranya *et al*. (2010) who reported 100 per cent mortality of cowpea aphid, *Aphis craccivora* by treating with *V. lecanii* and followed by *B. bassiana,* and *M. anisopliae*. Further, Husnain *et al.* (2014) reported *V. lecanii*, *M. anisoplaie* and *Paecilomyces lilacinus* as effective against aphids in Pakistan. *Verticillium lecanii* was also reported effective against cotton aphid, while the study of Palthiya and Nakat (2017) indicated that combination of entomopathogenic fungi like *V. lecanii* 1.15% WP + *M. anisopliae* 1.15% WP was very effective against okra aphid. In a study Janu *et al.* (2018) also reported *V. lecanii* and *B. bassiana* effective against mustard aphid, *Lipaphis erysimi.* Gore *et al.* (2021) also concluded that *V. lecani* was very effective against cotton aphid followed by *M. anisopliae* and *B. bassiana.* All these earlier studies thus, closely support the present findings.

Acknowledgements

The authors thank the Principal and Dean, N.M. College of Agriculture, Navsari as well as to the Director of Research and Dean PG Studies, Navsari Agricultural University, Navsari for providing necessary facilities.

Table 1: Efficacy of entomopathogenic fungi against Chrysanthemum aphid, *M. sanborni* under laboratory condition

Treatments	Con.	Corrected per cent mortality (Yr. 2019-2020)						Corrected per cent mortality (Yr. 2020-2021)						Corrected per cent mortality (Pooled)					
		3 DAT	5 DAT	7 DAT	10DAT	14DAT	Mean	3 DAT	5 DAT	7 DAT	10DAT	14DAT	Mean	3 DAT	5 DAT	7 DAT	10DAT	14DAT	Mean
B. bassiana	4g/l	20.49 (12.25)	22.9 (15.18)	29.97 (24.97)	42.98 (46.48)	49.99 (58.63)	34.14 (31.5)	21.42 (13.38)	23.5 (15.94)	31.1 (26.68)	43.97 (48.21)	50.37 (59.29)	35.49 (33.72)	20.95 (12.81)	23.2 (15.56)	30.53 (25.83)	43.48 (47.35)	50.18 (58.96)	34.5 (32.61)
M. anisopliae	4g/l	23.84 (16.33)	26.21 (19.54)	32.9 (29.52)	45.65 (51.14)	51.37 (61.01)	36.58 (35.51)	24.58 (17.33)	26.69 (20.2)	33.91 (31.13)	46.62 (52.82)	53.29 (64.23)	38.16 (38.17)	24.20 (16.83)	26.45 (19.87)	33.41 (30.33)	46.14 (51.98)	52.33 (62.62)	37.06 (36.84)
V. lecanii	4g/l	27.55 (21.42)	36.1 (34.72)	45.62 (51.08)	58.89 (73.21)	66.76 (84.23)	46.68 (52.93)	28.96 (23.46)	35.04 (32.97)	47.56 (54.45)	59.09 (73.51)	65.5 (82.74)	47.53 (54.4)	28.25 (22.43)	35.57 (33.85)	46.59 (52.77)	58.99 (73.36)	66.13 (83.48)	46.77 (53.66)
N. rileyi	4g/l	12.88 (5.08)	21 (12.96)	25.93 (19.23)	39.58 (40.64)	43.63 (47.62)	30.06 (25.11)	14.1 (6.08)	20.78 (12.73)	27.32 (21.1)	39.29 (40.14)	42.54 (45.71)	30.65 (26)	13.49 (5.58)	20.89 (12.84)	26.63 (20.17)	39.44 (40.39)	43.09 (46.67)	30.08 (25.55)
Dimethoate 30EC	1ml/L	47.92 (55.08)	53.84 (65.18)	59.26 (73.84)	76.2 (94.16)	90 (100)	61.79 (77.65)	48.76 (56.54)	54.3 (65.94)	58.21 (72.23)	79.35 (95.34)	90 (100)	62.03 (77.99)	48.34 (55.81)	54.07 (65.56)	58.73 (73.03)	77.77 (94.75)	90 (100)	61.88 (77.82)
Control	-	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
SE.m ±																			
Treatment (T)		0.56	0.79	0.85	1.16	1.11	0.39	0.78	0.76	0.63	1.93	0.92	0.45	0.47	0.55	0.53	1.13	0.72	0.25
(Y×T)		-	-	-	-	-	-	-	-	-	-	-	-	0.67	0.78	0.75	1.59	1.02	0.36
C.D. 5%																			
Treatment (T)		1.67	2.34	2.51	3.46	3.29	1.15	2.32	2.27	1.87	5.74	2.74	1.32	1.38	1.58	1.51	3.23	2.07	0.73
(Y×T)		-	-	-	-	-	-	-	-	-	-	-	-	NS	NS	NS	NS	NS	NS
C.V. (%)		5.10	5.92	5.24	5.31	4.40	2.23	6.80	5.72	3.81	8.64	3.67	2.50	6.04	5.82	4.57	7.20	4.05	2.04

Note: *Figures in parentheses are original values while those outside are arcsine transformed values, DAT: Days After Treatment

References

Blackman, R.L.and Eastop, V. F. 1984. Aphids on world crops, John Wiley and Sons, Chichester, UK. pp. 47-49.

Chan, C.K., Forbes, A. R., Raworth, O. A. 1991. Aphid transmitted viruses and their vectors of the world. Technical bulletin, Agriculture Canada Research Branch. pp. 208.

Datta, S. K. and Bhattacharjee, S.K. 2001. Chrysanthemum AICRP on Floriculture. Technical Bulletin, ICAR, New Delhi. 11: 50-56.

Gore, A. K., Sant, S. S., Kadam, A.K., Dhurgude, S. S. and Patange, S. B. 2021. Effect of botanicals and bio-pesticides on sucking pest in cotton. *Journal of Entomology and Zoology Studies* **9**(1): 1262-1265.Henderson, C. F. and Tilton, E W. 1955. Tests with acaricides against the brow wheat mite. *Journal of Economic Entomology*, **48**: 157-161.

Heie, O.E. 1995. The Aphidoidea (Hemipteral of Fennoscandia and Denmark) VI. Family Aphididae: Part 3 of tribe *Macrosiphini* of subfamily Aphidinae and Family Lachinidae. *Fauna Entomologica Scandinavica,* **31**: 1-217.

Husnain, H., Shahid, A.A., Haq, M. I., Ali, A., Muhammed. U. and Anam, U. 2014. Efficacy of entomopathogenic fungi as biological control agent against insect pests of *Gossypium hirsutum. Journal of Natural Sciences Research,* **4**(5): 68-72.

Janu, A., Yadav, G. S., Kaushik, H. D., Jakhar, P. 2018. Bioefficacy of *Verticillium lecanii* and *Beauveria bassiana* against mustard aphid, *Lipaphis erysimi* under field conditions. *Plant Archives,* **18**(1): 288-290.

Pal, S. and Sarkar, I. 2009. Pests infesting ornamental plants in hilly regions of West Bengal. *Journal of Plant Protection Sciences,* **1**(1): 98-101.

Palthiya, R. and Nakat, R. V. 2017. Efficacy of entomopathogenic fungi against aphids on okra. *International Journal of Current Microbiology and Applied Sciences*, **6**(8): 2980-2986.

Saranya, S., Ushakumari, R., Philip, P., Sosamma, D. and Jacob, B. M. 2010. Efficacy of different entomopathogenic fungi against cowpea aphid, *Aphis craccivora* (Koch). *Journal of Biopesticides,* **3**(1): 138-142.

Zahedi, K. 1999. Summer crops and ornamental plants pests and control in Iran. Iran University press, Tehran, Iran. p. 16.

MS Received 26 April 2022
MS Accepted 05 May 2022

DOI: 10.55278/WWXJ6156

Record of *Isotima* sp. (Hymenoptera: Ichneumonidae) from pink borer, *Sesamia inferens* (Walker)

Arun Baitha, Ankit K Mishra, Deepmala Kurre, P. K. Bareliya and Anuj Kumar
Division of Crop Protection
ICAR-Indian Institute of Sugarcane Research, R.B. Road, Dilkusha, P.O.
Lucknow-226 002, India
***Corresponding author:** arunbaitha@rediffmail.com*

The pink borer, *Sesamia inferens* (Walker) is a polyphagous pest and attacks many crops viz., rice, wheat, maize, sorghum, sugarcane, finger millet etc (Majumder, 2020). Due to the availability of one or the other host crops round the year, the pink borer is found throughout the year. However, during the peak winter (December to February) its activity is greatly reduced in sugarcane ecosystem but in a situation when paddy is grown near sugarcane field, it gets ready access to the adjoining paddy stubbles (after harvesting) during winter months. The larvae feed gregariously in the tillers of stubbles during winter months (Calora and Reyes, 1971). A large number of parasitoids were recorded on *S. inferens* i.e., *Trichospilus diatraeae*, *Cotesia* (*Apanteles*) *pallipes*, *Tropobracon scoenobii*, *Coccygomimus (Piimpla) laothoe*; *Devorgilla* sp., *Temelucha* sp., *Stenobracon nicevillae* (Rao *et al*., 1967 and Shepard *et al*., 1987).

Surveys were conducted in harvested field of paddy stubbles near sugarcane field at the research farm of ICAR-IISR, Lucknow. Different phases of development of the pink borer (larvae as well as pupae) and its parasitoids were collected in the tillers of paddy stubbles during November 2020 to February 2021. Further, different instars of larvae were kept in glass jars (15 x 2.5 cm) with tillers of paddy (as food) for development at room temperature. During different phases of development of larvae/pupae, a light brown cocoon was collected from glass jar and kept for emergence of parasitoid at 26 ± 2°C and 75 ± 5% relative humidity in BOD. On the completion of the development, adult parasitoid found its way out of the cocoon through a circular aperture which it cut on one side of the cocoon and it was identified as *Isotima* sp. This is the first record of *Isotima* sp. reared from stubble-inhabiting larvae of *S. inferens* in rice ecosystem. The males have slender body and absence of the white band in the antennae. It however has an additional white band on the abdominal segment.

Isotima sp. is a solitary ecto prepupal parasitoid of sugarcane top borer in India. It attacks the prepupal stage and deposits an egg either on the prepupa or near its vicinity (Gupta, 1958 and Kalra and David, 1967). The colour and texture of the cocoon of *Isotima* sp.depends upon the season through which it has to pass in the pupal stage (Ahmad and

Mathur, 1945).A long and rigorous winter imposes on the grub an equally long period of hibernation and calls for a compact and tough cocoon which one finds in the field during winter months. The silken materials used by the grub in spinning this cocoon is - light brown in rice ecosystem but dark brown in sugarcane ecosystem. It is interesting to note that the size of the cocoon varies not only with the environmental conditions, food etc,which affect the size of the grub, but also according to the sex,so much that the sex of the adult that would emerge from a cocoon can easily be predetermined by taking measurements of the cocoon. Under ordinary field conditions, the parasite goes into hibernation in its larval stage along with the host during winter months in sugarcane ecosystem (Baitha *et al*., 2017).

Cocoon of *Isotima* sp on paddy tiller

Circular hole upper side of cocoon

Male of *Isotima* sp.

The parasitoid *Isotima* sp. was first recorded and described by Rohwer (1918) from Java (Indonesia) on *Scirpophaga nivella intact* Snellen, the white moth borer of sugarcane and named as *Eripternimorpha javensis*. Indian specimens were erroneously identified as *Melcha ornatipennis* Cameron (1907) and all the work was carried out under this name till the misidentification was pointed by Townes *et al.* (1961) supported by Gupta (1961).It has been established that the ichneumonid parasite of top borer from Java as *Eripternimorpha javensis*,is a species belonging to the genus *Isotima* rather than *Eripternimorpha*. Various workers (Mathur,1942;Ahmad and Mathur ,1945 and Box,1953) mentioned that *S.nivella* as its only host but Khanna (1953,1954 and 1955) and Varma and Maninder (1981) reported as larval parasite of top shoot borer (*S.nivella*), stem borer (*Chilo infuscatellus*) and Gurdaspur borer, *Acigona Steniella* whereas Bennett (1965) opined that this parasite doesn't normally attack stem borers. It is also reported on yellow rice stem borer, *Scirpophaga incertulas* and Gyrinid beetle, *Dineutus unidentatus* (Vazirani, 1952; Gupta, 1964 and Beg and Khan, 1982).

Isotima sp. is a pre pupal parasite, and many times more effective than that of an egg parasitoid . Further studies need to be carried out to develope protocols for its mass rearing in the laboratory on an alternate host, release technique, taxonomical study and survival in the field.

References

Ahmad, T. 1942. Report of the second Entomologist (dipterist) in charge of the scheme for research on insect pests of sugarcane. Scientific Report, Agricultural Research Institute New Delhi, 1940-1941:64-65.

Baitha, A., Tripathi, G.M., Lal, R.J and Nigam, R. 2017. A note on parasitization of top borer by *Isotima javensis* Rohwer (Hymenoptera: Ichneumonidae) *International Journal of Agriculture and Inovation* 2 (1):82-84.

Beg M.N and Khan A.G. 1982. Natural enemies of paddy pests in Pakistan. *Pakistan Journal of Agricultural Research* 3(2):84-95.

Bennett, F.D. 1965. Test with parasites of Asian graminaceous moth-borers on *Diatraea* and allied genera in Trinidad. *Commonwealth Institute of Biological Control, Technical Bulletin* No.5:101-116.

Box, H.E. 1953. Lists of sugarcane insects. C.I.E London, 101 pp.

Calora, F B and Reyes, S.L. 1971. Ecology of Rice Stem Borers in the Philippines.In: *Proceedings of a Symposium on Tropical Agriculture Researches* 5:163-167.

Cameron, P. 1907. On some undescribed phytophagous and parasitic Hymenoptera from the oriental Zoological region. *Annals and Magazine of Natural History* 19:110,166-192.

Gupta, B.D. 1958. Some friends of the sugarcane top borer Pt.I. Parasites on the top borer, *Scirpophaga nivella* F. *Indian Sugar* 8(7):439-444.

Gupta, V.K. 1961. Identity and synonymy of an ichneumonids parasite of the top borer of sugarcane, *Scirpophaga nivella* Fabricius (Hymenoptera: Ichneumonidae). *Indian Journal of Entomology* 23 (1):7-9.

Gupta, V.K. 1964. Further notes on the distribution and hosts of *Isotima javensis*, (Hymenoptera: Ichneumonidae), an Ichneumonid parasite of the top borer of sugarcane, *Scirpophaga nivella*. *Indian Journal of Entomology* 26(2):252-254.

Kalra, A.N. and David, H.1967.Control of sugarcane top borer, *Scirpophaga nivella* F. through an indigenous parasite, *Isotima javensis* Rohwer (Ichneumonidae: Hymenoptera). *Indian Sugar* 16:1-4.

Khanna, K.L. 1953. Cane Entomology. Annual Report, Central Sugarcane Research Station, Pusa, Bihar for the year ending 31 st May 1953:237.

Khanna, K.L. 1954. Cane Entomology. Annual Report, Central Sugarcane Research Station, Pusa, Bihar for the year ending 31 st May 1954:220.

Khanna, K.L. 1955. Cane Entomology. Annual Report, Central Sugarcane Research Station, Pusa, Bihar for the year ending 31 st May 1955:299.

Majumder, S. K. D. 2020. Moth Borers of Sugarcane. Daya Publishing House, New Delhi, 639pp.

Mathur, I.D.1942.On *Melcha ornatipennis*, a parasite of *Scirpophaga nivella* F., the top shoot borer of sugarcane. *Indian Journal of Entomology* 4(2):234.

Rao, V.P., Basu, A.N., Phalak, V.R. Chacko, M.J Rao, H. 1968. Some new records of parasites of rice stem-borers in India. *Proceedings of the Indian Academy of Sciences, Section B* 68 (2): 91-110.

Rohwer, S.A.1918.Descriptions and notes on some Ichnemon-flies from Java. *Proceedings of the United States National Museum* 54 (2249):563–570.

Shepard, B. M., Barrion, A.T and Litsinger, J. A. 1987. Friends of the rice farmer: Helpful insects, Spiders and pathogens. IRRI, Philippines, 136 pp.

Townes H., Townes, M and Gupta, V.K. 1961. A catalogue and reclassification of the Indo-Australian Ichneumonidae. *Memoirs of the American Entomological Institute* 1, 1–522

Varma, G.C and Maninder 1981. Parasitoids of *Acigona Steniella* (Hampson) (Crambidae: Lepidoptera), their biology and role in nature. *Proceedings of National Symposium on Sugarcane Stalk borer* (*Chilo auricilius* Dudgeon), 127-131.

Vazirani, T.G. 1952. A new host record for the hymenopterous parasite, *Melcha ornatipennis* Cameron (Ichneumonidae). *Journal of Zoological Society*, India 4(1):101.

MS Received 26 April 2022
MS Accepted 15 May 2022

DOI: 10.55278/WGDF6587

Outbreak of common banded awl butterfly, *Hasora chromus* (Cramer) (Hesperiidae: Lepidoptera) in Bangalore

Suresh R. Jambagi*, Bhargava C. N[1]., Vinoda[1] and Vighnesh[2]
[1]*Department of Entomology, UAS GKVK Bangalore, Karnataka, India-560065*
[2]*Department of Agronomy, UAS GKVK Bangalore, Karnataka, India-560065*
Corresponding author: jambagisuru@gmail.com

Introduction

Butterflies, the flying jewels, serve human society economically and environmentally because of their undeniable beauty and ability to pollinate, a fundamental ecological process in natural sustainability around the world. Butterflies are important pollinators and are an important part of the life support system (Suryanarayana *et al*., 2015). Besides acting as pollinators, few butterfly species have economic importance as pests of several crops. Lepidopteran families like Hesperiidae, Papilionidae and Nymphalidae have major role as defoliators of several agricultural and forest crops, causing intensive damage. *Millettia (=Pongamia) pinnata*, often known as karanja, is a leguminous oil-producing multifunctional tree that can withstand a variety of environments. The tree is famed for its insecticidal properties, but it is also attacked by a variety of insect pests, reducing its overall vigor and oil yielding ability.

The common banded awl, *Hasora chromus*, is one of the principal defoliator pests, causing severe leaf losses and in extreme situations, total defoliation. This pest has recently been noticed fluttering in large numbers in the University of Agricultural Sciences, Gandhi Krishi Vigyana Kendra (UAS-GKVK) Campus (13°04'30.4"N, 77°34'46.4"E) (Figs. 1&2). During the pest occurrence, entire tree looked dried without leaves. All the karanja trees in the campus were almost infested heavily by *H. chromus* with 90 - 100% defoliation. Occurrence of the skipper was characterized by presence of numerous larvae on leaves, pupae in folded leaves and activity of adults were also noticed in and around the karanja planted area. Outbreak of *H. chromus* was also recorded earlier in HSR layout and NBAIR Yelahanka campus (Anonymous, 2016b).

Occurrence, Habit and Habitat

The Indian subcontinent, Southeast Asia (including the Malay Peninsula and the Indonesian archipelago), South China, Okinawa, Japan, Papua New Guinea, and Australia are all home to the common banded awl. It extends up to 7,000 feet in the plains and slopes (2,100 m). It can be found in both the forest and open land, in both light and heavy rainfall locations. The common banded awl, or Coeliadinae subfamily of skippers, is the most abundant in India. It has a whirring, fast flight that may be heard at close range. It is less sun-sensitive than other awls, and it is frequently seen soaring among shrubs in full sunlight. It can be spotted early in the day visiting flowers and basking on leaves, frequently with its wings slightly separated. It closes its wings and rests.

Life cycle

Eggs: It lays single eggs both above and below on young shoots or fresh leaves. When the egg is laid, it is pinkish white, dome-shaped with a flattened top and minute longitudinal ridges. These have delicate transverse striations and are bead patterned. As the egg matures, it turns a dirty white color.

Figure 1: Completely defoliated Pongamia/ Karanja tree at UAS GKVK campus due to *Hasora chromus* (Image by: Suresh R. Jambagi)

Figure 2: Severity of banded awl skipper, *Hasora chromus* on *Millettia pinnata* (Image by: Suresh R. Jambagi)

Larva: The caterpillar is cylindrical in shape, with a constricted second segment that resembles a neck with a black collar. The head is lobed, spherical, and the colour is yellowish red. The caterpillar is yellowish black in colour with brown sides ranging from light to dark brown. The markings are really varied. The caterpillar's underside is yellow-tinged greenish white. The green, coupled with the dark patterns, can sometimes cover the entire body. When the caterpillar is first hatched, it eats the eggshelf in bits and scurries off to a leaf, where it quickly constructs a cell for itself. It is active when young but becomes inactive as it matures. Only when the light is very low and at night does the caterpillar venture out to feed.

Figure 3: Pupation of *H. chromus* on different vegetation adjacent to karanja trees (Image by: Suresh R. Jambagi)

Pupa: The pupa is robust, pale brown, and has a conspicuous projection on the head between bulbous eyes, as well as a white belly. It will pupate in the folded fresh leaves and show shelter building behavior. During the intense infestation, it is observed that the larva can pupate in the vegetation (weed plants) present in around the main host (Fig. 3).

Adult: The wings of adult butterfly are entirely covered with scales and are brownish black in color. Male butterfly wings are unmarked, whereas female butterfly wings feature two spots on both sides of the fore wings and a horizontal white band on the lower side of the hind wings in both sexes. Adult butterflies are quite active. The antenna is long and progressively grows larger towards the tip, having a hook-like projection on the terminal segment.

Host range: Larva of *H. chromus* recorded on many host plants but its intense defoliation is noticed in castor, Indian beech (karanja/ pongemia), orange climber, *Derris scandens* and *Heynea trijuga*.

Management

Even though the trees were heavily damaged/defoliated by skipper, soon they rejuvenated after receiving early monsoon showers during May and larval population was also reduced drastically. Meanwhile, the activity of many insectivorous birds feeding on caterpillars was noticed. As per the earlier report, *Crinibracon chromusae* Gupta and van Achterberg (Hymenoptera: Braconidae) act as a pupal parasitoid of *H. chromus* (Anonymous, 2016a; Anonymous, 2017; Rani *et al*., 2020). Hence, there is no need to use any insecticides.

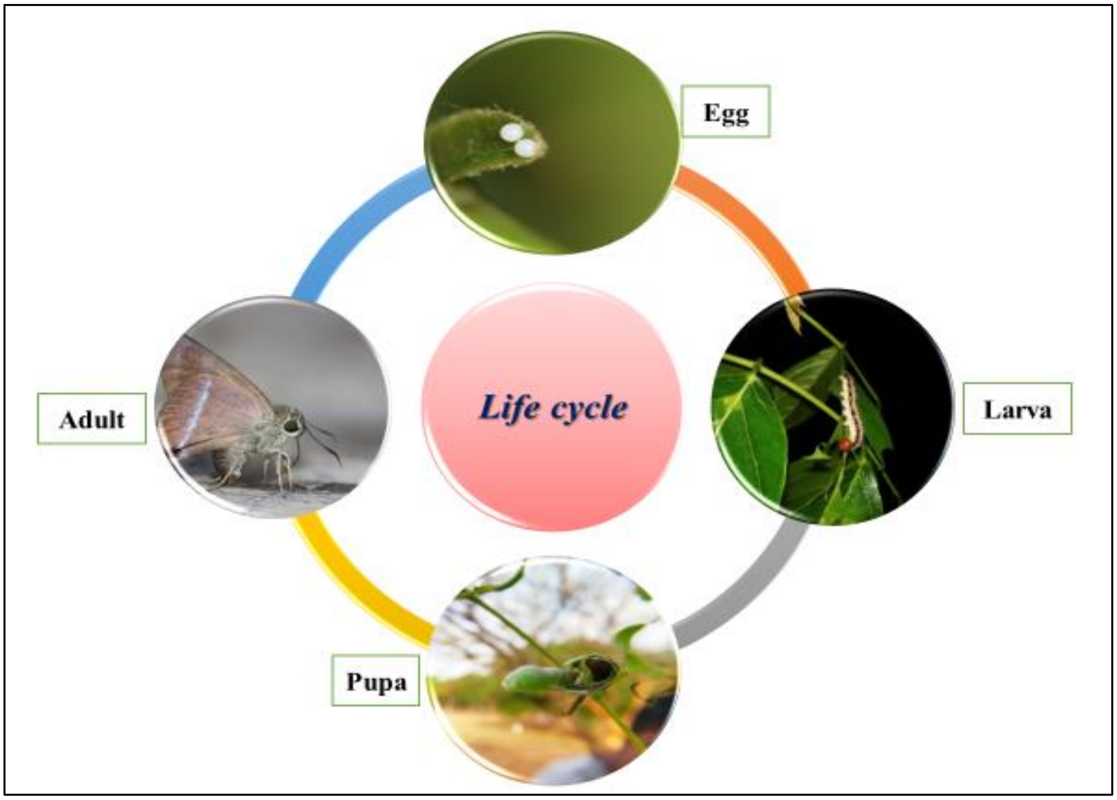


Figure 4: Different life stages of common banded awl skipper, *Hasora chromus* (Image by: Suresh R. Jambagi)

References

Anonymous, 2016a. High incidence of the skipper *Hasora chromus* in Bengaluru. *NBAIR News Letter*, **8**(1):2. https://www.nbair.res.in/sites/default/files/201812/NBAIR%20Newsletter%20%28March%202016%29.pdf

Anonymous, 2016b. Skipper- *Hasora chromus* (Cramer) in transient stage fluttering in and around Bangalore. https://www.nbair.res.in/sites/default/files/201901/Skipper%20outbreak_0.pdf

Anonymous, 2017. All India Co-ordinated Research Project on Biological Control of Crop Pests: Project Coordinator's Report. *XXVI AICRP Workshop on Biological Control of Crop Pests 16-17 March, 2017*, pp. 4. https://www.nbair.res.in/sites/default/files/2020-05/Report%202017.pdf

Devika Rani, D., Jagadesh, K. S. and Jemla Naik, D., 2020. Biology of the common banded awl, *Hasora chromus* Cramer (Lepidoptera: Hesperiidae) on *Pongamia pinnata* at Bengaluru. *Journal of Pharmacognosy and Phytochemistry* **9**(1): 2086-2089.

Suryanarayana, K., Harinath, P., Meerabai, P., Venkata Reddy, M. and Venkata Ramana, S. P., 2015. Life cycle of the common banded awl *Hasora chromus* (Cramer) (Lepidoptera: Rhopalocera: Hesperiidae) from Southern Andhra Pradesh. *Cibtech J Zoo* **4**(1): 45-51.

MS Received 30 April 2022
MS Accepted 12May 2022


CPG
FERTILIZER
TM
With best compliments
PLANET CROP GENETICS
No.1779/23,Nainika Primerose,Flat No 303,3rd
Floor 20th Cross, Vidyanagar Main Road
Davangere-577005,Karnataka
India
Mobile- +91 9902232975

DOI: 10.55278/PXQW5650

Efficacy of new molecules of insecticides against aphid, *Aphis gossypii* (Glover) in summer sesame

Mohanlal Pensiya, G. M. Parmar*, Asha C. Detroja and R. M. Vikani
Department Entomology, College of Agriculture, Junagadh Agriculture University, Junagadh, Gujarat-362001
****Corresponding author – gmparmar@jau.in***

Abstract

Experiment was undertaken during 2021 at Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh to determine the efficacy of new molecules of insecticides against aphid in summer sesame. The results showed that the seed treatment with (fipronil 40% + imidaclopride 40% WG) @ 5 g/kg + FS of afidopyropen 50 DC @ 2 ml/l and (fipronil 40% + imidaclopride 40% WG) @ 5 g/kg + FS of sulfoxaflor 24% SC @ 1.5 ml/l were found highly effective against aphid. The highest yield of 692 kg/ha was obtained from the treatment of (ST with fipronil 40% + imidaclopride 40% WG) @ 5g/kg + FS of afidopyropen @ 2 ml/l which was statistically at par with seed treatment of (chlothiodin 50 WDG) @ 7.5 g/kg + FS of afidopyropen 50 DC @ 2ml/l (680 kg/ha) and ST with (fipronil 40% + imidaclopride 40% WG) @ 5 g/kg + FS of sulfoxaflor 24% SC @ 1.5 ml/l (672 kg/ha). The highest ICBR (1:8.68) was obtained from the treatment of (ST with fipronil 40% + imidaclopride 40% WG) @ 5g /kg + FS of sulfoxaflor 24% SC @ 1.5 ml/l.

Keywords: sesame, aphid, sulfoxaflor, fipronil, afidopyropen, imidacloprid, efficacy

Introduction

Sesame is the ancient oilseed crop of India, is grown from time immemorial. Its seeds contain 52-57 per cent oil and 25 per cent protein (Smith *et al*., 2000). Its cultivation gained impetus because of high quality edible oil, rich source of carbohydrate, protein, calcium and phosphorus (Prasad *et al*., 2002), So, known as queen of oil seeds. It is used in confectioneries, cookies, cake, margarine, bread making etc. Sesame is rich in natural antioxidants or lignin's, which are both oil and water soluble provide very long shelf life and stable characteristics of sesame seed and oil (Ermia *et al*., 2009).

Sesame is attacked by different species of insect pests but sucking insects have great economic importance to sesame plants. Aphid, *Aphis gossypii* (Glover) is serious pest which suck the cell sap from leaves, flowers and capsules. Due to this downward curling of leaf margins, reddening of leaf margins, stunted growth of the plants, sickly appearance of the crop and subnormal growth of the leaf tissue occur (El-Gindy, 2002). The use of insecticides has undoubtedly resulted in the maximum production of food grain for the world food supply, but the proliferation of insecticides and their unilateral utilization have posed many problems such as development of resistance in insect pests to insecticides, resurgence of insect pests, outbreak of secondary insect pests, insecticidal residues etc. Frequent use of single pesticide will not provide effective management of these pests. Therefore, in sesame crop, it is a prime need to find out such pesticides which was effectively control the various sucking pest attacking this crop. Presently, various new molecules with different mode of action are available, that necessitate evaluation against the aphid in summer sesame.

Materials and Methods

In order to study the efficacy of different molecules of insecticides against aphid, the experiment was conducted in summer 2021 at the Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh. Sesame variety G.Til-3 was sown at a spacing of 30 cm x 10 cm. All the recommended agronomical practices were followed. Seed treatment was given at the time of sowing, whereas foliar spray was given at the time of substandard population of aphid. The data on population of aphid was recorded on three leaves (top, middle and bottom canopy of the plants) per plant by randomly selecting five plants from each plot and tagged. The pre-treatment observation was recorded at one day before 1st spray and post treatment observations were recorded at 3, 7 and 10 days after each spray. Statistical analysis was carried out using ANOVA technique given by Panse and Sukhatme (1985).

Treatment details

No.	Treatment*	Dose
T_1	ST with clothianidin 50% WDG	7.5 g/kg seed
T_2	ST with fipronil 40% + imidacloprid 40%WG	5 g/kg seed
T_3	T_1+FS of afidopyrofen 50 DC	7.5 g/kg seed+2 ml/l
T_4	T_1+FS of flupyradifurone 200 SL	7.5 g/kg seed+1.5 ml/l
T_5	T_1+FS of sulfoxaflor 24% SC	7.5 g/kg seed+1.5 ml/l
T_6	T_2+FS of afidopyrofen 50 DC	5 g/kg seed+ 2 ml/l
T_7	T_2+FS of flupyradifurone 200 SL	5 g/kg seed+1.5 ml/l
T_8	T_2+FS of sulfoxaflor 24% SC	5 g/kg seed+1.5 ml/l
T_9	Control	

*ST: Seed Treatment; FS: Foliar Spray; WDG/WG: Water Dispersible Grannules; DC: Dispersible Concentrate; SC: Suspension Concentrate; SL: Soluable Concentrate.

Results and discussion

Results showed that all the treatments having treated seeds were found significantly superior over the control in reducing the incidence of aphid. The result based on mean aphid population are presented in Table 1 indicate the pre foliar spray count of aphid showed that the aphid population in plots having treated seed with fipronil 40% + imidaclopride 40% WG @ 5g /kg varied from (1.58 to 1.68 aphid /3 leaves) and seed treated with clothianidin 50 WDG @ 7.5 g/kg varied from (1.84 to 1.91 aphid /3 leaves). However, significantly higher population of aphid (2.38 aphid /three leaves/plant) was recorded in control plot.

The data on mean number of aphid population after three days of application of insecticides presented in Table 1 indicate that all the treatments were found significantly superior over untreated plot. Seed treatment with fipronil 40% + imidaclopride 40% WG @ 5g /kg + FS of sulfoxaflor 24% SC @ 1.5 ml/l and seed treatment with clothianidin 50 WDG @ 7.5g /kg + FS of sulfoxaflor 24% SC @ 1.5 ml /l were found most effective (0.38 /3 leaves), which was at par with seed treatment of fipronil 40% + imidaclopride 40% WG @ 5g/kg + FS of flupyradifurone 200 SL @ 1.5 ml/l and seed treatment of clothianidin 50 WDG + FS of flupyradifurone 200 SL @ 1.5 ml/l which gave (0.52 aphid /3 leaves). Seed treatments with fipronil 40% + imidaclopride 40% WG @ 5g /kg + FS of afidopyropen 50 DC @ 2 ml/l (1.14/3 leaves) and ST with clothianidin 50 WDG @ 7.5g /kg + FS of afidopyropen 50 DC @ 2 ml /l (1.33/3 leaves) were found medium in their effectiveness.

All the treatments were found significantly superior over untreated plot after seven days of application of insecticides. Seed treatment with fipronil 40% + imidaclopride 40% WG @ 5g/kg + FS of afidopyropen 50 DC @ 2 ml/l was found most effective which gave 0.26 aphid per three leaves which was at par with seed treatment of clothianidin 50 WDG @ 7.5 g/kg + FS of afidopyropen 50 DC @ 2 ml/l (0.31/3 leaves). While, treatments comprising of ST with fipronil 40% + imidaclopride 40% WG @ 5g /kg + FS of sulfoxaflor 24% SC @ 1.5 ml/l (0.79/3 leaves), ST with clothianidin 50 WDG @ 7.5 g/kg + FS of sulfoxaflor 24% SC @ 1.5 ml/l (0.96/3 leaves), ST with clothianidin 50 WDG @ 7.5 g/kg + FS of flupyradifurone 200 SL @ 1.5 ml/l (1.14/3 leaves) and ST with fipronil 40% + imidaclopride 40% WG @ 5g/kg + FS of flupyradifurone 200 SL @ 1.5 ml/l (1.16/3 leaves) were found next best in their effectiveness.

Seed treatment with fipronil 40% + imidaclopride 40% WG @ 5g/kg + FS of afidopyropen 50 DC @ 2 ml/l was found most effective (0.99 per three leaves) and it was statistically at par with seed treatment of clothianidin 50 WDG @ 7.5 g/kg + FS of afidopyropen 50 DC @ 2 ml/l (1.06/3 leaves) after ten days of application of insecticides.

The seed treatment with clothianidin 50 WDG @ 7.5 g/kg + FS of sulfoxaflor 24% SC @ 1.5 ml/l (1.27 /3 leaves), ST with fipronil 40% + imidaclopride 40% WG @ 5g/kg + FS of sulfoxaflor 24% SC @ 1.5 ml/l (1.46/3 leaves), ST with fipronil 40% + imidaclopride 40% WG @ 5g/kg + FS of flupyradifurone 200 SL @ 1.5 ml/l and ST with clothianidin 50 WDG @ 5g/kg + FS of flupyradifurone 200 SL @ 1.5 ml/l (1.52 /3 leaves) and seed treatment with fipronil 40% + imidaclopride 40% WG @ 5 g/kg (1.66 /3 leaves) were found next effective in order of efficacy. More or less similar trend of aphid population recorded after second spray of insecticides.

Data presented in Table 3 indicate that a difference in grain yield was significant. The highest yield of 692 kg/ha was obtained from the treatment of ST with fipronil 40% + imidaclopride 40% WG @ 5g /kg + FS of afidopyropen 50 DC @ 2 ml/l which was found statistically at par with the seed treatment of clothianidin 50 WDG @ 7.5g/kg + FS of afidopyropen 50 DC @ 2 ml/l (680 kg/ha) and ST with fipronil 40 % + imidaclopride 40% WG @ 5g/kg + FS of sulfoxaflor 24% S.C @ 1.5 ml/l (672 kg/ha). The highest (1:8.66) Incremental Cost Benefit Ratio was obtained from the seed treatment of fipronil 40% + imidaclopride 40% WG @ 5g/kg + FS of sulfoxaflor 24% SC @ 1.5 ml/l it is followed by seed treatment of clothianidin 50 WDG @ 7.5 g/kg + FS of sulfoxaflor 24 % SC @ 1.5 ml /l (1:8.33) and ST with fipronil 40% + imidaclopride 40% WG @ 5g/kg + FS of flupyradifurone 200 SL @ 1.5 ml/l (1:7.44).

According to Ambarish *et al*. (2017), the lowest number of aphids (1.71) was recorded in the application of sulfoxaflor 30 % @ 108 g. *a.i* /ha. Prasad (2017) recorded that flupyradifurone 200 SL at lower dose of 150g *a.i.*/ha was found superior in efficacy against cotton aphid. Garg *et al.* (2018) reported that flupyradifurone 200 SL @ 125, 150, 175 g *a.i.*/ha was found effective for managing aphid population in okra. Singh *et al*. (2020) reported the lowest population of aphid 1.33/five leaves/plant after 10 days of spray in flupyradifurone 200 SL @ 2.5 ml/l in okra. Susheel kumar *et al.* (2020) reported that afidopyropen 50 DC @ 2 ml/l showed 82.91, 77.48, and 76.59% aphid reduction in the pest population. So, the results obtained from the present finding are closely fitted with the result reported by earlier worker.

Conclusion

Considering the efficacy, yield and economics of insecticides, seed treatment with fipronil 40% + imidaclopride 40% WG @ 5g/kg + FS of afidopyropen 50 DC @ 2 ml/l were found highly effective against aphid. The treatment comprising of ST with fipronil 40% + imidaclopride 40% WG @ 5 g/kg + FS of sulfoxaflor 24% SC @ 1.5 ml/l and ST with clothianidin 50 WDG @ 7.5 g/kg + FS of afidopyropen 50 DC @ 2ml/l were found moderately effective.

Table 1. Bio-efficacy of different insecticide against aphid after first spray

Sr. No.	Treatment	Dose (g/kg & ml/l)	Mean number of aphid /3 leaves			
			Before spray	3 DAS	7 DAS	10 DAS
T_1	ST with clothianidin 50WDG	7.5g	1.36 (1.84)	1.31 (1.72)	1.36 (1.86)	1.38 (1.91)
T_2	ST with Fipronil 40% + Imidaclopride 40%WG	5g	1.26 (1.58)	1.26 (1.59)	1.31 (1.72)	1.29 (1.66)
T_3	T_1+FS of afidopyropen 50DC	7.5g + 2ml	1.38 (1.91)	1.15 (1.33)	0.56 (0.31)	1.03 (1.06)
T_4	T_1+FS of flupyradifurone 200SL	7.5g +1.5ml	1.36 (1.85)	0.72 (0.52)	1.07 (1.14)	1.23 (1.52)
T_5	T_1+FS of sulfoxaflor 24% SC	7.5g +1.5ml	1.36 (1.84)	0.62 (0.38)	0.93 (0.96)	1.13 (1.27)
T_6	T_2+FS of afidopyropen50DC	5g + 2ml	1.30 (1.68)	1.07 (1.14)	0.51 (0.26)	1.00 (0.99)
T_7	T_2+FS of flupyradifurone 200 SL	5g +1.5ml	1.26 (1.58)	0.72 (0.52)	1.06 (1.12)	1.23 (1.52)
T_8	T_2+FS of sulfoxaflor 24% SC	5g +1.5ml	1.28 (1.65)	0.62 (0.38)	0.89 (0.79)	1.21 (1.46)
T_9	Control		1.54 (2.38)	1.59 (2.53)	1.55 (2.40)	1.57 (2.45)
	S. Em.±	T	0.08	0.06	0.06	0.06
		P	-	-	-	-
		T×P	-	-	-	-
	C. D. at 5 %	T	0.23	0.17	0.18	0.18
		P	-	-	-	-
		T×P	-	-	-	-
	C. V.%		10.21	9.57	9.92	8.62

Figures within parentheses indicate retransform values, while outside are squire root transformed value

Table 2. Bio-efficacy of different insecticide against aphid after second spray

Sr. No.	Treatment	Dose (g/kg & ml/l)	Mean number of aphid /3 leaves			
			Before spray	3 DAS	7 DAS	10 DAS
T_1	ST with clothianidin 50WDG	7.5g	1.46 (2.12)	1.46 (2.12)	1.48 (2.19)	1.52 (2.32)
T_2	ST with fipronil 40% + Imidaclopride 40%WG	5g	1.38 (1.91)	1.43 (2.05)	1.46 (2.12)	1.46 (2.12)
T_3	T_1+FS of afidopyropen 50DC	7.5g + 2ml	1.43 (2.05)	1.07 (1.14)	0.62 (0.38)	1.00 (0.99)
T_4	T_1+FS of flupyradifurone 200SL	7.5g +1.5ml	1.41 (1.99)	0.80 (0.65)	1.18 (1.39)	1.28 (1.65)
T_5	T_1+FS of sulfoxaflor 24% SC	7.5g +1.5ml	1.38 (1.90)	0.76 (0.58)	1.09 (1.20)	1.26 (1.59)
T_6	T_2+FS of afidopyropen50DC	5g + 2ml	1.34 (1.79)	1.15 (1.33)	0.51 (0.26)	0.84 (0.71)
T_7	T_2+FS of flupyradifurone 200 SL	5g +1.5ml	1.36 (1.84)	0.68 (0.46)	1.13 (1.27)	1.26 (1.59)
T_8	T_2+FS of sulfoxaflor 24% SC	5g +1.5ml	1.34 (1.79)	0.62 (0.38)	1.09 (1.20)	1.23 (1.51)
T_9	Control		1.48 (2.19)	1.50 (2.25)	1.57 (2.46)	1.63 (2.65)
	S. Em.±	T	0.07	0.07	0.06	0.07
		P	-	-	-	-
		T×P	-	-	-	-
	C. D. at 5 %	T	NS	0.20	0.17	0.22
		P	-	-	-	-
		T×P	-	-	-	-
	C. V.%		8.47	10.86	8.79	9.84

Figures within parentheses indicate retransform values, while outside are squire root transformed value

Table 3. Economics of different treatment applied for the control of aphid of summer sesame

Sr	Treatments	Total quantity for 2 sprays (g or ml/ha)	Price of Insecticide (Rs./lit. or kg)	Cost of Insecticide (Rs./ha.)	Total cost of Treatment (Rs./ha)	Yield/ha	Gross Realization (Rs./ha)	Net realization (Rs./ha)	ICBR
T_1	ST with clothianidin 50WDG	30g	13000	390	890	399	45087	5424	1:6.09
T_2	ST with fipronil 40% + Imidacloprid 40%WG	20g	15600	312	820	404	45652	5989	1:7.37
T_3	T_1+FS of afidopyropen 50DC	30+1.600	3197	390+5115	6505	680	76840	37177	1:5.71
T_4	T_1+FS of flupyradifurone 200SL	30+1.200	4080	390+4896	6286	652	73676	34013	1:5.41
T_5	T_1+FS of sulfoxaflor 24% SC	30+1.200	2390	390+2868	4258	665	75145	35482	1:8.33
T_6	T_2+FS of afidopyropen50DC	20+1.600	3197	312+5115	6427	692	78196	38533	1:6.00
T_7	T_2+FS of flupyradifurone 200 SL	20+1.200	4080	312+4896	6208	658	74354	34691	1:5.59
T_8	T_2+FS of sulfoxaflor 24% SC	20+1.200	2390	312+2868	4180	672	75936	36273	1:8.68
T_9	Control	-	-	-	-	351	39663	-	-

References

Ambarish, S., Shashi, K. C., Somu, G. and Shivaray, N. 2017. Studies on the bio-efficacy of new insecticide molecules against insect pests on cotton. *Journal of Entomology and Zoology Studies*,**5** (6): 544-548.

El-Gindy, M. A. 2002. Studies on certain homopterous insect vectors of plantpathogenic disease. Ph.D. Thesis, Faculty of Agriculture, Zagazig University, Zagazig, Egypt.

Ermia, S., Geremew, T., Bayeh, M., Zeray, M. and Bayou, B. 2009. Research on insect pests of oil crops in Ethopia. In: increasing crop production through improved plant protection. *Plant Protection Society of Ethiopia*, **23**(2): 115-118.

Garg, V. K., Patel, Y., Raghuwanshi, M. S. and Jamliya, G. S. 2018. Bio-efficacy of Flupyradifuron 200 SL against sucking pest and their natural enemies on brinjal *Annals of Plant and Soil Research*, **20**(1): 73-76.

Panse, V. G. and Sukhatme, P. 1985. Statistical method for Agricultural workers, ICAR, New Delhi, pp. 361.

Prasad, N. V. 2017. Bioefficacy of novel insecticide flupyradifuron SL 200 against leaf hopper, aphids and whitefly in cotton. *International Journal of Bioengineering and Life Science*, 11(10).

Prasad, S. S; Yadav, U. S. and Srivastava, R. K. 2002. Integrated management studies against olitorius jute pests. *Annals of Plant Protection Sciences*, **10**:248-51.

Singh, B. K., Pandey, R., Singh, A. K. and Mishra, M. K. 2020. Effectiveness of flonicamid 50 WG and flupyradifurone 200 SL against leaf hopper and whitefly in okra. *Journal of Entomology and Zoology Studies,* **8**(3): 181-185.

Smith, D. T., Grichar, W. J. and Mccallum, A. A. 2000. Nutritional and nutraceuticals properties of sesame. Texas Agricultural Experiment Station, College Station and Yoakum prepared, 1-19.

Susheelkumar, M. J., Rajash, K. K., Ramesh, M., Jayalaxm, H. N. and Gangaprasad, S. 2020 Bio-efficacy of insecticides against okra leaf hopper, *Amrasca biguttulabiguttula* (Ishida). *International Journal Current Microbiology Application Science*, **9**(2): 460-465.

MS Received 30 April 2022
MS Accepted 11May 2022

DOI: 10.55278/FSTS2281

Commercial meliponiculture- beekeeping with stingless bee, *Tetragonula iridipennis* Smith (Hymenoptera: Apidae: Meliponini)

Stephen Devanesan,* K.S. Premila* and Abraham Verghese #

**Former Professor and Heads, AICRP on Honey Bees and Pollinators,*
College of Agriculture, Vellayani, Kerala Agricultural University, Trivandrum, 695522,
 # Former Director, ICAR-National Bureau of Agricultural Insect Resources, Bangalore 560024
Corresponding author: devanesanstephen@gmail.com

Tetragonula iridipennis, belonging to the family Apidae under subfamily Apinae, is known as stingless bees as they do not have sting apparatus (Devanesan & Raakhee 1999). They are also called dammar bees as they construct numerous elliptical cells for storing pollen and honey by using a special material called “cerumen” consisting of wax and resin (Raakhee and Devanesan 2000).

Stingless bees are ancient eusocial bees which populated the earth 65 million years ago, quite earlier to *Apis* species and are limited to tropics and subtropics because of their inability to maintain the hive temperature. Honey bees and the stingless bees are honey producers coming under the order Hymenoptera, family Apidae and subfamily Meliponinae. They lack sting hence the name “stingless bee” and defend by biting with mandibles. Unlike honey bees stingless bees do not use pure wax for nest building and water for nest cooling. Brood production is similar to solitary bees and they follow mass provisioning to rear their larvae. Both groups make honey in perennial nests founded by a swarm of sterile workers and a queen and colonies occasionally produce male bees.

The ICAR All India Co-ordinated Research Project (AICRP) on Honey bees and Pollinators, Vellayani Centre of Kerala Agricultural University, pioneered the research on Meliponiculture in India (Devanesan & Raakhee 1999).

We happened to notice the presence of dammar bees in different districts of Kerala in basements of buildings and compound walls during Thai sac Brood virus (TSBV) disease survey (1992-93) . The photographs were shown to Dr. O.P. Dubey, the then Assistant Director General (PP), who advised us to conduct detailed studies about the bee species. The ICAR sanctioned a project entitled “Bio-ecology, domestication and management of stingless bees in Kerala” (9-7-1999 to 8-1-2003 for INR. 13 lakhs).

We succeeded in standardizing technologies for commercial meliponiculture by a team of scientists (Raghee M, Shailaja K.K, Premila K.S. and Nisha, M. M) under the leadership of Dr. Stephen Devanesan. We developed technologies for hiving, domestication and management of stingless bees with a view to enhance the number of colonies and this centre has a prime role in popularization of Meliponiculture in the State. As instructed by ICAR, the final report was printed out as "STATUS PAPER ON STINGLESS BEE *TRIGONA IRIDIPENNIS* SMITH" authored by S. Devanesan, K.K. Shailaja and K.S. Premila. The same was released in the Annual Group Meeting held at Rajendra Agricultural University, Pusa, Samasthipur, Bihar in February 2009 by then Assistant Director General (PP), Dr.T.P. Rajendran. It was resolved in the group meeting that the research on stingless bees has to be promoted in all AICRP Centres and Vellayani centre as nodal centre for stingless bee research (Fig. 1).

Out of more than 500 species described worldwide, about 50 species occur in Asia. They have a wide distribution in India with reports of the following nine species. *Lepidotrigona arcifera* (Cockerell, 1929), *Lisotrigona cacciae* (Nurse, 1907), *Lisotrigona mohandasi* Jobiraj & Narendran, 2004, *Tetragonula ruficornis* (Smith, 1870), *Tetragonula bengalensis* (Cameron, 1897), *Tetragonula iridipennis* (Smith, 1854), *Tetragonula praeterita* (Walker, 1860), *Tetragonula aff. laeviceps* (Smith, 1857), *Tetragonula gressitti* (Sakagami, 1978). Asiatic stingless bee *Tetragonula (Trigona) iridipennis* Smith is the common stingless bees found in Kerala which was identified by Dr. David W Roubik, Smithsonian Tropical Research Institute, USA.

Their small size (2-16 mm) allows them to access varied flowers whose openings are too narrow for nectar and pollen from which the *Apis* bees cannot forage (Devanesan, *et al*., 2002). They also collect nectar and pollen from low lying herbs and weeds having comparatively smaller flowers, which are not commonly visited by *Apis* spp. including medicinal plants (Premila, *et al*., 2007). The stingless bees make less honey compared to *Apis* honey bees and are widely distributed in diverse tropical regions of India (Vijayakumar *et al.,* 2013). Although it produces far less honey the honey is unique having great medicinal value fetching high price. It is used in folk medicine, Ayurveda, Sidha, Unani etc for curing many diseases. Stingless bees are excellent pollinators of both rest/agricultural/horticultural flora and crop plants, and exhibit great flower constancy which increases the ecological importance of these bees for conservation of biodiversity and yield enhancement through crop pollination.

Meliponiculture is the art and science of rearing stingless bees on a commercial scale for honey production or pollination. It is reared as backyard beekeeping practice mainly for honey production. It is being popularized in the rural homesteads for additional income generation. In Kerala, the stingless bee colonies are reared in logs, earthen and clay pots, bamboo bits, wooden boxes and coconut shells. Creating awareness about the scientific meliponiculture will be helpful to the farmers for rearing them in homesteads so as to benefit for the pollination of vegetables and other fruit crops available in and around promoting commercial meliponiculture (Fig. 2). Handling of stingless bees is easier, even children and women can rear stingless bees. Hence it is recommended that "each homestead to have one stingless bee colony". The production of stingless honey does not match the demand. As it is recommended for the cure of different diseases including cancer, the demand has increased in the market due to its medicinal properties.

Natural domicile and nest architecture

Stingless bees prefer darkness and the natural domicile is the crevices in the basements of old buildings, compound walls, tree trunks, hollow blocks etc. The colonies found in natural conditions are called 'feral' colonies. They remain in the same location if there is no disturbance. The nest of stingless bee essentially consists of hive entrance, brood cells, storage pots of honey and pollen, resin dumps, pillars of wax, waste dumps etc.

Openings to the nest are through resin tubes of varying shapes, lengths and sizes, normally built of wax and mud, sometimes sticky in nature. The structure of hive entrance of *T. iridipennis* colonies in wooden boxes, bamboo bits and earthen pots varies in their shape and size (long or short tubular, round or cryptic, half oval in shape etc). Major part of entrance tube material is made up of resin. Some dust materials like soft barks, mud and cobweb like silky material is also found over the tubes (Fig. 3). The texture is not brittle and the nest consist of five parts; an entrance, brood comb, involucrum, store pots and batumen. In the construction of brood comb, storage pot and involucrum they use cerumen (Raaghee and Devanesan, 2020) (Fig.4).

The arrangement of brood cluster is loose in *T. iridipennis.* They build multi-layered combs one over the other and each expanding concentrically and horizontally. Cell construction starts from the bottom of the pillars and proceeds in an upward direction. At a time, a batch of cells is constructed through successive and intermittent contributions of several workers. Brood cells are dark brown in colour in the early stages and as the pupae mature, the cerumen from walls of the brood cells are removed and became creamy in colour so that the cocoons get exposed.

Most of the removed cerumen is used again to build another brood cell, storage pot or other nest structures. The queen cells of *T. iridipennis* are larger (4.00 mm) than that of worker cells (0.22 mm). Queen cells could be seen in stingless bee colonies from November to March. They are intermixed with worker cells or seen at the periphery of the brood cluster. The food chambers are normally oval in shape and larger than the brood cells. The pollen pots are located near the entrance and seen intermixed whereas the honey pots are seen either near the entrance or far from the entrance. The honey pots are also seen intermixed with pollen pots.

Stingless bees also lead a colonial social life and each colony consists of a single queen few drones more and workers as in the case of *Apis* bees. Usually one queen is present in a colony and the queen lays egg and controls and co-ordinates all the activities in it. The queen is much larger than workers and drones, lacking corbiculae and wax glands. It has longer scape, shorter tongue, smaller mandibles, wings partially covering the swollen abdomen and less distinct glabrous streaks on mesonontum, abdomen is dark brown in colour with white stripes. Queen lays 80-120 eggs per day. The developmental period of a queen (egg to adult) is 65-70 days. The newly emerged queen is called 'gyne' or virgin queen. The new queen makes her nuptial flight, where she is mated with a single male. The virgin queen will mate only once. The sperm is stored in a special sac 'spermatheca' in her body for her entire life. The queen's ovaries initiate egg development, enlarging the abdomen, so that she cannot fly anymore. Egg laying commences within 10 days after mating. She can choose whether or not to fertilize each egg with the sperm. The queen and workers develop from the fertilized eggs, and drones/ males develop from the unfertilized eggs. The life span of queen is up to five years, though her stamina for egg laying will be reduced over time. The life span of queen is reported to be up to five years (Raaghee 2000) (Fig.5).

The drones or male bees are developed from unfertilized eggs and are few in a colony and function is mating. Number of drones increase in the colonies during the brood rearing season. The drones can be identified by straightly arranged ocilli, laterally arranged compound eyes, smallest scape, longest antennae, smallest mandibles, less distict glabros streaks on mesonotum, rudimentary corbicula, and wings projecting slightly beyond the blunt abdomen and genitalia (Fig. 6).

Worker bees are females developed from fertilized eggs. Most of the works in a colony are performed by the worker bees. The worker bees are smaller in size than the queen with small abdomen and entire body is black to blackish-brown. Males and workers are very similar and difficult to differentiate. The developmental period of a worker (egg to adult) is found to be 44.5 days. The young workers after emergence perform different jobs, preparation and repairs of the brood chamber, construction of the involucrum and provisioning of cells. Some will become nurse bees, producing royal jelly to feed the larvae, young adults and queen. As age advances, perform duty as guards and foragers and with a life span of 80 days - (Fig. 7).

Honey and pollen are the food of stingless bees as *Apis* bees. Stingless bees do not go far distance for foraging as other boney bees. They visit plants within an area of 1 km around the hive. They forage from medicinal plants, agricultural and horticultural crops, spices, vegetables, cash crops, ornamental plants and number of weed plants around the locality. They start foraging activity in the early morning.

Studies conducted to document the plants visited by the stingless bee revealed that there are 142 plant species, which provide either nectar or pollen or both to stingless bees in the State (AICRP, 2014). Out of the 142 plants, 70 provided nectar alone, 25 provided pollen only and 47 provided both nectar and pollen. These include medicinal plants, plantation crops, condiments and spices, vegetables, field crops, ornamental plants, wild plants and weeds.

The AICRP on Honey bees and Pollinators, Vellayani centre has standardized technologies for hiving, domestication, management such as division of colonies, honey extraction, hygienic honey processing and dearth season management. These techniques helped meliponiculturists to adopt commercial meliponiculture. The centre disseminated to the public by imparting trainers training in different districts of Kerala in which 2074 women and 8322 men were trained. It is estimated that more than 50,000 stingless bee colonies are domesticated in the state for pollination service, ensuring sustainable agriculture and the conservation of biological diversity resulting in food security.

Hiving of feral colonies to artificial hives (earthen pot/wooden hive) will damage the buildings/ walls and the public hesitate to demolish the structures. However, feral colonies can be easily transferred to hives. For this, the mouth of an earthen pot is to be placed in front of the entrance of a feral colony and its rim is to be firmly attached to the wall using mud. Adequate support to the pot should be provided wherever required. An opening is to be given at the opposite side of the pot as bee entrance and surrounded with wax of stingless bee. The worker bees pass through the hole in the pot using it as new entrance. Gradually the bees realize that there is sufficient space inside the pot to store the brood and food reserves and hence they newly construct pollen and honey pots inside the earthen pot. Eventually they build the brood cells and start brood rearing inside it. The colony and pot should be left undisturbed for at least six months for the feral colony to settle inside the mud pot (Fig. 8). Later the pot with brood, pollen, honey, worker bees and a queen can be detached and shifted to a suitable site to establish as a new colony. Similarly wooden hives can also be used for hiving feral colonies (AICRP, 2011) (Fig. 8).

For transferring feral colonies from electric meter boxes or such structures, tubes/bent tubes are to be used. For this carefully remove the entrance tube of the bee colony. Then fix the detached entrance tube to one end of the plastic tube (1cm diameter). Fix the other end of the tube or bent tube in the original position of the hive entrance. The foragers will pass through the newly fitted plastic entrance hole. After a week time, a new wooden box hive / earthen pot with entrance hole at opposite side is to be attached to the feral colony. It should be left undisturbed for at least six months.

Kerala Agricultural University (KAU) wooden hive

Among the different types of hives (wooden box, earthen pot, bamboo bit with volume of 1500 cc, 2250 cc, 3000 cc, and 3750 cc) evaluated for domestication, bamboo hive with 1500 cc capacity showed better brood development and maximum storage of pollen and honey followed by earthen pot and wooden hive. Considering the scarcity of bamboo bits, this centre has designed and developed a new 'KAU wooden hive' with two equal halves for the domestication of stingless bees. Volume of the box is 1960 cc and the internal measurements are: length - 35 cm, breadth – 7 cm and height - 4 cm, providing a hole in the centre of two halves on one side of the hive will act as the hive entrance. This hive is suitable for easy hiving, domestication, proper brood development, division of colonies and honey collection (Fig.9).

Seasonal Management of stingless bee colonies

The stingless bees have brood rearing season (October - December) followed by honey flow season (February - May) and a dearth season (June -September). Brood rearing season is best suited for the beginners to start meliponiculture. Acquiring knowledge about scientific meliponiculture through trainings and field practical will help for sustainable meliponiculture. Weekly observations of hives are not required as in *Apis* bees. Open the colonies for honey extraction during April-May and division of colonies during October-November. Protective measures have to be taken to prevent the attack of ants, predatory spiders, mites etc.

Growth period management

During the natural growth period, worker bees construct pillars of wax, which serve as base to the brood cells, over which oval/elliptical brood cell cups are constructed with the help of several workers. Queen bee lays more eggs during growth period. The laying queen bee, inspect the cup cells and few workers fill the cups with food materials for the growth and development of larvae. Then the queen lays an egg over the food stuff in the cup. This is known as 'mass provisioning.' After oviposition worker will close the cup cell with the resin. Once the first set of brood cells are provisioned and oviposit newer cells are constructed above it (Fig.10). When, the population of worker bees increase, new queen cells (royal cells) are produced naturally resulting in swarming of stingless bees colonies. Keeping empty KAU hive in the apiaries with stingless bees, pasted with stingless bee wax in the hive entrance will help to trap the swarm. Management of colonies properly during the growth period will help to increase the number of colonies through division.

Division of the colonies

Healthy and disease-free, active colonies having sufficient mature brood, young brood, pollen, honey and queen cells are to be selected for division. Division of the colonies is to be done during evening hours. Rainy and cloudy days are unsuitable for opening the hive.

While dividing the colonies many worker bees may be lost. To minimize the loss of worker bees, they are to be safely removed from the colony before opening it, as done during honey extraction. After removing the worker bees, locate the queen/queen cells and transfer the queen along with half the quantity of mature brood, one-fourth quantity of young brood and half the volume of pollen and honey pots to a new hive. A good healthy queen cell is retained in the mother colony. If no queen cell is present in the selected colony a queen cell is to be grafted from another colony. The daughter colony with queen is to be shifted to a new site approximately 1000 ft. (300 m) away from the original site. Mother colony with queen cell is to be maintained in the original site.

The colonies maintained in the newly designed wooden hive with two equal halves is easier to divide. Open the hive and equalize the brood, pollen and honey storage in both the halves and provide an empty half box above the bottom piece of the hive. Similarly, provide the other empty half below the other piece to make a full hive. Care should be taken to provide either a queen or queen cell in each of the newly divided colonies (Fig.11).

Avoid damage of the honey pots during division which may cause invasion of ants and fermentation of honey. Since the brood cells are very soft, care should be taken to minimize the damage of brood cells, otherwise the colony fails to establish. Presence of excess pollen and honey in the colony make them prone to pests and disease incidence and hence, it is desirable to remove excess pollen and honey periodically to maintain healthy colonies. While handling a hive, the direction of hive opening is to be marked so that the hive entrance can be retained in the original direction itself to avoid the confusion of foraging bees to find the entry.

Dearth season management

Feed can be prepared by using previous year's waste honey (collected during honey processing). A plastic tray used in the fridge for keeping the vegetables, with small ventilation (2-3 mm), is used as feeding tray, through which only the stingless bee workers can pass. Place a rectangular glass piece at the bottom of the tray. Put a cotton layer over the glass plate and drip with honey syrup using a wash bottle. 10-20 ml of syrup can be used for a single colony. Close the device with another piece of glass and keep the tray in a stand with proper ant protection devise (Fig.12).

Honey extraction

The honey from stingless bee colonies is extracted once in a year during April -May. The traditional method of honey extraction from stingless bee colonies is by squeezing the honey pots along with the pollen pots and brood cells resulting in unhygienic honey. The honey extracted by this method contained large quantity of pollen and other extraneous matters, which caused contamination. It also resulted in the destruction of bees, brood and ultimately the colony. Care should be taken to use sterile knife, spoons, vessels and cover head and mouth with mask and use glouse.

While opening the colonies for honey extraction many worker bees will bite the beekeeper and may be lost. To minimize the loss of worker bees, before opening the colony for honey extraction the bees are to be removed and protected in empty water bottles. For this, the mouth of an empty water bottle (dried), with adequate small holes is to be placed at the hive entrance tube. Gently tap on the hive so that the worker bees' start coming out from the hive and will enter into the bottle. Two or more bottles can be used according to the strength of the colony. Cap the bottles, keep them aside and open the hive for extraction (Figs. 13, 14).

The pots alone are collected by using a sterile spoon from the nest and are kept in a clean tray. The tray is to be exposed to sunlight in a slanting position. The wax of the honey pots melt due to the heat of the sun and the honey pouring out is to be filtered and bottled. There is no need for heating stingless bee honey like *Apis* honey. This method is relatively simple and yield clear honey without extraneous matters. After extraction, the bees in the bottles may be released.

Stingless bee honey

The stingless bee honey (SBH) is a natural product produced and marketed worldwide, collected from stingless bees which is only produced in tropical and subtropical regions and features a distinct sweetness, mixed with an acidic taste, fluid texture, high moisture content and minimal crystallization. Stingless bee honey is popular for its unique behavior of collecting nectar from multiple flowers and extra floral nectaries. The nectar then goes through a conversion in the bees' 'honey stomach' to transform into honey and deposited into cerumen pots which are developed from propolis. This gives the honey rich in nutrients and phenolic compounds, mainly flavonoids and phenolic acids, which act as potent antioxidants.

The stingless bee honey (SBH) has high nutritional and therapeutic value due to the diversified plants foraged including medicinal plants and structure of nest, the antimicrobial activity of SBH is little bit stronger than other honeys with unique therapeutic properties with great potential to be developed for modern medical uses. It is used in many medicines in Indian System of

Medicine, the Ayurveda for many diseases, in reducing the heat of the body, inflammation, bleeding in the throat, impurities of the blood, boils and even for cancer. SBH as a therapeutic agent in various health issues such as anti-diabetic wound healing, anticancer, treatment of eye diseases, and also in fertility. Studies have proven that the SBH has excellent potential and portrays beneficial effects as antimicrobial, anticancer agent, improving hypertension, lipid profiles, and with some studies showing better anti-diabetic effects. In order to provide a major comprehensive understanding on the potential uses and benefits of the SBH, more systematic studies need to be carried out. In terms of quality control, methods to authenticate pure SBH need to be developed. A rapid and destructive analysis technique is required to avoid possible adulteration by irresponsible manufacturers. The quality standard can be established by the identification of its bioactive component since SBH is rich in antioxidants and innovative efforts should be taken to fully explore and utilize these benefits. Honey-based products should be diversified, such as making supplement capsules or tablets which contain probiotics isolated from the SBH that can aid in gastrointestinal health. These properties should also be made readily in the form of topical creams or gels for wound healing or other purposes (Fig.15).

Pollination service and playhouses

There is ample potential for utilization of stingless bees in pollination service as they are better pollinators of some crops than honey bees which thrive much better in tropical areas and are polylectic. The smaller body size, shorter foraging distance, less aggressiveness, floral constancy, higher longevity of the colonies, efficient worker recruitment behavior towards food sources, medium colony size, lesser swarming tendency, tolerant to high temperature and less pest and disease incidence are the advantages of stingless bees as pollinators. Studies conducted at Tamil Nadu Agricultural University (Tej *et al*., 2017) revealed that keeping stingless bees in greenhouse cucumber can improve its pollination and thus fruit weight and yield. Stingless bees play an important ecological role as pollinators of many wild plant species and seem good candidates for future alternatives in commercial pollination. Eleven stingless bee species across six genera have been found to forage effectively under enclosed conditions, indicating the potential of stingless bees as pollinators of greenhouse crops- over the past six years the number of crops reported to be effectively pollinated by stingless bees has doubled, putting the total figure on 18 crops. (Judith *et al.,* 2006*).* It is reported in sweet pepper *Capsicum annuum* L. that despite flowers are considered autogamous, this crop benefits from pollination by stingless bee *Melipona subnitida*, producing fruits significantly heavier and wider, containing a greater number of seeds and of better quality (lower percentage of malformed fruits) than self-pollinated sweet pepper. Thus, *M. subnitida* can be considered an efficient pollinator of greenhouse sweet pepper (Cruz *et al.*,2006). The potential of stingless bees for seed production, pollination and yield enhancement of various crops under protected cultivation to be explored in India has by conducting scientific studies.

Pests / Enemies of stingless bee

Studies conducted at this centre could identify some enemies of stingless bees, either attacking while foraging or encountering the colony. They are dipteran fly *Hermetia illucens* L., Nitidulid beetle *Aethina* sp. reduviid bug *Acanthaspis siva*, Assassin Bug *Sycanus* sp., predatory spiders *viz*., *Thomisus lobosus*, *Thomisus projectus*, *Menemerus bivittas*, *Neoscona nautica*, *Heteropoda venetoria*, ants *Solenopsis geminata*, a species of megachilid bee, a mite *Amblyseius* sp. etc

Fig. 1. Dr.T.P. Rajendran, Assistant Director General (PP), released the book "status paper on stingless bee *Trigona iridipennis* smith"

Fig. 2. Commercial meliponiculture

Fig. 3. Hive entrance helps to detect the presence of feral colony

Fig. 4. Nest architecture

	
Fig. 5. Stingless bee queen	Fig. 6. Stingless drone
	
Fig. 7. Stingless worker	Fig. 8. Hiving feral colonies without damaging compound wall
	
Fig. 9. KAU hive for commercial meliponiculture	Fig. 10. Mass provisioning

Fig. 11. Division of colonies

Fig. 12. Dearth season management-Artificial feeding of colonies

Fig. 13. Worker bees transferred in the empty water bottle.

Fig. 14. Honey extraction without harming the worker bees

Fig. 15. Hygienic pure honey pots

Conclusions

Practicing commercial meliponiculture in the homesteads will provide the service of stingless bees in pollination of various crops particularly vegetables and fruits and their yield enhancement. The services of stingless bees can be utilized for quality seed production too. "If the bee disappears from the surface of the earth, man would have no more than four years to live. No more bees, no more pollination, no more plants, no more animals, no more man." (Albert Einstein)

Acknowledgements

The Indian Council of Agricultural Research (ICAR) is greatly acknowledged for providing funding for the studies and we are indebted to lateDr. O.P. Dubey, the then Assistant Director General for his encouragement.

Kerala Agricultural University, AICRP on Honey Bees and Pollinators, Vellayani Centre, College of Agriculture, Vellayani gave the facilities for conducting the studies.

The cooperation of the researchers Dr. K.K. Shailaja, Former Research Associate, Raghee M, Dr. Nisha, M. M, and the beekeepers Mr. S.A. John (Trivandrum) and R.S. Gopakumar (Kollam) need to be acknowledged.

References

AICRP. 2011. Annual Report of AICRP on Honey bees and Pollinators, Vellayani centre. p.92

AICRP. 2013. Annual Report of AICRP on Honey bees and Pollinators, Vellayani centre. p.96

AICRP. 2014. Annual Report of AICRP on Honey bees and Pollinators, Vellayani centre. p 55

AICRP 2013-15 Biennial report 2011-2013 of AICRP on Honey bees and Pollinators Vellayani centre of Kerala Agricultural University, 34p.

Amano, K., Nemoto, T. and Heard, A. 1999. What are stingless bees and why and how to use them as crop pollinators. *Rev. Biol. Trop.* 47 : 130-142

Amano, K. 2004. Attempts to introduce stingless bees for the pollination of crops under greenhouse conditions in Japan. Available: http://www.ûtc.agnet.org/library/article/tb167.html. [Sept 16.2014].

Basavaraj, R., Nidagundi. and Sattagi, H.N. 2005. Pollinator fauna and foraging activity of bees in bittergourd. *Karnataka J. Agric. Sci*. 18(4):982-985.

Crane, E. 1999. The world history of beekeeping and honey hunting. Routledge, New York , 682pp

Darci de Oliveira Cruz, Breno Magalhães Freitas, Luis Antônio da Silva, Eva Mônica Sarmento da Silva and Isac Gabriel Abrahão Bomfim (20060) Pollination efficiency of the stingless bee

Melipona subnitida on greenhouse sweet pepper. Universidade Federal do Ceará, Dep. de Zootecnia, Caixa Postal 12168, Campus do Pici, CEP 60021-970 Fortaleza, CE. E-mail: freitas@ufc.br

Devanesan, S Raakhee, M (1999). Dammer bee, *Trigona irridipennis* in Kerala, Insect Environment, Vol 5(2) July-Sept,1999

Devanesan. S, Nisha, M.M., Bennet, R. Shailaja, K.K (2002). Foraging behaviour of stingless bee *Trigona iridipennis* Smith. *Insect Environment* 8:3 p 131

Devanesan. S, Nisha, M.M., Bennet, R. Shailaja, KK (2002). Hermetia illucens (L) Stratiomyidae: Diptera) A new pest of stingless bee *Trigona iridipennis* Smith. *Insect Environment* 8:3 p 130 *Insect Environment* 8:3 p 130

Devanesan, S., Nisha, M.M., Shailaja, K.K., Bennet, R (2003). Natural enemies of stingless bee *Trigona irridipennis* Smith in Kerala. Insect Environment 9(1):30

Devanesan, S, K.K. Shailaja, M. Raakhee, R Bennet, S. Premila (2004). Morphometric characters of the queen and workers of stingless bee *Trigona iridipennis* Smith, Insect Environment 9(4) 2004 p 154-155

Devanesan, S, K.K. Shailaja, K.S. Premila (2004). Morphometroc characters of the queen and worker of stingless bee *Trigona iridipennis* Smith. Insect Environment. 9:4 p 154

Devanesan, S., Shailaja, K.K. and Premila, K.S. 2009. Status paper on Stingless bee *Trigona iridipennis* Smith. pp 79.

Dollin, A. 2001. *Australian stingless bees*. Technical Bulletin No.9 Australian Native Bee Research Centre. North Richmond, Australia p.14

Ester Judith S, Luis Alejandro S, Katia Sampaio M, Frouke Elisabeth H, 2006. Stingless bees in applied pollination: practice and perspectives. Apidologie 37 (2006) 293–315 293 c INRA/DIB-AGIB/ EDP Sciences, 2006 DOI: 10.1051/apido:2006022

Nisha, M.M. 2002. Management of Stingless bee *Trigona iridipennis* Smith (Meliponinae: Apidae) in the homesteads of Kerala. M.Sc. (Ag.) thesis, Kerala Agricultural University, Thrissur, p. 93

Percy, A.P. 1989. Division of *Trigona iridipennis* Smsith. colony. *Indian Bee J.* 51 : 149

Premila K, S., Devanesan, S., ArthurJacob. J, and Shailaja K.K., 2007. Foraging plants of Stingless bee *Trigona iridipennis* Smith. And physic-Chemical characteristics of its honey.

Abstr. No.183, 40th Apimondia, International Apicultural congress, Melbourne, Australia, Sept. 9-14, 2007. P.129

Raakhee, M. 2000. Bioecology and management of stingless bees (Apidae : Meliponinae). M.Sc. (Ag.) thesis, Kerala Agricultural University, Thrissur, p. 68

Raakhee, M and Devanesan, S (2000). Studies on the behaviour of stingless bee *Trigona iridipennis* Smith (Apidae : Meliponinae). *Indian Bee Journal* 62(3&4):2000 p 59-62

Sakagami, S.F. and Inove, T. 1989. Stingless bees of the genus *Trigona* (Subgenus – *Geniotrigona)* (Hymenoptera :Apidae). *Jap. J. Ent.* 57 : 605-620

Subhakar, G., Sreedevi, K., Manjula, K. and Reddy, N.P.E. 2011. Pollinator diversity and abundance in bittergourd, *Momordica charantia* Linn. *Pest Manag. Hortic. Ecosyst.* 17(1): 23 – 27.

Tej K.M, Srinivasan MR, Rajashree V and Thakur RK, 2017.Stingless bee *Tetragonula iridipennis* Smith for pollination of greenhouse cucumber. Journal of Entomology and Zoology Studies 2017; 5(4): 1729-1733Vijayakumar, K, muthuraman, m, & Jayaraj, R. (2013). Propagating *Trigona iridipenis* colonies (Apidae; meliponini) by eduction method. *Scholars academic journal of biosciences*, I(I), 1-3

Woo, K.S., Kim, J. H.and Mappatoba, I.S.A. 1996. The foraging activity of stingless bees, *Trigona* sp. (Apidae, Meliponinae) in the green house. *Korean J. Apic.* 11: 82-89.

MS Received 20 April 2022
MS Accepted 01May 2022


Unigen Seeds
UNITED GENETICS INDIA PVT. LTD.
a member of KAGOME group
With best compliments
UNITED GENETICS INDIA PVT. LTD
No.328, 2nd Floor, Aditya Arcade, HIG A Sector,
3rd 'A' Cross, Yelahanka New Town,
Bangalore- 560064,
INDIA
Phone: +91 9886885369 / 080 41228377

DOI: 10.55278/GFFC4307

Erebid Moths of Lonavala: A tourist spot in the Western Ghats with tremendous anthropogenic pressure, and a new range extension record

Aparna Sureshchandra Kalawate[1*], Shital Pawara[2], Prachee Surwade[1]

[1]Zoological Survey of India, Western Regional Centre, Vidhya Nagar, Sector 29, P.C.N.T. (PO), Rawet Road, Akurdi, Pune, Maharashtra 411044, India.

[2]GSDP & PhD. Student S.G. Patil Arts, Science & Commerce College, Sakri, Maharashtra 424304, India.

Correspondng author: devarpanento@gmail.com (https://orcid.org/0000-0001-6595-6749)

Abstract

The present study was taken up with an aim to document the diversity of Erebid moth from Lonavala, Maharashtra. A total of 44 species of 36 genera in 10 subfamilies belonging to Erebidae, Lepidoptera have been reported. It was a part of a short project conducted by the Green Skilled Development Programme (GSDP) students of the certificate course on para-taxonomy [including Peoples Bio-diversity Register (PBRs)] at Zoological Survey of India (ZSI), Western Regional Centre (WRC), Pune. This article also presents a new distribution and range extension of *Calesia* sp. One endemic moth, *Olepa clavatus* (Swinhoe, 1885) is also reported from the studied site. Additionally, the data on type species, type locality along with their distributional record from India and outside India, bionomics for each species are also presented.

Key words: Moths, Northern Western Ghats, diversity, anthropogenic, *Calesia*.

Introduction

Insects are the most successful creatures on the earth. Among them, Lepidoptera is one of the most diverse insect orders. Moths and butterflies are the insect groups under Lepidoptera. There are approximately 160,000 species of moths (Nieukerken *et al*., 2011) and most of them are major and minor pest. Moths are nocturnal feasting on the varied crops, wild trees, ornamental plants, etc. They are of economic importance as the larvae of majority of the moths feed voraciously on the plant parts (leaves, flowers, stem, seeds) and are the damaging stage responsible for food losses. Erebidae moths are of immense economic importance as some adults (fruit sucking moth) feed on the commercial fruits like citrus, causing economic loss to the farmers. In case of a widely distributed fruit sucking moth, *Eudocima phalonia* (Linnaeus, 1763), the adults have destructive feeding habits and not the larvae. Larvae of this moth feed on wild trees (Menispermaceae and Fabaceae) (Kumar and Lal, 1983). The damage in citrus orchard in India may vary from 10–55% (Dadmal and Pawar, 2001) and 57% in pomegranate (Mote *et al*., 1991). Some microorganisms introduced on the citrus orchards due to the feeding habits of these moths cause rotting and premature fruit fall (Sands *et al*., 1993). The damage caused by the moth is also severe in economic crops like cotton, brinjal, citrus, tomato, sugarcane, cereals, millets, pulses, vegetables and plantation crops.

Besides, some are indicator taxa that utilize lichens as a food source and are useful in pollution monitoring (Kendrick, 2002). They are preyed in different life stages by bats, birds, lizards, amphibians, dragonflies, spiders, small mammals, fungi, bacteria etc. It is one of the most speciose families with the species count of 24,569 in 1,760 genera (Nieukerken *et al*., 2011) and are well-studied. From Maharashtra, 86 species have been reported by Mitra *et al*., (2019); 128 species from northern Western Ghats of Maharashtra by Subhalaxmi *et al*., (2011); 101 species from the northern Maharashtra (Gurule and Nikam, 2013); 10 species from Pench National Park, Maharashtra (Kalawate & Sharma, 2017); 44 species from northern Western Ghats of Maharashtra (Kalawate, 2018a); two species of erebid moths, *Gurna indica* (Moore 1879) (Kalawate *et al*., 2019) and *Mecodina metagrapta* Hampson, 1926 (Kalawate, 2018b) were recently rediscovered from India.

The present study was a part of short project undertaken by the GSDP students of Para-Taxonomy [including Peoples Bio-diversity Register (PBR)] certificate course of ZSI, WRC, Pune, and hence was a time bound project (course duration: 03 months). The nearby study site selected was Lonavala, a small town and a hill station in Pune district of Maharashtra and a part of Western Ghats, which is an important Biodiversity Hotspots and a UNESCO world heritage site. It is surrounded by the highly urbanised cities like Mumbai and Pune, thus faces lot of pressure of tourists being a hills station. The biodiversity in Northern Western Ghats faces degradation by human exploitation. The global conservation problem is the loss and fragmentation of tropical rainforest forming a major proportion of the world's biodiversity (Whitmore, 1997; Kapoor, 2006). Fragmentation of natural habitat is a problem in the northern Western Ghats, and moths are sensitive to habitat fragmentation and the species whose larvae are monophagous are more affected by the loss of habitat than the polyphagous (Ockinger *et al*., 2010).

The distributional records of the species from India and outside India along with the type species and type locality data and bionomics have been provided in this paper. On perusal of literature, it was found that less or no work on the moth fauna of Lonavala in general and Erebidae in particular has been carried out and hence in the present study an attempt has been made to assess the Erebid moth fauna of Lonavala.

Materials and methods

Moths were collected from Lonavala, Maharashtra (Fig. 2) using light trap (Fig. 1).

The light trap is consisting of white cloth measuring 3 m long x 1.5 m and was hung in between the two poles. The light source used was Mercury Vapour Lamp of 160 W powered by portable generator and was hanged middle of the white cloth. The collected specimens were euthanized by ethyl acetate vapors and preserved as dry. The specimens were relaxed, pinned and preserved in the laboratory for further studies. They were studied under Leica EZ 4 HD stereozoom microscope. All identified specimens were labelled, duly registered and deposited at National Zoological Collection, ZSI, WRC, Pune, Maharashtra, India. The latitude and longitude coordinate of the collection site was 18.7546171°N & 73.4062342°E and elevation 626m. The map of the study site (Fig. 2) was prepared using open free software QGIS. Images of the moths are depicted in Fig. 4 to Fig. 5.

The identification of the moths was done with the help of Hampson (1894, 1895). The classification and sequences of the subfamilies followed is as per Kononenko & Pinratana (2013); Zahiri *et al*., 2011, 2012. The distribution and larval host plants have been consulted from Hampson (1894; 1895); Shubhalaxmi *et al*., (2011); Gurule & Nikam (2013); Smetacek (2008) and Sivasankaran *et al*., (2017).

In the foregoing pages, the taxonomic account along with their distributional record and bionomics has been documented.

Abbreviations used: Coll.: Collected by; WRC: Western Regional Centre; ZSI: Zoological Survey of India.

Results and discussion

This study was a part of the short-term project conducted by the students of the Certificate course on Para-taxonomy [including Peoples Bio-diversity Register (PBRs)] of GSDP at ZSI, WRC, Pune. The certificate course was of three months duration and hence was given a short period bound project to the students. Lonavala, a part of the Sahyadri ranges is a famous hills station near metro cities like Mumbai and Pune and hence, faces tremendous anthropogenic pressure. On literature review, it was found that report on moths of Lonavala is lacking.

The present study resulted in enumeration of 44 species in 36 genera belonging to 10 Subfamilies of Erebid moth fauna of Lonavala, Maharashtra. One new range extension records of the species, *Calesia fuscicorpus* Hampson, 1891 is reported in this study. To confirm the new distributional record and its range extension, Hampson (1891) and Sondhi *et al*., (2018) were consulted. One endemic moth to India has been recorded from the study area. From Fig. 3, it can be seen that the maximum number of species recorded was from the subfamily Erebinae (17 species) followed by Arctiinae (13 species), Aganainae (05 species), Tinoliinae (02 species), Calpinae (01 species), Lymantriinae (01 species), Hypeninae (01 species), Hypocalinae (01 species) and Scoliopteryginae (01 species).

Taxonomic account
Superfamily NOCTUOIDEA Latreille, 1809
Family EREBIDAE Leach, [1815]
Subfamily EREBINAE Leach [1815]

Genus	Species	Type locality	Material Examine	Distribution	Bionomics
Hypospila Guenée, 1852 Type Species: *Hypospila bolinoides* Guené, 1852.	*Hypospila bolinoides* Guenée, 1852	Java.	05 ex., Lonavala, Pune, 23.viii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1605).	India: Throughout India including Maharashtra (Mumbai, Satara, Nashik and Dhule). Elsewhere: Australia, China, Japan, Malaysia, Myanmar, New Guinea, Sri Lanka. Elsewhere: Australia, Cambodia, China, Indonesia, Japan, Korea, Malaysia, Nepal, New Guinea, Sri Lanka, Thailand, Vietnam (Mitra *et al*., 2019).	The larval host plant is *Derris* (Leguminosae) (Holloway, 2005). In present study, it is reported in the late July, and Mitra *et al*., (2019) recorded it in October from Raigad, Maharashtra. As per Holloway (2005) it is a lowland species and is recorded up to a level of 1930m.
Hamodes Guenee, 1852 Type Species: *Ophiusa propitia* Boisduval, 1832 [=*Hamodes propitia* (Guerin-Meneville, 1831)].	*Hamodes propitia* (Guerin-Meneville, 1831)	Nouvelle-Irlande [Bismarck Archipelago].	03 ex., Lonavala, Pune, 23.viii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1585).	Throughout India including Maharashtra (Nashik, Dhule, Jalgaon and Nandurbar). Elsewhere: Australia, Indonesia, Malaysia, Myanmar, New Ireland, Philippines, Solomon Islands, Thailand (Mitra *et al*., 2019).	The larval host plant is *Dalbergia* (Leguminosae) (Holloway, 2005). This species is found in the altitude ranging from sea-level to almost high-altitude level of 2110m and in various forest types and also in cultivated area of agricultural lands.
Erebus Latreille, 1810 Type Species: *Phalaena crepuscularis* Linnaeus, 1758.	*Erebus caprimulgus* (Fabricius, 1781)	China.	01 ex., Lonavla, Pune, 23.viii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1608).	Throughout India including Maharashtra (Amravati, Pune, Sindhudurg, Nashik and Dhule). Elsewhere: Indonesia, Malaysia, Myanmar, Sri Lanka (Mitra *et al*., 2019).	The larval host plants are *Smilax macrophylla*, *Smilax ovalifolia* (Smilacaceae) (Leong and Kueh, 2011). Adult feeds on the ripened fruits of *Melastoma malabathricum* (Melastomataceae) (Leong and Kueh, 2011). The species prefers mostly lowland forest but some are recorded from the high altitudinal areas (Holloway, 2005).
	Erebus macrops (Linnaeus, 1768)	"India Orientali" [India].	02 ex., Lonavala, Pune, 23.viii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1609).	India: Kerala, Maharashtra, Tamil Nadu, Uttarakhand. Elsewhere: China, Indonesia, Malaysia, Myanmar, Nepal, Sri Lanka, Thailand (Kalawate, 2018; Mitra *et al*., 2019).	The larval host plant is *Acacia* (Leguminosae) (Holloway, 2005); adult is a fruit piercer (Bänziger, 1982). It is a common species and found commonly near the human dwellings.
Artena Walker, 1858 Type Species: *Artena submira* Walker, 1858.	*Artena dotata* (Fabricius, 1794)	"India Orientali" [India].	04 ex., Lonavala, Pune, 23.viii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1606).	India: Throughout India including Maharashtra (Mumbai, Pune, Sindhudurg, Nashik, Dhule, Jalgaon and Nandurbar). Elsewhere: Indonesia, Japan Malaysia, Sri Lanka, Taiwan (Mitra *et al*., 2019).	The larval host plants recorded are *Combretum*, *Getonia*, *Quisqualis*, *Terminalia* (Combretaceae) (Holloway, 2005). Adult feeds on fruits by piercing it and sucking the juice (Bänziger, 1982). As per Holloway (2005), the species prefers lowland forest areas, with secondary vegetation after logging. The recorded flight period is from April to June and August to December.
	Artena submira Walker, 1858	Hindostan.	01 ex., Lonavala, Pune, 23.viii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1795).	India: Jharkhand, Kerala, Maharashtra. Elsewhere: Bangladesh, Myanmar, Thailand, Vietnam (Singh & Ranjan, 2016; Mitra *et al*., 2019).	The Larval food plants are *Getonia floribunda*, *Quisqualis indica*, *Terminalia paniculate*, *T. tomentosa* (Combretaceae) (NHM, 2021). It is reported in the month of July in this study.
Thyas Fabricius, 1775 Type Species: *Thyas honesta* Hübner, 1824.	*Thyas honesta* Hübner, 1806	[India. East Indies]?	01 ex., Lonavala, Pune, 23.viii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1607).	India: Throughout India including Maharashtra (Pune, Satara, Nashik, Dhule, Jalgaon, Nandurbar). Elsewhere: Borneo, Indonesia, Malaysia, Myanmar, Philippines, Sumatra, Thailand (Mitra *et al*., 2019).	The larval host plants are *Careya*, *Barringtonia*, *Planchonia* (Lecythidaceae); *Terminalia* Combretaceae (Holloway, 2005); *Citrus* (Rutaceae) (Ngampongsai *et al*., 2005). It is recorded in August in this study and by Sambath (2014) from Jharkhand. It is recorded from 300m to 1620m (Holloway, 2005).

	Thyas coronata (Fabricus, 1775)	China.	03 ex., Lonavala, Pune, 23.viii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1610).	Throughout India including Maharashtra. Elsewhere: Australia, Borneo, Indonesia, Myanmar, Sri Lanka (Mitra *et al*., 2019).	The larval host plants are *Quisqualis indica* (Combretaceae) (Hampson, 1894); *Terminalia* (Combretaceae), *Litsea* (Lauraceae), *Anamirta* (Menispermacea), *Pinus* (Pinaceae), *Nephelium* (Sapindaceae) (Holloway, 2005). The adult is a piercer of fruit on *Citrus* (Rutaceae) (Bänziger, 1982) and commonly called as fruit piercing moth. It is mainly found in the forests, disturbed habitats and upto 2600m (Holloway, 2005).
Buzara Walker, [1865] 1864 Type Spcies: *Buzara chrysomela* Walker, 1865.	*Buzara onelia* (Guenee,1852)	Silhet, Bangladesh.	02 ex., Lonavala, Pune, 23.viii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1807.	Distribution: India: Himachal Pradesh, Maharashtra (Satara, Sindhudurg). Elsewhere: Bangladesh, China, Indonesia, Malaysia, Myanmar, Malay Peninsula, Nepal, Philippines, Singapore, Sri Lanka, South Japan, Taiwan, Thailand, Vietnam, (Kononenko & Pinratana, 2013; Mitra *et al*., 2019).	The larval host plants are *Breynia*, *Phyllanthus*, *Sauropus* (Euphorbiaceae) (Holloway & Miller, 2003). This species found from lowland to mid montane forest. In this study the specimen is collected in August.
Polydesma Boisduval, 1833 Type Species: *Polydesma umbricola* Boisduval, 1833.	*Polydesma boarmioides* Guenee,1852	Java.	03 ex., Lonavala, Pune, 23.viii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1661.	India: Sikkim, Uttar Pradesh, Maharashtra (Mumbai, Pune, Dhule, Jalgaon). Elsewhere: Australia, Bangladesh, Fiji, Hawaii, Malaysia, New Caledonia, Sri Lanka (Mitra *et al*., 2019).	The larval host plants are *Gmelina* (Lamiaceae); *Acacia*, *Albizia*, *Pithecellobium* (Leguminosae); *Salix* (Salicaceae); *Litchi* (Sapindaceae) (Holloway, 2005). This species is recorded in August, November and December.
Ericeia Walker, [1858] Type Species: *Ericeia sobria* Walker, 1858.	*Ericeia inangulata* (Guenee,1852)	Silhet.	01 ex., Lonavala, Pune, 23.viii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1813).	India: Throughout India including Andaman and Nicobar Islands, Himachal Pradesh, Madhya Pradesh, Maharashtra (Mumbai, Pune, Nashik and Jalgaon) and Uttarakhand, West Bengal. Elsewhere: Africa, Australia, China, Myanmar, Sri Lanka (Mitra *et al*., 2019).	The Larval host plants are *Acacia*, *Albizia*, *Cassia*, *Dalbergia*, *Mimosa*, *Paraserianthes*, *Senna*, *Xylia* (Leguminosae); *Adiantum* (Adiantaceae); *Lagerstroemia* (Lythraceae); *Citrus* (Rutaceae) (Holloway, 2005). The adult moth is a fruit piercer (Bänziger, 1982). Records have been made from the lowlands to 2600m, but the species is commoner above 1500m.
Parallelia Hübner, 1818 Type Species: *Parallelia bistriaris* Hübner, 1818.	*Parallelia stuposa* (Fabricius,1794)	"India Orientali" [India].	01 ex., Lonavala, Pune, 23.viii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1810.	India: Maharashtra (Mumbai, Pune, Sindhudurg, Nashik, Dhule, Jalgaon, Nandurbar). Elsewhere: China, Indonesia, Japan, Korea, Philippines, Sri Lanka (Mitra *et al*., 2019).	The Larval host plants are Salicaeceae; Euphorbiaceae; Rosaceae; Lythraceae (Leley, 2016). In the present study it is reported in August.
Achaea Hübner, [1823] Type Species: *Phalaena melicerta* Drury, 1773 [=*Achaea janata* (Linnaeus, 1758)].	*Achaea* (*Acanthodelta*) *janata* (Linnaeus, 1758)	Indiis [India].	01 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1603).	India: Andaman and Nicobar Islands, Himachal Pradesh, Maharashtra (Pune, Sindhudurg, Satara, Mumbai, Nashik, Dhule, Jalgaon, Nandurbar). Elsewhere: Australia, China, Indonesia, Japan, Myanmar, New Guinea, New Zealand, Philippines (Mitra *et al*., 2019).	Polyphagous: The larval host plants are *Ricinus* (Euphorbiaceae); Leguminosae; *Agathis*, *Araucaria* (Araucariaceae); *Anogeissus*, *Terminalia* (Combretaceae); *Ipomoea* (Convolvulaceae); *Brassica*, *Raphanus*, *Cucurbita* (Cucurbitaceae); *Cupressus* (Cupressaceae); *Shorea* (Dipterocarpaceae); *Acalypha*, *Aleurites*, *Andrachne*, *Bischofia*, *Chamaesyce*, *Codiaeum*, *Croton*, *Euphorbia*, *Excoecaria*, *Flueggea*, *Jatropha*, *Manihot*, *Pedilanthus*, *Phyllanthus*, *Ricinus*, *Sapium* (Euphorbiaceae); *Saccharum* (Gramineae); *Planchonia* (Lecythidaceae); *Acacia*, *Albizia*, *Arachis*, *Bauhinia*, *Dalbergia*, *Desmanthus*, *Glycine*, *Leucaena*, *Mimosa*, *Paraserianthes*, *Phaseolus*, *Prosopis*, *Vigna*, *Zylia* (Leguminosae); *Strychnos* (Loganiaceae); *Lagerstroemia*, *Punica* (Lythraceae); *Abutilon*, *Gossypium* (Malvaceae); *Ficus* (Moraceae); *Eucalyptus*, *Psidium* (Myrtaceae); *Cocos* (Palmae); *Emex* (Polygonaceae);

					Polypodium (Polypodiaceae); *Macadamia* (Proteaceae); *Ziziphus* (Rhamnaceae); *Rosa* (Rosaceae); *Litchi*, *Nephelium*, *Schleichera* (Sapindaceae); *Madhuca*, *Mimusops*, *Palaquium* (Sapotaceae); *Capsicum* (Solanaceae); *Sterculia*, *Theobroma* (Sterculiaceae); *Grewia* (Tiliaceae); *Tribulus* (Zygophyllaceae) (Holloway, 2005). The adult makes the fruit unfit for consumption by piercing it and feasting upon it (Bänziger, 1982). The adult moth is attracted to the light traps
Bastilla Swinhoe, 1918 Type Species: *Ophiusa redunca* Swinhoe, 1900 [=*Bastilla hamatilis* (Guenée, 1852)].	*Bastilla joviana* (Stoll, 1782)	Cote de Coromandel [India].	02 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (Reg. No. ZSI-WRC-L-1604).	India: Adaman Islands, Maharashtra (Pune, Sindhudurg, Nashik), West Bengal. Elsewhere: Australia, Bangladesh, Bhutan, China, Indonesia, Malaysia, Myanmar, Nepal, New Guinea, Pakistan, Sri Lanka, Thailand (Mitra *et al*., 2019).	The larval host plants are *Acalypha*, *Breynia* and *Phyllanthus* (Euphorbiaceae) (Holloway & Miller, 2003). It is like other fruit sucking moths' pierces fruit (Bänziger, 1982). Recorded from lowlands to 1930m and from forested and cultivated areas as per Holloway (2005). In this study it is recorded from 626m.
Grammodes Guenée, 1852 Type Species: *Noctua geometrica* Fabricius, 1775 [=*Grammodes geometrica* (Fabricius, 1775)].	*Grammodes geometrica* (Fabricius, 1775)	India Orientali [India].	01 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1793).	India: Andaman and Nicobar Islands, Assam, Madhya Pradesh, Maharashtra (Mumbai, Pune, Satara, Sindhudurg, Nashik, Dhule, Jalgaon and Nandurbar), Odisha, Punjab, Rajasthan, Sikkim, Tamil Nadu, Uttar Pradesh, West Bengal. Elsewhere: Africa, Australia, Bangladesh, China, Europe, Indonesia, Myanmar, New Guinea, Singapore, Sri Lanka, Taiwan (Mitra *et al*., 2019).	The larval host plants are *Phyllanthus*, *Sapium* (Euphorbiaceae); *Cistus* (Cistaceae); *Diospyros* (Ebenaceae); *Ricinus* (Euphorbiaceae); *Oryza* (Gramineae); *Polygonum* (Polygonaceae); *Ziziphus* (Rhamnaceae); *Tamarix* (Tamaricaceae) (Holloway, 2005). Adults are fruit piercer (Bänziger, 1982). It is recorded in forests and cultivated area. Adults are attracted to the light trap.
Spirama Guenée, 1852 Type Species: *Phalaena retorta* Clerck, 1764 [=*Spirama retorta* (Clerck, 1764)].	*Spirama retorta* (Clerck, 1764)	Not known.	01 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1611).	India: Andaman and Nicobar Islands, throughout India including Himachal Pradesh, Maharashtra (Mumbai, Pune, Sindhudurg, Matheran, Nashik, Dhule, Jalgaon, Nandurbar). Elsewhere: Japan, China, Sri Lanka, Mynamar, Andamans, Java (Sekhon and Singh, 2015; Mitra *et al*., 2019).	The larval host plant are *Vitis* (Vitaceae); *Acacia mangium* (Fabaceae) (NHM, 2021). It is attracted to light and recorded at an altitude of 626m.
Mocis Hübner, [1823] Type Species: *Phalaena virbia* Cramer, 1780 (=*Mocis undata* (Fabricius, 1775)).	*Mocis undata* (Fabricius, 1775)	East Indies.	01 ex., Amby valley Road, 23.vii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1903).	India: Throughout India including Andaman and Nicobar Islands, Himachal Pradesh, Madhya Pradesh, Maharashtra, Uttarakhand, West Bengal. Elsewhere: Africa, throughout Oriental region (Mitra *et al*., 2019).	The larval host plants are *Cytisus*, *Desmodium*, *Wisteria* (Fabaceae); *Arachis, Butea, Cajanus, Calopogonium, Crotalaria, Derris, Desmodium, Glycine, Indigofera, Mucuna, Phaseolus, Pueraria, Rhynchosia, Tephrosia, Vigna* (Leguminosae); *Shorea* (Dipterocarpaceae); *Hevea* (Euphorbiaceae); *Gossypium* (Malvaceae); *Nephelium* (Sapindaceae); *Solanum* (Solanaceae) (Holloway, 2005). It is recorded mostly from the open habitat, cultivation and disturbed forest. It is usually found from lowlands to 1200m (Holloway, 2005).
EREBINAE *incertae sedis*					
Ischyja Hubner, [1823] 1816 Type species: *Phalaena manlia* Cramer, 1776.	*Ischyja manlia* (Cramer, 1776)	Cote de Coromandel (=Tamil Nadu).	01 ex., Amby valley Road, 23.viii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1584).	India: Throughout India including Maharashtra. Elsewhere: Indonesia, Myanmar, Sri Lanka (Sambath, 2014).	The larval host plants are Lauraceae, Lardizabalaceae, Ebenaceae, Rosaceae, Combretaceae, Rubiaceae (Leley, 2016), Theaceae (Holloway, 2005). As per Kononenko and Pinratana (2013) the flight period is from August – November. But, in the present study, it is reported in late July.

Subfamily Arctiinae (Leach, 1815)					
Amata Fabricius, 1807 Type Species: *Zygaena passalis* Fabricius, 1781.	*Amata passalis* (Fabricius, 1781)	[India or Sri Lanka?].	01 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1806).	India: Andhra Pradesh, Assam, Karnataka, Maharashtra (Aurangabad, Solapur, Pune, Mumbai), Manipur, Tamil Nadu, West Bengal. Elsewhere: Sri Lanka (Mitra *et al.*, 2019).	The larval host plants are *Ipomoea* (Convolvulaceae); *Phaseolus*, *Cajanus* (Leguminosae); *Dahlia*, *Cosmos* (Compositae); *Santalum album* (Santalaceae); *Vigna unguiculata* (Leguminosae) (Venkatesha and Gopinath, 1992). This species breeds throughout the year and passes through 6-11 generations a year.
	Amata bicincta (Kollar, [1844])	Not known.	03 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1586).	Arunachal Pradesh, Himachal Pradesh, Maharashtra, Meghalaya, North West India, Sikkim, Uttarakhand, West Bengal, Elsewhere: China (Hampson, 1898; Shubhalaxmi *et al*., 2011; Singh *et al*., 2014).	The larval host plant is not known.
	Amata bicincta (Kollar, [1844])	Not known.	03 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1586).	India: Arunachal Pradesh, Meghalaya, North West India, Sikkim, West Bengal, (Singh *et al*., 2014).	The larval host plant is not known.
Creatonotos Hubner, 1819 Type Species: *Phalaena interrupta* Linnaeus, 1767.	*Creatonotos gangis* (Linnaeus, 1763)	Not known.	01 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1587).	India: Throughout India including Maharashtra (Nashik, Nandurbar). Elsewhere: Australia, China, Japan, Malaysia, Nepal, New Guinea, Pakistan, Philippines, Sri Lanka, Taiwan, Thailand (Mitra *et al*., 2019).	The larval host plants are *Arachis hypogaea*, *Medicago sativa*, *Vigna mungo* (Fabaceae); *Eleusine coracana*, *Oryza sativa*, *Pennisetum glaucum*, *Zea mays* (Poaceae); *Ipomoea batatas* (Convolvulaceae); *Mimulus gracilis* (Phrymaceae) (NHM, 2021). They found in the secondary habitats from the lowlands to the montane region. They are attracted to light. The males of this species have four eversible coremata at the tip of the abdomen which emit pheromones, and is longer than the abdomen. It breeds throughout the year.
	Creatonotos transiens (Walker, 1855)	Assam.	01 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1588).	India: Arunachal Pradesh, Assam, Maharashtra, (Mumbai, Pune, Satara, Sindhudurg, Nashik), Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Uttarakhand, West Bengal. Elsewhere: China, Indonesia, Japan, Malaysia, Nepal, Philippines (Mitra *et al*., 2019).	The larval host plants are Polyphagous: *Beta* (Chenopodiaceae); *Dioscorea* (Dioscoreaceae); *Paspalum*, *Zea* (Gramineae); *Pithecelbobium*, *Vigna*, *Wisteria* (Leguminosae); *Toona* (Meliaceae); *Musa* (Musaceae); *Salix* (Salicaceae); *Cayratia*,*Cissus* (Vitidaceae) (Holloway, 1988). The species is common in cultivated agricultural fields, open habitats and secondary vegetation. Adults are commonly attracted to light.
Mangina Kaleka & Kirti, 2001 Type Species: Euprepia argus Kollar, [1844] (=Argina argus Kollar, 1844).	*Mangina syringa* (Cramer, 1775)	"Coromandel" [India].	01 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1589).	India: Throughout India including Maharashtra (Pune). Elsewhere: Australia, Sri Lanka (Mitra *et al*., 2019).	Larval host plants are *Crotalaria assamica*, *Crotalaria juncea*, *Crotalaria longipes*, *Crotalaria saltiana* (Leguminosae); *Musa × paradisiaca* (Musaceae) (Kirti and Singh, 2015). In this study it is recorded in August. It is not a frequent visitor at light trap.
Olepa Watson, 1980 Type Species: *Alope ocellifera* (Walker, 1855) [=*Olepa*	*Olepa clavatus* (Swinhoe, 1885)	Bombay (India).	01 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1590).	India: South India, Maharashtra (Cotes and Swinhoe, 1887; Dubatolov, 2010; Kalawate *et al*., 2020).	The larval host plant is not known. It is usually attracted to the light. Remark: Endemic to India.

ocellifera (Walker, 1855)].	*Olepa ricini* (Fabricius, 1775)	"Indiae orientalis ricino" (India).	01 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1826).	India: Throughout India including Maharashtra (Mumbai, Pune, Ahmednagar, Satara). Elsewhere: Bangladesh, Nepal, Northern Pakistan, Sri Lanka, Thailand (Cotes and Swinhoe, 1887; Dubatolov, 2010; Kalawate *et al*., 2020).	Larval host plants are *Calotropis procera* (Apocynaceae); *Camellia sinensis* (Theaceae); *Campsis grandiflora* (Bignoniaceae); *Gossypium* (Malvaceae), *Ricinus communis* (Euphorbiaceae); *Helianthus* (Asteraceae), *Zea mays* (Poaceae); *Coccinia grandis* (Cucurbitaceae); *Solanum melongena* (Solanaceae); *Ipomoea batatas* (Convolvulaceae); *Musa* (Musaceae) (Farooqui *et al*., 2020; TNAU, 2021; Shubhalaxmi, 2018). They are attracted to light.
	Olepa zedesi Kalawate, 2020	Pune, India.	01 ex., Lonavala, Pune, 23.viii.2017, coll. A.S. Kalawate (ZSI-WRC-L-2154).	India: Maharashtra (Pune, Lonavala, Satara) (Kalawate, 2021).	Data deficient.
Rajendra Moore, 1879 Type Species: *Rajendra lativitta* Moore, 1879.	*Rajendra biguttata* (Walker,1855)	Canara, Malabar Coast [India].	03 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1591).	India: Arunachal Pradesh, Bihar, Himachal Pradesh, Karnataka, Kerala, Maharashtra, Madhya Pradesh, Orissa, Punjab, Sikkim, Tamil Nadu, West Bengal. Elsewhere: Bangladesh (Dubatolov *et al*., 2007).	The larval host plants is *Elettaria cardamomum* (Zingiberaceae) (Kirti and Singh, 2015). The flight period is from April to December. It is attracted to light.
Argina Hübner, [1819] Type species: *Phalaena cribraria* Clerck, 1764 (=*Argina astrea* (Drury, 1773)).	*Argina astrea* (Drury, 1773)	[Ghana], Africa, Gold Coast.	01 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1595).	India: Throughout India including Maharashtra (Pune, Mumbai, Satara, Amravati) (Dubatolov, 2010; Cotes and Swinhoe, 1887). Elsewhere: China, Myanmar, Mauritius, New Guinea, Sri Lanka (Kaleka and Kirti, 2001).	The larval host plants are *Crotalaria* spp., *Lablab purpureus*, *Melilotus indica* (Leguminosae); *Beaumontia* (Apocynaceae); *Buddleja* (Buddlejaceae); Theobroma cacao (Steculiaceae) (Holloway, 1988; NHM, 2021). The flight period is throughout the year. It is attracted to the light. It is found in the lowlands, cultivated areas and open habitats.
Cyana Walker, 1854 Type Species: *Cyana detrita* Walker, 1854.	*Cyana puella* (Drury, 1773)	Madras [India].	02 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1592).	India: Chhattisgarh, Himachal Pradesh, Madhya Pradesh, Maharashtra (Mumbai, Pune), North West Himalayas, Sikkim, South India, Uttarakhand. Elsewhere: Africa, Indonesia, Madagascar, Nepal, Sri Lanka (Mitra *et al*., 2019).	The larval host plant is unknown. In this study, the specimen was collected in August.
Brunia Moore, 1878 Type Species: *Lithosia antica* Walker, 1854.	*Brunia antica* (Walker, 1854)	Ceylon (=Sri Lanka).	01 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1594).	India: Andaman and Nicobar Islands, Maharashtra (Mumbai, Pune, Satara, Nashik, Dhule), West Bengal. Elsewhere: China, Indonesia, Malaysia, Sri Lanka (Mitra *et al*., 2019).	The larval host plants are *Hevea* (Euphorbiaceae), *Terminalia* (Combretaceae) and *Theobroma* (Sterculiaceae) (Holloway, 2005). It's a lowland species and observed frequently in coastal vegetation and mangrove (Holloway, 2001). In this study it is found in August and at an altitude of 626m and is attracted to light.
Nannoarctia Koda, 1988 Type Species: *Pericallia takanoi* *Sonan*, 1934. Subgenus *Pseudorajendra* Dubatolov, 2007 Type Species: *Aloa dentata* Walker, 1855.	*Nannoarctia* (*Pseudorajendra*) *dentata* (Walker, 1855)	Canara [India].	01 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1593).	India: Eastern India, Karnataka, Maharashtra (Mumbai, Pune), Kerala, Tamil Nadu (Dubatolov, 2010; Mitra *et al*., 2019).	The larval host plant is unknown. This species is attracted to light. Remarks: This species is endemic to India.

Subfamily Aganainae Boisduval, 1833					
Mecodina Guenée, 1852 Type Species: *Mecodina lanceola* Guenée, 1852.	*Mecodina metagrapta* Hampson, 1926	Bali.	01 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (Reg. No. ZSI-WRC-L-1808).	India: Karnataka, Maharashtra (Lonavala). Elsewhere: Bali, Singapore, Java, Sulawesi (Hampson, 1926; Holloway, 2005; Kalawate, 2018b).	The larval host plant is unknown. The species rarely attracted to the light.
Asota Hubner, [1819] Type Species: *Phalaena javana* Cramer, [1780] [=*Asota javana* (Cramer, [1780])].	*Asota producta* (Butler, 1875)	Not known.	01 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1597).	India: Assam, Sikkim, South India, Maharashtra, Kerala. Elsewhere: Borneo, Burma, Malaysia, Penang, Sri Lanka, Sumatra, (Gurule, 2013; Sondhi *et al*., 2018).	The larval host plants is unknown. The species is attracted to light and is recorded from the disturbed cultivated land.
	Asota ficus (Fabricius, 1775)	India.	01 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1597).	India: Throughout India including Maharashtra. Elsewhere: China, Japan, Malaysia, Myanmar, Nepal, Sri Lanka, Taiwan, Thailand (Mitra *et al*., 2019).	The larval host plants are *Ricinus communis* (Euphorbiaceae); *Ficus carica, F. hispida, F. racemosa, F. pumila, F. infectoria, F. religiosa, Ficus* sp. (Moraceae); *Mitragyna diversifolia* (Rubiaceae) (ICAR-NBAIR, 2020). It is generally attracted to light trap.
Digama Moore, [1860] Type Species: *Digama hearseyana* Moore, 1858.	*Digama marchali* (Guérin-Méneville, 1843)	Not known.	15 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1598).	India: Gujarat, Maharashtra (Mumbai, Pune and Raigad), South India. Elsewhere: Myanmar (Mitra *et al*., 2019).	The larval host plant is *Carissa carandus* (Apocynaceae) (NHM, 2021). The flight period is from January to March and June to November. It is attracted to light.
Psimada Walker, 1858 Type Species: *Psimada quadripennis* Walker, 1858.	*Psimada quadripennis* Walker, 1858	Canara.	03 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1599).	India: Andaman and Nicobar Islands, Chhattisgarh, Himachal Pradesh, Madhya Pradesh, Karnataka, Kerala, Maharashtra (Pune, Nashik and Nandurbar). Elsewhere: China, Myanmar, Sri Lanka, Thailand (Mitra *et al*., 2019).	The larval host plant is *Ficus* (Moraceae) (Holloway, 2005). The adult of this species is attracted to the light. They are recorded in forest and cultivated lands.
Subfamily Tinoliinae Moore, [1885]					
Calesia Guenée, 1852 Type Species: *Calesia comosa* Guenée, 1852 [=*Calesia dasypterus* (Kollar, 1844)].	*Calesia stillifera* Felder & Rogenhofer, 1874	Manila.	01 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1812).	India: Throughout India including Maharashtra (Satara, Nashik). Elsewhere: Sri Lanka, Thailand (Mitra *et al*., 2019).	The larval host plants are *Thunbergia* sp., *Neuracanthus phaerostachys* (Acanthaceae) (Anonymous, 2021a). It is recorded from July to November.
	Calesia fuscicorpus Hampson, 1891	Nilgiri.	08 ex., Lonavala, Pune, 23.vii.2017, A.S. Kalawate & party (ZSI-WRC-L-1801).	India: Nilgiris (Tamil Nadu), Travancore (Kerala). Elsewhere: Ceylon (Sri Lanka) (Hampson, 1894).	The larval host plant is *Justicia wynaadensis* (Acanthaceae) (NHM, 2021). Not much known about its habitat. Remark: New distributional and Range extension in Northern Western Ghats' Maharashtra.
Subfamily Hypeninae Herrich-Schäffer, [1851]					
Dichromia Guenée, 1854 Type Species: *Phalaena orosia* Cramer, 1780 [=*Dichromia sagitta* (Fabricius, 1775)].	*Dichromia pullata* Moore, 1885	Ceylon [=Sri Lanka].	07 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1600).	India: Maharashtra (Pune, Sindhudurg, Nashik, Dhule). Elsewhere: Sri Lanka (Mitra *et al*., 2019).	The larval host plants are *Anacardium occidentale* (Anacardiaceae); *Tylophora*, Dregea (Apocynaceae) (Swafvan and Sureshan, 2021).

Subfamily Scoliopteryginae Herrich-schaffer, [1851]					
Rusicada Walker, 1858 Type Species: *Rusicada nigritarsis* Walker, 1858.	*Rusicada* (*Anomis*) *fulvida* (Guenée, 1852)	Java	01 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1601).	India: Throughout India including Maharashtra (Nashik, Dhule, Nandurbar). Elsewhere: Africa, Australia, Sri Lanka. (Mitra *et al*., 2019)	The larval host plants are *Abutilon*, *Alcea*, *Gossypium*, *Hibiscus*, *Kydia*, *Pterospermum*, *Sterculia*, *Thespesia* Urena, *Waltheria* (Malvaceae); Cissampelos (Menispermaceae) (Anonymous, 2021a). Adult moth appears rarely to light traps.
Subfamily Calpinae Boisduval, 1840					
Eudocima Billberg, 1820 Type Species: *Phalaena salaminia* Cramer, 1777.	*Eudocima phalonia* (Linnaeus, 1763)	Africa.	01 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1602).	India: Karnataka, Madhya Pradesh, Maharashtra (Mumbai, Pune, Satara, Sindhudurg, Nashik, Dhule, Jalgaon, Nandurbar), Punjab, Tamil Nadu, Uttar Pradesh, Uttarakhand. Elsewhere: Australia, China, Indonesia, Japan, Korea, New Guinea, New Zealand (Mitra *et al*., 2019).	Polyphagous: The larval host plant are *Leschenaultia* (Goodeniaceae); *Anamirta, Arcangelisia, Cissampelos, Cocculus, Coscinium, Cyclea, Diploclisia, Legnephora, Sinomedium, Stephania, Tiliacora, Tinomiscium, Tinospora* (Menispermaceae); *Theobroma* (Sterculiaceae); *Erythrina* (Leguminosae) (Holloway, 2005) preferred for egg laying (Leong and Kueh, 2011). Adult sucks fruit juice from ripe or ripening fruit and is a major pest on *Citrus* sp. (Rutaceae) (Leong and Kueh, 2011); *Punica granatum* (Lythraceae) (Jayanthi *et al*., 2015); *Lycopersicon* (Solanaceae); *Malus pumila* (Rosaceae); *Mangifera indica* (Anacardiaceae) (Bhumannavar, and Viraktamath, 2000). This species is attracted to light.
Subfamily Lymantriinae Hampson, 1893					
Nygmia Hübner, [1820] Type species: *Phalaena icilia* Stoll, 1790.	*Nygmia icilia* (Stoll, [1790])	Coromandel coast.	01 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1817).	India: Jharkhand, Karnataka, Kerala, Maharashtra (Pune, Mumbai), NW. Himalaya, S. India, Tamil Nadu. Elsewhere: Sri Lanka (Cotes and Swinhoe, 1887; Sambath, 2014).	The larval host plants are *Dendrophthoe glabrescens*, *Loranthus* (Loranthaceae); *Mallotus paniculatus* (Euphorbiaceae) (NHM, 2021). In the present study it was recorded in August.
Subfamily Hypocalinae Guenée, 1852					
Hypocala Guenée, 1852 Type Species: *Hyblaea deflorata* Fabricius, 1794.	*Hypocala deflorata* (Fabricius, 1794)	India Orientalis [India].	01 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1794).	India: Himachal Pradesh, Karnataka, Maharashtra (Sindhudurg, Nashik, Dhule, Jalgaon, Nandurbar), North West Himalayas, Tamil Nadu. Elsewhere: Africa, Australia, China, Hong Kong, Indonesia, Japan, Korea, Madagascar, Malaysia, Nepal, New Zealand, Sri Lanka, Taiwan, Thailand (Mitra *et al*., 2019).	The larval host plants are *Diospyros dichrophylla* (Ebenaceae); *Pouteria sapota* (Sapotaceae) (Holloway, 2005). The adult moth sucks fruit juice making it unfit for consumption.
Erebidae incertae sedis					
Chrysopera Hampson, 1894 Type Species: *Achaea combinans* Walker, 1858 [=*Chrysopera combinans* (Walker, 1858)].	*Chrysopera combinans* (Walker, 1858)	Ceylon (Sri Lanka).	15 ex., Lonavala, Pune, 23.vii.2017, coll. A.S. Kalawate & party (ZSI-WRC-L-1575).	India: Maharashtra (Mumbai, Pune, Satara, Nashik, Dhule), North Western Himalayas, Peninsular India. Elsewhere: Australia, China, Indonesia, Malaysia, Nepal, Sri Lanka, Thailand. Elsewhere: Australia, China, Indonesia, Malaysia, Nepal, Sri Lanka, Thailand (Mitra *et al*., 2019).	The larval host plant is not known. In the present study it is recorded from 626m elevation and as per Holloway (2005) the highest report of this species is from 500m.

Erebinae emerged as the dominant subfamily with 39% (Fig. 3) diversity in the present survey and this finding is in consistent with Farooqui *et al*., (2020). The subfamily Arctiinae resulted as the second dominant with 30% diversity and this is in consistent with the reports of Shivaperuman (2014) and Gurule & Nikam (2013). Recently, Arctiidae family has been incorporated in the Erebidae as the subfamily due to the results of phylogenetic study. Noctuoidea is the highly unstable superfamily hence, studies on this group is warrant to resolve the instability in this economic important group. Noctuoidea is a cosmopolitan superfamily and the highest diversity of these moths is in Oriental tropics. In the present study an attempt has been made to document the diversity of Erebid moth fauna from Lonavala, which comes under an important Biodiversity Hotspots i.e. Western Ghats, a UNESCO world heritage site (Anonymous, 2021b). Diversity study plays a very important role in decision making for planning conservation and management actions. The present study may be helpful to the decision-making authority for making conservation and management plans.

Conclusions

The study resulted in identification of 44 species placed in 36 genera of Erebid moths. One new distributional and range extension record of *Calesia fuscicorpus* Hampson, 1891 has been recorded. To exactly predict the diversity of this important eco-region and other parts in the Sahyadri ranges, more extensive surveys are warranted for all the families of the moth.

Acknowledgements

The authors are grateful to the Director, ZSI, Kolkata and the Officer-in-Charge, ZSI, WRC, Pune for the support and encouragement. Due acknowledgement to the survey team of ZSI, WRC, Pune for collection efforts.

Conflict of Interest: The authors declare that they have no conflict of interest.

Declaration

"We declare that the manuscript has not been published in any journal/book or proceedings or in any other publication, or offered for publication elsewhere in substantially the same or abbreviated form, either in print or electronically.

Fig. 1 Light trap for moth study.

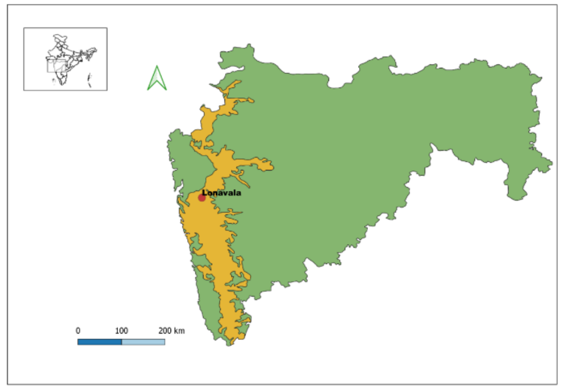


Fig. 2 Map showing survey locality.

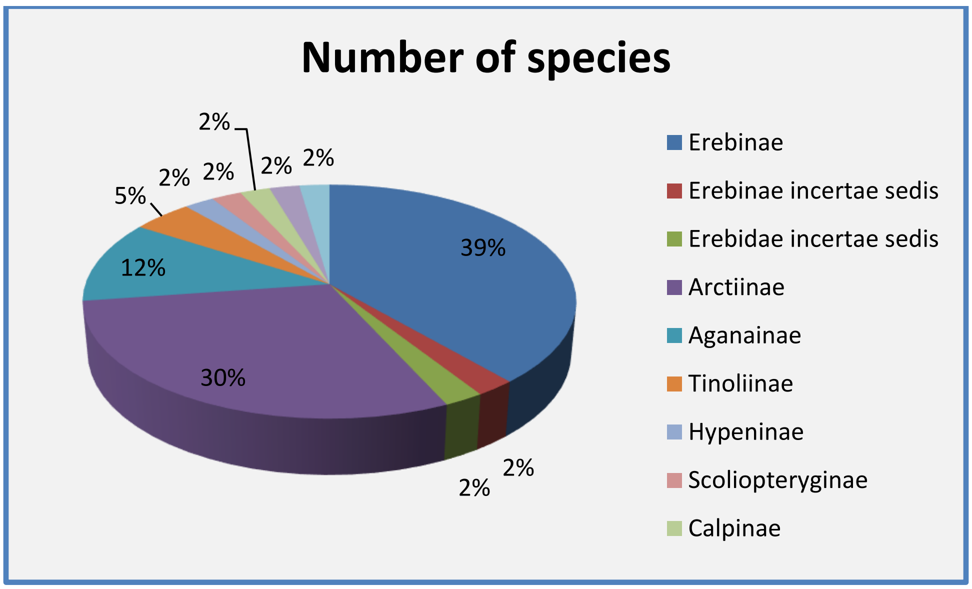


Fig. 3 Number of species recorded from the subfamilies of Erebidae from Lonavala, Maharashtra.

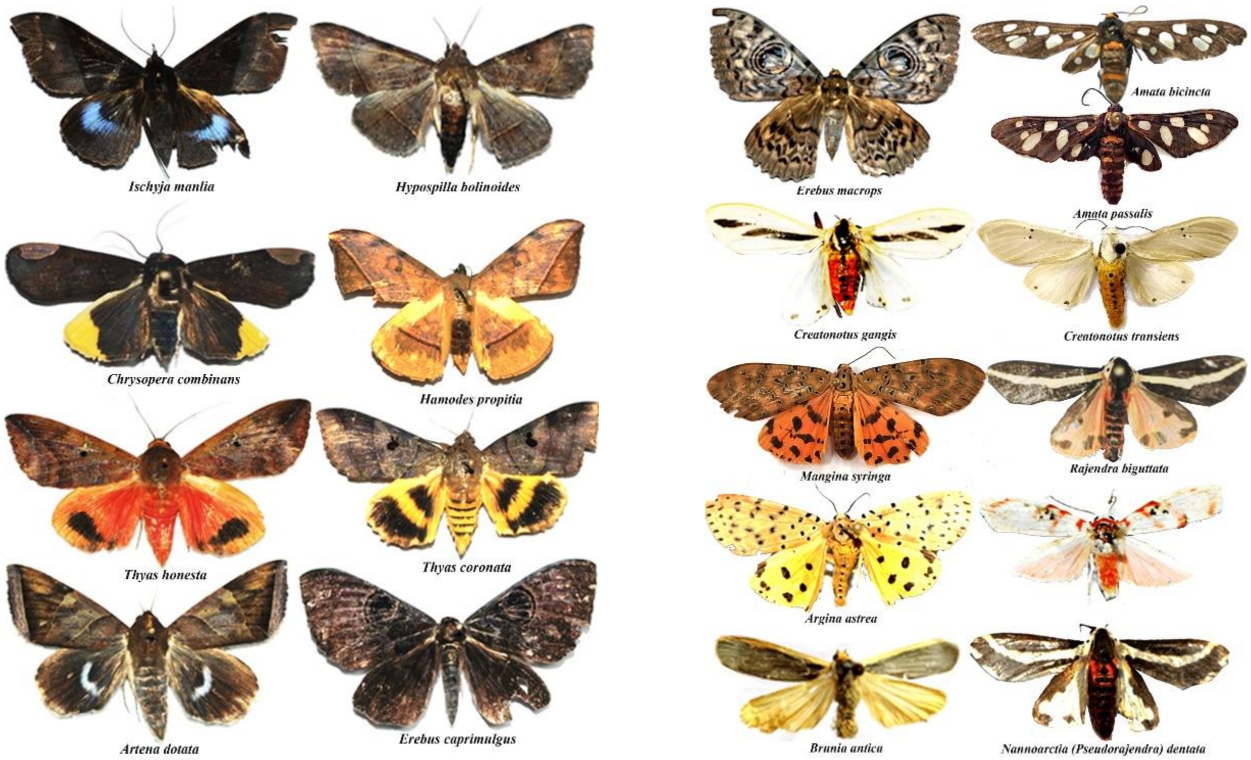


Fig. 4 Some erebid moths from the studied area.

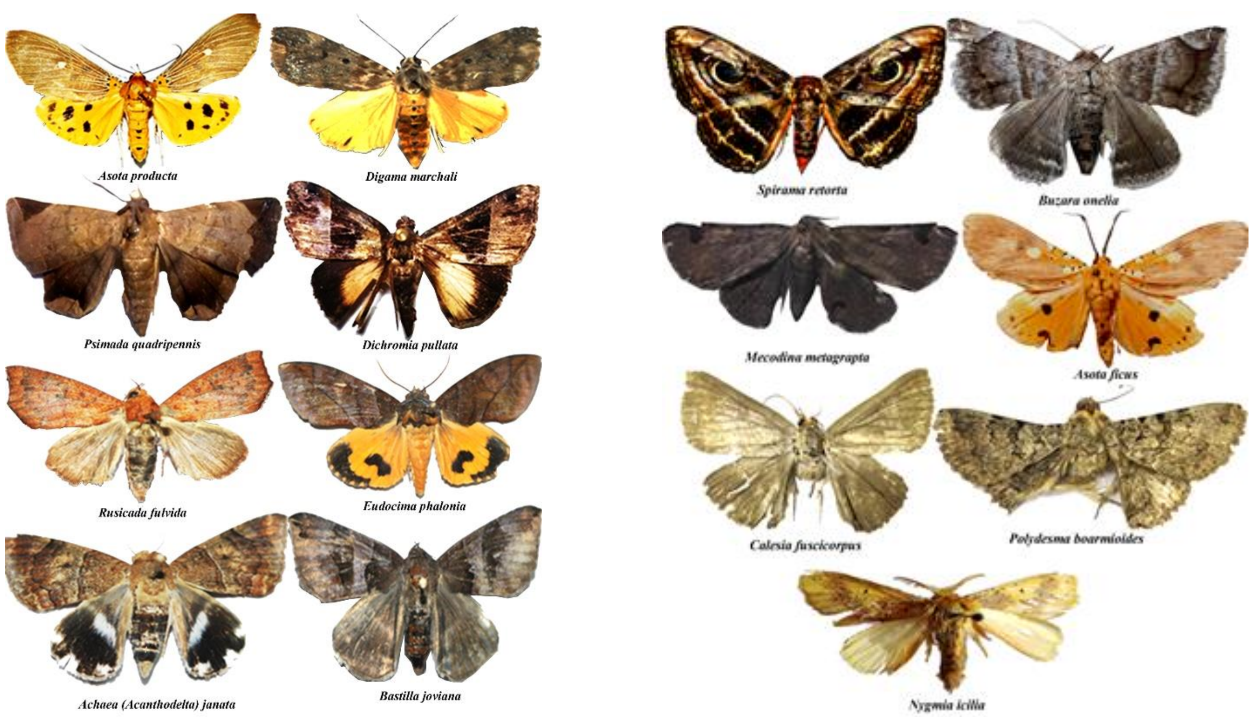


Fig. 5 Some erebid moths from the studied area.

References

Anonymous. 2021a. List of Host Plants of Moths. ttps://img1.wsimg.com/blobby/go/66978be1-a053-4fb2-841e0baad2e0dafe/downloads/1cjrcemji_782350.pdf?ver=1563804372253. Assessed on 16.11.2021.

Anonymous. 2021b. Western Ghats. https://whc.unesco.org/en/list/1342/ Assessed on 01.12.2021.

Bänziger, H. 1982. Fruit-piercing moths in Thailand: a general survey and some new perspectives. *Mitt. Schweiz. ent. Ges*., **53**: 127-142.

Bhumannavar, B.S. and Viraktamath, C.A. 2000. Biology and behaviour of *Euplectrus maternus* Bhatnagar (Hymenoptera: Eulophidae), an ectoparasitoid of *Othreis* spp. (Lepidoptera: Noctuidae) from southern India. *Pest Management in Horticultural Ecosystems*, **6 (1)**:1-14

Cotes, E. C. & Swinhoe, C. 1886-1889. *A catalogue of Moths of India*: 1-801.

Dadmal, S.M. and Pawar, N.P. 2001. The fruit sucking moth, *Eudocima* (*Othreis*) *fullonia* on Nagpur mandarin in Vidarbha region. *Insect Environment*, **6**: 167.

Dubatolov, V.V, Haynes, P. and Kishida, Y. 2007. Review of the genus *Rajendra* Moore, with systematic notes on the genus *Nannoarctia* Kôda (Lepidoptera, Arctiidae). *Tinea*, **20** (1): 68 2007.

Dubatolov, V.V. 2010. Tiger moths of Eurasia (Lepidoptera: Arctiinae). *Neue Entomologische Nachrichten*, **6**S : 1-106.

Farooqui, S.A., Parwez, H., Joshi, R. 2020. A preliminary study and new distributional records of family Erebidae (Leach, [1815]) (Lepidoptera: Noctuoidea) from Aligarh, Uttar Pradesh, India. *Notulae Scientia Biologicae*, **12**(4):794-806.

Gurule, S. and Nikam, S. 2013. The moths (Lepidoptera: Heterocera) of northern Maharashtra: a preliminary checklist. *Journal of Threatened Taxa*, **5** (12): 4693–4713.

Hampson, G.F. 1891. Illustrations of typical specimens of Lepidoptera Heterocera in the collection of the British Museum. Part 8. The lepidoptera of heterocera of the Nilgiri district *Ill, typical Spec. Lep. Het. Colln Br. Mus.*, **8** : 1-144.

Hampson, G.F. 1894. *The Fauna of British India including Ceylon and Burma, Moths* - volume 2. Taylor and Francis, London, 609pp.

Hampson, G.F. 1895. *The fauna of British India including Ceylon and Burma,* *Moths* - volume 3. Taylor and Francis, London, 546pp.

Hampson, G.F. 1898. Catalogue of the Syntomidae in the British Museum Vol. 1. Taylor and Francis, London, 106-107pp.

Holloway, J.D. 1988. The Moths of Borneo. Part 6. Family Arctiidae, subfamilies Syntominae, Euchromiinae, Arctiinae; Noctuidae misplaced in Arctiinae (Camptoloma, Aganainae). Southdene Sdn Bhd., Kuala Lumpur.

Holloway, J.D. and Miller, S.E. 2003. The composition, generic placement and host-plant relationships of the *joviana*-group in the *Parallelia* generic complex (Lepidoptera: Noctuidae, Catocalinae). *Invertebrate Systematics*, **17**: 111-128.

Holloway, J.D. 2005. The Moths of Borneo (part 15 & 16): Family Noctuidae, Subfamily Catocalinae. *Malayan Nature Journal*, **58**: 1–529.

ICAR-NBAIR (2020) *Asota ficus*. https://www.nbair.res.in/Databases/ Databases/insectpests/Asota-caricae.php+&cd=12&hl=en&ct=clnk &gl=in. Assessed on 08.12.2020.

Jayanthi, P.D.K, Aurade, R.M., Kempraj, V. and Verghese, A. 2015. Aromatic fruits as baits for the management of fruit-piercing moths in pomegranate: exploiting olfaction. *Current Science*, **109** (8): 1476-1479.

Kalawate, A. and Sharma, R.M. 2017. Moths (Lepidoptera: Heterocera) from Pench National Park, *Bugs R All* #154. In: *Zoo's Print* **32**(2): 29-40.

Kalawate, A.S. 2018a. On a collection of Moths (Lepidoptera: Heterocera) from the northern Western Ghats of Maharashtra, India. *Zoology and Ecology*, **28** (3):231–251.

Kalawate, A.S. 2018b. A record after 92 years, and a first report of the moth *Mecodina metagrapta* Hampson, 1926 (Lepidoptera: Erebidae: Aganainae) from the Western Ghats' part of Maharashtra, India. *Journal of Threatened Taxa*, **10**(13): 12847–12849. https://doi.org/10.11609/ jott.4600.10.13.12847-12849

Kalawate, A.S., Upadhyay, N., Mukhopadhyay, B. 2019. Rediscovery of an endemic Indian moth *Gurna indica* (Moore, 1879) (Lepidoptera: Erebidae: Arctiinae) after 125 years. *Journal of Threatened Taxa*, **11**(6): 13808–13810. https://doi.org/10.11609/jott.4649.11.6 .13808-13810

Kalawate, A.S., Dinesh, K. P. and Shabnam, A. 2020. DNA barcoding unravels three new species and a subspecies of *Olepa* Watson, 1980 (Lepidoptera, Erebidae, Arctiinae) from India, with morphotypes. *Journal of Insect Biodiversity*, **019** (2): 044–060.

Kaleka, A.S. and Kirti, J.S. 2001. A new genus *Mangina* along with the taxonomy of *Argina* Hubner (Arctiinae : Arctiidae : Lepidoptera). *Journal of the Bombay Natural History Society*, **98**(2) : 250-253.

Kapoor, V. 2006. Hanging by a thread: spider communities in rainforest fragments and shade-coffee plantations in the Anamalai Hills, Western Ghats, India. Technical Report No.13, Nature Conservation Foundation, Mysore.

Kendrick, R.C. 2002. Moths (Insecta: Lepidoptera) of Hong Kong. PhD Thesis. University of Hong Kong, 660pp+47pls.

Kirti, J. and Singh, N. 2015. Arctiid Moths of India *Arctiid Moths India* 1 : 1-205 (Published by : Nature Books India, 6 Gandhi Market, Minto Raod, New Delhi-110002).

Kononenko, V. S. & Pinratana, A. 2013. Moth of Thailand Vol. 3, Part 2. Noctuoidea. An illustrated Catalogue of Erebidae, Nolidae, Euteliidae and Noctuidae (Insecta, Lepidoptera) in Thailand. Brothers of St. Gabriel in Thailand. Bangkok. 625 pp

Kumar, K. and Lal, S.N. 1983. Studies on the biology, seasonal abundance and host-parasite relationship of fruit sucking moth *Othreis fullonia* (Clerck) in Fiji. *Fiji Agricultural Journal*, **45**: 71–77.

Leley 2016. Annotated catalogue of the insects of Russian Far East. Volume II. Lepidoptera. *Cat. ins. Russian Far East*, **2** : 1-812.

Leong, S.C.T. and Kueh, R.J.H., 2011. Seasonal Abundance and Suppression of Fruit Piercing Moth *Eudocima phalonia* (L.) in a Citrus Orchard in Sarawak. *The Scientific World Journal*, **11**: 2330–2338.

Mitra, B., Chandra, K., Shah, S.KR. and Kumar, J. 2019. Insecta : Lepidoptera. *Fauna of Maharashtra, State Fauna Series*, **20**(Part-3) : 89-209.

Mote, U.N., Tambe, A.B. and Patil, C.S. 1991. Observations on incidence and extent of damage of fruit sucking moths on pomegranate fruits. *Journal of Maharashtra Agricultural Universities*, **16**(3):438-439.

NHM 2021. HOSTS - a Database of the World's Lepidopteran Hostplants. https://www.nhm.ac.uk/our-science/data/hostplants/search/detail.dsml?PK_MainID=891&browse.dsml. Assessed on 02.12.2021

Ngampongsai, A., Barrett, B., Permkam, S., Suthapradit, N. and Nilla-or R. 2005. A preliminary study on some ecological aspects of the fruit piercing moths in Songkhla Province of Southern Thailand. *Songklanakarin Journal of Science and Technology*, **27** (6): 1135–1145.

Nieukerken, Van, E.J., Kaila, L., Kitching, I.J., Kristensen, N.P., Lees, D.C., Minet, J., Mitter, C., Mutanen, M., Regier, T.J., Simonsen, N., Wahlberg, Yen, S.H., Zahiri, R., Adamski, D., Baixeras, J., Bartsch, D., Bengtsson, B.A., Brown, J.W., Bucheli, S.R., Davis, D.R., Prins, J.D., Prins, W.D., Epstein, M.E., Poole, P.G., Gielis, C., Hattenschwiler, P., Hausmann, A., Holloway, J.D., Kallies, A., Karsholt, O., Kawahara, A.Y., Koster, S., Kozlov, M.V., Lafontaine, J. D., Lamas, G., Landry, J.F., Lee, S., Nuss, M., Park, K.T., Penz, C., Rota, J., Schintlmeister, A., Schmidt, B.C., Sohn, J.C., Solis, M.A., Tarmann, G.M., Warren, A.D., Weller, S., Yakovlev, R.V., Zolotuhin V.V. and Zwick, A. 2011. *Order Lepidoptera Linnaeus*, 1758. *In*: Zhang, Z.Q. (ed.). Animal Biodiversity: An Outline of higher-level Classification and Survey of Taxonomic Richness, *Zootaxa*, **3148**: 212–221.

Ockinger, E., Schweiger, O., Crist, T.O., Debinskim, D.M., Kraussm, J., Kuussaari, M., Petersen, J.D., Pöyry, J., Settele, J., Summerville, K.S., Bommarco, R. 2010. Life-history traits predict species responses to habitat area and isolation: a cross-continental synthesis. *Ecol. Letters*, **13** (8):969-79 10.1111/j.1461-0248.2010.01487.x.

Sambath, S. 2014. Taxonomic Studies of Lepidoptera (Insecta) of Dalma Wildlife Sanctuary, Jharkhand (India). *Records zoological Survey of India*, Occasional Paper **359**: 1–103.

Sands, D.P.A., Liebregts W.J.M.M., and Broe, R.J. 1993. Biological control of the fruit piercing moth, *Othreis fullonia* (Clerk) (Lepidoptera: Noctuidae) in the Pacific, *Micronesica Series*, vol. 4, pp. 25–31.

Swafvan, K. and Sureshan, P.M. 2021. Erebid moths in the agroecosystems of northern Kerala. *Indian Journal of Entomology*, **83**(2021): 1-15. 10.5958/0974-8172.2021.00094.8.

Sekhon, C.K., and Singh, J. 2015. Inventory of owlet moths from Western Ghats of India (Noctuidae: Lepidoptera). *International Journal of Applied research*, **1**(5):175-181.

Sivasankaran, K., Anand, S., Mathew, P., and Ignacimuthu, S. 2017. Checklist of the superfamily Noctuoidea (Insecta, Lepidoptera) from Tamil Nadu, Western Ghats, India. *Check List*, **13** (6). 1101–1120. https://doi.org/10.15560/13.6.1101

Singh, J., Singh, N. and Joshi, R. 2014. A Checklist of Subfamily Arctiinae (Erebidae : Noctuoidea : Lepidoptera) from India. *Records zoological Survey of India*, Occ. Paper No., **367** : 1-76.

Singh, N. and Ranjan, R. 2016. Additions to the moth fauna of Dalma Wildlife Sanctuary, Jharkhand (India). *Records of zoological Survey of India*, **116**(Part-4) : 323-336.

Shivaperuman, C. 2014. Faunal resources in the Ritechie's Archipleago, Andaman and Nicobar Islands. *Records of zoological Survey of India, Occ. Paper No*. **360** : 1-76.

Shubhalaxmi, V., Kendrick, R.C., Vaidya, A., Kalagi, N. and Bhagwat, A. 2011. Inventory of moth fauna (Lepidoptera: Heterocera) of the northern Western Ghats, Maharashtra, India. *Journal of the Bombay Natural History Society*, **108**(3): 183-205.

Shubhalaxmi, V. 2018. *Field guide to Indian moths*, Birdwing Publishers, INDIA. (Ed. 1) 461 pp.

Smetacek, P. 2008. Moths recorded from different elevations in Nainital district, Kumaon Himalaya, India. *Bionotes*, **10**(1): 5-15.

Sondhi, Y., Sondhi, S., Pathour, S.R., and Kunte, K. 2018. Moth diversity (Lepidoptera: Heterocera) of Shendurney and Ponmudi in Agastyamalai Biosphere Reserve, Kerala, India, with notes on new records. *Tropical Lepidoptera Research*, **28**(2): 66-89.

TNAU (2021). Agriculture Crop Protection. https://agritech.tnau.ac.in/crop_protection/banana_pest/banana_7.html. Assessed on 02.12.2021.

Whitmore, T.C. 1997. Tropical forest disturbance, disappearance, and species loss. Pp. 3-12. *In*: Laurance, W.F. & R.O. Bierregaard Jr. (*Eds*): Tropical Forest Remnants: Ecology, Management, and Conservation of Fragmented Communities. The University of Chicago Press, Chicago.

Zahiri, R., Holloway, J.D., Kitching, I.J., Lafontaine, D., Mutanen, M. and Wahlberg, N. 2011. Molecular phylogenetics of Erebidae (Lepidoptera, Noctuoidea). *Systematic Entomology*, 1–23. http://dx.doi.org/10.1111/j.1365-3113.2011.00607.x

MS Received 30 April 2022
MS Accepted 10 June 2022

DOI: 10.55278/XDQS6388

Diversity of ants (Hymenoptera: Formicidae) in the mangrove patches of reclaimed Sunderbans, West Bengal, India

Damayanti Bakra*, Sheela S and S. Bhattacharyya***
**West Bengal State University, North 24 Parganas, Barasat, Kolkata-700126*
***Zoological Survey of India, 'M' Block, New Alipore, Kolkata-700053, India.*
Corresponding author: damayanti.zoology@gmail.com

Abstract

Ants are highly diverse social insects distributed in every terrestrial habitat except the north and south poles. Even though they are a dominant group in the mangrove ecosystem the study of ant diversity in Sunderbans mangrove, the world's largest mangrove ecosystem is yet to start. The objective of this study was to understand the ant diversity in mangrove patches in the villages of Indian Sunderbans. Ants were collected from the reclaimed areas of Indian Sunderbans. Total of 35 species, 21 genera of ants belonging to 5 subfamilies were found in this study. The highest number of species was found in the subfamily Myrmicinae. *Dilobocondyla gasteroreticulatus* reported first time from West Bengal. Ant species *Paratrechina longicornis, Crematogaster spp., Monomorium spp, Camponotus spp. and Tetraponera rufonigra* were the most abundant species in the mangrove habitat. Most of the ants were found from the mangrove associate plant, *Excoecaria agallocha*. The ant species diversity index in this study is moderate (H'= 2.37), while the evenness index classified as moderate (E =0.5), and no species of ants dominate this area (D = 0.1).

Key words: ants, mangrove, biodiversity, Sunderbans

Introduction

Ants are most impressive group of social insects. They belong to the order Hymenoptera and class Insecta and are placed in a single family of Formicidae. They are abundant in most of the habitats and trophic levels in several terrestrial ecosystems. Ants play important roles in terrestrial ecosystem as predators, detritivores, mutualists, herbivores and sometime pollinators (Holldobler and Wilson, 1990). Many species of ants contribute to pest suppression in agricultural systems (Way and Khoo, 1992). Although there are 17 subfamilies, about 344 genera and about 14,150 described species of ants in the world (www.antwiki.org).

Sunderbans is the active deltaic complex of Ganga- Brahmaputra estuarine system which covers an area of approximately 10,000 sq. km. of which 62% lies within Bangladesh and 38% in India (ref). In India, the land area measures about 9,629 sq. km of which 4,493 sq. km. is inhabited by people and rest is reserve forest. During high tide vast areas are inundated with brackish water, covered by halophytic herbs, shrubs and trees called mangroves. Mangrove swamps occur on the intertidal mudflats of estuaries, creeks and inlets. Mangrove habitats are among the most productive and biologically diverse wetland ecosystem on earth. In comparison to Bangladesh, Indian portion of Sunderbans has a poor formation of mangrove due to higher salinity and human interference (Naskar, Guha & Bakshi, 1987). Inspite of these problems, Sunderbans in West Bengal still possess 34 true mangrove plants and 62 mangrove associate plants (Mandal & Nandi, 1989). The most common floras are *Avicennia alba*, *A. officinalis*, *Bruguiera gymnorhiza*, *Ceriops decandra, Excoecaria agallocha*, *Rhizophora apicultala*, *Sonneratia apetala*. Beyond this, Sunderbans have rich aquatic and terrestrial faunal diversity. More than 40 species of mammals, 163 species of birds, 56 species of reptiles, 165 species of fish, 23 species of molluscs, 15 species of prawns, 67 species of crabs have so far been reported in Sunderban Biosphere Reserve (www.UNESCO.org).

Ants are often regarded as the most abundant and influential insect group in mangroves (Hogarth, 2007). It is reported that they play an important role in predation of insect pest on *Sonneratia*, *Rhizophora* and *Bruguiera* (Dakir, 2009). Ants and their pheromone could deter herbivorous insects and can reduce crab herbivory (Offenberg, 2006). Many studies of ants from India have been conducted previously except ant diversity in mangrove ecosystem of Sunderbans. By this study a baseline data is generated on ant biodiversity in Sunderbans mangroves which will bring out more of its associations and activities in further studies.

Material and Methods

Sampling sites

Sampling sites selected from inhabited areas of eastern, central and western parts of Indian Sunderbans are given below (Fig.1):

Location	Block	District	Coordinates
Sahebkhali	Hingalganj	24 Parganas North	22º20′4.000″N/88º58′18.000″E
Dayapur	Gosaba	24 Parganas South	22º7′44.040″N/88º50′24″E
Bhagabatpur	Patharpratima	24 Parganas South	21º43′28.39″N/88º18′35.54″E
Bakkhali	Namkhana	24 Parganas, South	21º 33′40.57″N/88º16′4.49″E
Radhakrisnapur	Sagar	24 Parganas, South	21º42′56 ″N/88º03′30″E

Fig. 1: A satellite image showing five locations of ant sampling in Indian Sunderbans

Methodology

Ants were collected directly by forceps and brush soaked in alcohol from stems, leaves and hollow branches of trees, from the soil, leaf litter and lower vegetation during pre-monsoon (April-June) and post-monsoon(October-November) during 2019-2020. The specimens were ientified by referring to Bolton (1995), Bingham (1903), Tiwari (1998) and various keys available.

Results and discussion

A total of 35 species of ants were collected from mangrove patches of reclaimed areas of Indian Sunderbans belonging to 5 sub families, 21genera and 752 individuals (Table1). The highest number of species were found in Myrmicinae (16 species, 46%), followed by Formicinae (8 species, 23%), Ponerinae (11%) and Pseudomyrmicinae (11%) both had 4 species while Dolichoderinae had 3 species (9%) (Table 2 & Fig.2). *Monomorium* was most common genus with highest number of species collected. The genus *Tetraponera* is usually an arboreal species which represents two common species, *T. rufonigra* and *T. allaborans*. Here we found two more species *T. nitida* and *T. nigra* in which *T. nitida* is not a common species and reported in India, only from Andamans. The most abundant genus were *Paratrechina* (RA=18%), *Crematogaster* (RA=17%), *Monomorium* (RA=14%), *Camponotus* (11%) *and Tetraponera* (9%) (Table3). We identified *Dilobocondyla gasteroreticulatus* (the species is so named due to the presence of fine reticulations on the gaster) from Patharpratima CD block of South24 Parganas district on the stem of mangrove trees. *Dilobocondyla gasteroreticulatus* was first reported from Northwest Shivalik range of the Northwest Himalayas (Bharti & Kumar, 2013). We identified four tramp species named *Tetramorium simillimum*, *Paratrechina longicornis*, *Trichomyrmex destructor* and *Solenopsis geminata* from mangrove forest. Primarily these tramp species are closely associated with human and have a detrimental effect on the original inhabitants of ant species of mangroves. We also found that *Excoecaria agallocha*, a mangrove plant is most preferred microhabitat of ants (Table 4 and 5). It was observed that a total 18 genera of ants were using this plant for various purposes. Furthermore, *Camponotus compressus* lives exclusively in twigs of Acacia in a mutualistic relationship with tree hoppers (Fig. 3). *Crematogaster anthracina* found in a small nest cavities and hollow branches of Gum Arabic tree (Fig. 4). Dakir (2009) conducted a study on diversity of ants in mangrove forest of Kolaka, South-East Sulawesi and Muare Angke, Jakarta but he found 18 species. Arryanto *et al.* (2018) studied mangrove forest of North Kayong and recorded only 8 species. Further, Roy *et al*. (2018) reported 12 species from mangroves of Purba Medinipur district, West Bengal.

We calculated species diversity by using Shannon Diversity Index (H'), dominance by using Simpson’s Dominance Index (D) and Evenness by Shannon Evenness Index (E) (Pielou 1966; Shannon & Weaver 1963; Simpson 1949). We found that the ant species diversity index is moderate (H'= 2.37), while the evenness index classified as moderate (E=0.5) and no species of ants dominate this area (D = 0.1). Therefore, the diversity index indicates that the mangrove areas are rich in biodiversity of ants and this will impact the floral and faunal diversity of mangrove ecosystem.

Conclusions

Mangroves are diverse and highly productive ecological communities at the land-sea interface. The paper deals with the Formicidae fauna collected from five different localities like Sagar Island, Bakkhali, Patharpratima, Gosaba and Hingalganj in Sunderban delta of West Bengal during 2019-2020. The study revealed that ants are very much diverse in mangrove habitat with highly diverse vegetation. They can adapt to extreme physiological condition during high tide and cyclonic storms. Consequently, it is evident that the biological resources rely one another to sustain a functioning environment.

Acknowledgements

Authors are grateful to Director, Zoological Survey of India for facilities provided for this study. Authors are also thankful to the Dept. of Science and Technology, Govt. of West Bengal for providing financial assistance to conduct the entire research work.

Table 1. List of ant species recorded from mangrove patches of Indian Sunderbans

Sub family	Genus	Species
Dolichoderinae	*Tapinoma*	*Tapinoma indicum*Forel
		*Tapinoma melanocephalum*Fabricius
	Iridomyrmex	*Iridomyrmex anceps* Roger
Formicinae	*Camponotus*	*Camponotus compressus*Fabricius
		*Camponotus sericeus*Fabricius
	Lepisiota	*Lepisiota sericea*Forel
		*Lepisiota opaca*Forel
	Nylanderia	*Nylanderia indica*Forel
	Oecophylla	*Oecophylla smaragdina*Fabricius
	Paratrechina	*Paratrechina longicornis*Latreille
	Polyrachis	*Polyrachis rastelleta*Latreille
Myrmicinae	*Crematogaster*	*Crematogaster anthracina*Smith
		*Crematogaster rogenhoferi*Mayr
		*Crematogaster aberrans*Forel
	Carebara	*Carebara affinis*Jerdon
	Monomorium	*Monomorium atomum*Forel
		*Monomorium indicum*Forel
		*Monomorium latinode*Mayr
		*Monomorium floricola*Jerdon
	Trichomyrmex	*Trichomyrmex destructor* Jerdon
		*Trichomyrmex scabriceps*Mayr
	Pheidole	*Pheidole watsoni*Forel
		*Pheidole sagei*Forel
		*Pheidole parva*Mayr
	Solenopsis	*Solenopsis geminata*Fabricius
	Meranoplus	*Meranoplus bicolor*Guerin-Meneville
	Dilobocondyla	*Dilobocondyla gasteroreticulatus*Bharti & Kumar
Ponerinae	*Anochetus*	*Anochetus madaraszi*Mayr
	Diacamma	*Diacamma rugosum*Le Guilou
	Leptogenys	*Leptogenys hysterica*Forel
	Pseudoneoponera	*Pseudoneoponera rufipes*Jerdon
Pseudomyrmicinae	*Tetraponera*	*Tetraponera allaborans*Walker
		*Tetraponera nigra*Jerdon
		Tetraponera nitida Smith
		*Tetraponera rufonigra*Jerdon

Table 2. Percentage contribution of various subfamilies of mangrove ants in Sunderbans

Subfamily	Genus (%)	Species (%)
Dolichoderinae	2(10%)	3(9%)
Formicinae	6(29%)	8(23%)
Myrmicinae	8(38%)	16(46%)
Ponerinae	4(19%)	4(11%)
Pseudomyrmicinae	1(5%)	4(11%)
Total	21	35

Fig. 2: Subfamilies of mangrove Ants found in reclaimed Sunderbans, India

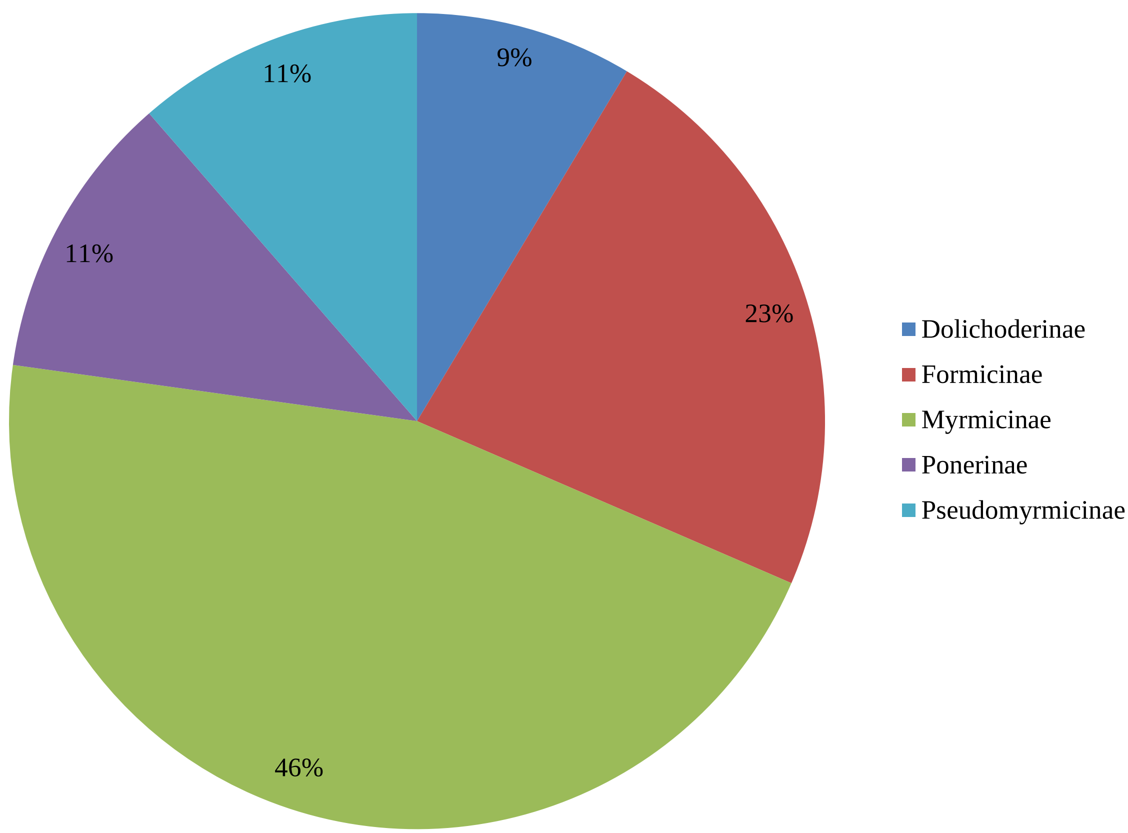


Table 3: Calculation of Relative abundance (RA), Simpson Dominance Index (H')**, Shannon Diversity Index** (D) **and Evenness Index**(E) **of ants in Sunderbans mangrove**

Genus	Relative Abundance	Simpson Dominance Index(H')	Shannon Diversity Index(D)	Shannon Evenness Index (E)
Paratrechina	18.21809	0.116395	2.37236	0.5106
Crematogaster	17.42021			
Monomorium	13.56383			
Camponotus	11.03723			
Tetraponera	8.510638			
Pheidole	7.845745			
Lepisiota	6.117021			
Nylanderia	4.654255			
Tapinoma	4.255319			
Diacamma	2.792553			
Pseudoneoponera	1.06383			
Solenopsis	0.930851			
Trichomyrmex	0.930851			
Leptogenys	0.531915			
Carebara	0.398936			
Meranoplus	0.398936			
Anochetus	0.265957			
Calalaucus	0.265957			
Dilobocondyla	0.265957			
Iridomyrmex	0.265957			
Tetramorium	0.265957			

Table 4: Preferred host plants of ants in Sunderbans mangrove

PLANT / ANT GENUS	Gewa (*Excoecaria* sp.)	Baen (*Avicennia* sp.)	Kankra (*Bruguiera* sp.)	Gum Arabic tree (*Vachellia* sp.)	*Casuarina*	Ear leaf acacia (*Acacia* sp.)
Anochetus	P	-	-	-	-	-
Catalacus	P	-	-	-	-	-
Camponotus	P	P	P	P	P	P
Carebara	P	-	-	-	-	-
Cardiocondyla	P	-	-	P	-	-
Crematogaster	P	P	-	P	P	-
Diacamma	P	-	P	-	-	-
Dilobocondyla	P	-	-	-	-	-
Iridomyrmex	P	-	-	-	P	-
Lepisiota	P	P	-	P	-	P
Leptogenys	P	-	-	-	-	-
Monomorium	P	P	-	P	P	P
Meranoplus	-	-	-	P	-	-
Nylanderia	P	-	-	P	P	-
Paratrechina	P	P	-	-	P	P
Pheidole	P	P	-	P	P	P
Pseudoneoponera	P	-	-	P	P	-
Solenopsis	-	P	-	-	-	-
Tapinoma	P	P	-	P	P	P
Tetramorium	-	-	-	P	-	-
Tetraponera	P	P	-	P	P	-
Trichomyrmex	P	P	-	-	-	-

Table 5: Species richness of ants in different pants in Sunderbans mangrove

Microhabitat	Species richness
Gewa tree (*Excoecaria agallocha*)	18
Gum Arabic tree	12
Casuarina tree	10
Baen tree *(Avicennia* sp.)	10
Ear Leaf Acacia tree	6

Fig. 3: *Camponotus compressus* feeding on the excretion of tree hoppers i at Bakkhali, Sunderbans

Fig. 4: *Crematogaster antracina* nest in cavity of gum Arabic tree at Patharpratima, Sunderbans

References

Arryanto R, Prayogo H, dan Anwari M. S. 2018. Keanekaragaman Jenis Semut (Formicidae) Pada Hutan Mangrove Desa Podorukan Kecamatan Seponti Kabupaten Kayong Utara. Jurnal Hutan Lestari, **6(4)**: 904-910.

Antwiki.www.antwiki.org.>wiki>India

Bingham, C. T. 1903. The fauna of British India, including Ceylon and Burma. Hymenoptera, Vol. II. Ants and Cuckoo-wasps. London: Taylor and Francis, 506 pp

Bolton, B. A. 1987. Review of the *Solenopsis* genus-group and revision of Afrotropical *Monomorium* Mayr (Hymenoptera: Formicidae). *Bull. Br. Mus. (Nat. Hist.) Entomol.* **54**: 263-452.

Bolton, B. A. 1995. New general catalogue of the ants of the world. Cambridge, Mass.: Harvard University Press, 504 pp.

Bharti H, Guénard B, Bharti M, Evan P. Economo. 2016. An updated checklist of the ants of India with their specific distributions in Indian states (Hymenoptera, Formicidae). Zoo Keys. **551**:1 -83.

Bharti H, Kumar R. Five new species of Dilobocondyla (Hymenoptera: Formicidae) with a revised key to the known species. Asian Myrmecology.2013, 5: 29–44.

Dakir, 2009. Komposisi Semut (Hymenoptera: Formicidae) pada Vegetasi Mangrove Kabupaten Kolaka Sulawesi Tenggara dan Muara Angke Jakarta. Thesis, Pasca Sarjana, InstitutPertanian Bogor.

Guofang, J. 1997. A preliminary analysis of species composition and its seasonal fluctuation of insects in Shankou mangrove area. – Journal of Guangxi Academy of Science 13: 7.

Hogarth, P. 2007. The biology of mangroves and seagrasses. 2nd edition. – Oxford University Press, Oxford, UK, X + 273 pp.

Hölldobler, B. and Wilson, E.O. 1990. The ants. – The Belknap Press of Harvard University Press, Cambridge, MA, 732 pp.

Hutchings, P and Saenger, P. 1987. Ecology of mangroves. – University of Queensland Press, St. Lucia, Qld., XXII + 388 pp.

Mandal, A. K. and N. C. Nandi. 1989. *Fauna of Sundarban Mangrove Ecosystem West Bengal, India*. Calcutta, Zoological Survey of India., 116.

Naskar, K. R. and Guha Bakshi, D. N. 1987. Mangrove swamps of the Sundarbans. Naya Prokash, Calcutta.

Offenberg, J., Macintosh, D. J. and Nielsen, M. G. 2006. Indirect ant-protection against crab herbivory: Damage-induced susceptibility to crab grazing may lead to its reduction on ant-colonized trees. – *Functional Ecology* **20**: 52-57.

Offenberg, J., Nielsen, M.G., Macintosh, D., Havanon, S. &Aksornkoae, S. 2004b: Evidence that insect herbivores are deterred by ant pheromones. – *Proceedings of the Royal Society B-Biological Sciences* **271**: 433-435.

Roy M, Panja B, Das A and Mitra B., 2018. First report of mangrove inhabiting ants from Bajkul forest range of Purba Medinipur district, West Bengal**. 7(11)**:81-82.

Simberloff, D. S. and Wilson, E. O., 1969. Experimental zoogeography of islands – colonization of empty islands. – Ecology **50:** 278-296.

Tiwari, R. N., Kundu, B. G., Roy Chowdhury, S. and Ghosh, S. N. 1998, Insecta: Hymenoptera; Formicidae. *Zoological Survey of India, State Fauna Series 3: Fauna of West Bengal*, Part 8.: 211-294.

Way M. J and Khoo K. C. 1992, Role of ants in pest-management. *Annu. Rev. Entomol*. **37**:479-503.

Walker, F. 1859. Characters of some apparently undescribed Ceylon insects. [part]. *Ann. Mag. Nat. Hist*.; **3(4)**: 370-376.

MS Received 26 April 2022
MS Accepted 25 May 2022

DOI: 10.55278/ZCAE6099

Incidence of *Oxycetonia versicolor* Fabricius on sunflower from West Bengal, India – A new report

Sabyasachi Ray[1] and A. Banerjee[2]
[1] *Department of Agricultural Entomology, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia-741252, W.B., India*
[2]*AICRP on MULLaRP (Mungbean, Urdbean, Lentil, Lathyrus, Rajmash & Pea) Directorate of Research, B.C.K.V., Mohanpur, Nadia-741252, W.B., India*
Corresponding author: amitavakvk@gmail.com

Sunflower, botanically known as *Helianthus annus* and representing the family Asteraceae (formerly known as Compositae), is a crucial oil yielding crop that originated in north America. Seeds are the main economic portion of the crop that is processed for several products and commercialization of these products are executed in cooking purpose as well as feed supply for the livestock animals (Yegorov *et al*., 2019). Significant health benefits are provided by the crop through the supply of premium oil and dietary fibre (Khan *et al.*, 2015). Seed of the crop contains unsaturated fatty acids like palmitic acid (5%), stearic acid (6%), monounsaturated fatty acid like oleic acid (30%) and polyunsaturated fatty acid like linoleic acid (59%) (Anon., 2005). As per the scenario, worldwide sunflower oil production reached up to 18 million tonnes. Ukraine and Russia are the leading sunflower oil producing country among the world accounting for 53% of the total global production. In the Indian context it was observed that total production of sunflower seed during the fiscal year 2021 was 185 thousand metric tonnes (Anon, 2022). In West Bengal during 2016-2017 the production of sunflower seed was 0.02 million tonnes from an area of 0.01 million ha where as during 2017-2018 the sunflower growing area in West Bengal remains almost same but production level reduces considerably and became 0.01 million tonnes (Anon., 2018). During the past years sunflower production decreased due to several biotic and abiotic constraints in India as well as in West Bengal. Previous investigation revealed that sunflower has been attacked by 43 insect species in India (Sandhu *et al*., 1973; Makhdoomi *et al*., 1984). Hassan *et al.* (1984) reported that about 19 insect pests infested sunflower crop and among them *Helicoverpa armigera* Hubn., *Aphis gossypii* Glover., *Bemisia tabaci* Genn., *Amrasca devastans* (Ishi.) and *Atractomorpha crenulata* (Fab.) causes economic damage to the crop (Satter *et al.,* 1984). Climate change over the years may bring changes in the pest and natural enemy complex of crop ecosystem including sunflower in different growing regions (Geetha and Hegde, 2018). Besides this mono-cropping with intensive cultivation using high yielding varieties, using of higher external inputs including fertilizers and pesticides may lead to the change in pest incidence on a particular crop. Under the changed circumstances some pest which were previously not known for causing economic damage to the concerned crop are becoming a matter of concern as well as some new insects also are appearing on a particular crop of a concerned region which have no previous history of association with that crop of that particular region (Taggar *et al.*, 2012). One such insect is flower chafer beetle, *Oxycetonia versicolor* Fabricius (Scarabaeidae: Coleoptera).

The flower chafer beetle (*O. versicolor*) feeds on floral parts of several crops causing considerable damage as the reproductive parts gets damaged. It is belonging to the family Scarabaeidae and subfamily Cetoniinae under the order Coleoptera. The insect is also known as *Cetonia versicolor* and *Gametis versicolor* Fabricius, 1775. The existence of this insect in the Seychelles was first noticed by Fairmaire (1893) who reported it as *Glycyphana versicolor*. Dupont in 1917 noticed the infestation of this insect in the rose bushes during day (Matot, 2000). Afterwards several provinces and regions of the world like Samoa, China, India, Sri Lanka, Chagos, Madagascar, Mascarenes and South Africa reported this insect (Matot, 2000). In the Indian subcontinent the earliest incidence of this insect was recorded from Indore district of Madhya Pradesh (Arrow, 1910).

The occurrence of these beetles on sunflower cv. KBSH 1 was first noticed in the farmer's field located at Bhayna (23.3110° N, 88.6386° E) under the district Nadia, West Bengal (Fig. 1). Incidence of the adult beetles was observed during last week of March, 2021 when the crop was at fifty per cent flowering stage coinciding with the peak flowering from March to April. The infestation was low to moderate (2-3 beetles/ flower) and their occurrence on the flowers was recorded after 11 am in the day time. Feeding of the adult beetles was noticed on the floral head (Fig. 2) from where they fed on the petals, pollens (Fig. 3), nectars and ovaries. Feeding of those floral parts causes substantial feeding injury and chaff in the grain. Association of this insect with sunflower is not previously reported from West Bengal. This is the first observation on the occurrence of chafer beetle (*O. versicolor*) on sunflower crop from West Bengal and also from Eastern India as per the available literature.

The chafer beetles are mainly known for infesting the floral parts particularly they feed on the pollen grains of several crop flowers and most of their activity takes place during daytime. Immature stages of these beetles generally harbored the decomposed soil organic materials and few of them infest plant roots (Taggar *et al.*, 2012). The mouthparts of the adult chafer beetles lack enough potential to penetrate resistant and sclerified plant tissues as they are less sclerotized. For that reason the main damage is caused by the dentate tibiae rather than the mouthparts as they use the tibiae for making slits in the floral parts which results in the destruction of the flower. This situation happens frequently when the flower inhabits more population causing competition in between the individuals (Viggiani, 1926; Tremblay, 2000).

There are several reports about the insect infesting different crops having economic importance. The insect was found to be distributed among different parts of South India and some northern parts also. In these regions several crops like sorghum, maize, ragi, ground nut were reported to be infested by this insect (Fletcher, 1914). Previous investigation suggested that the adult chafer beetle not only damaged the flowers but also the leaves and shoots of groundnut and okra whereas grubs were the root feeders but no considerable damage was caused by them (Fletcher, 1917). Grubs generally get nourished from grass compost, sawdust and organic matter (Hinckley, 1967). Bhatnagar (1970) discovered the existence of the insect as a pest in different crops like citrus, cotton, okra, sorghum, maize, and groundnut cultivated in some parts of Rajasthan. Different red gram growing parts of India were infested with this beetle where they mainly fed on the pollen grains (Reed *et al.*, 1989). Voracious feeding by these insects was observed from pearl millet panicles in Rajasthan (Nwanze and Youm, 1995). From Tamil Nadu these chafer beetles were noticed to inflict damage the brinjal crop by devouring the tender shoots, floral buds and flowers (Ambethgar, 2000). The insects were also known for causing injury to *Jatropha curcas* in mild level (Shanker and Dhyani, 2006). Incidence of chafer beetle (2.08%) was also recorded from Doddaballapur, Lalbagh (Bangalore) where they damaged the rose flowers and leaves also; preferably they fed on the flowers (Kumar *et al.*, 2009). The pest was also recorded from green gram at flowering and pod developing stage of the crop (Duraimurugan and Srinivasan, 2009). Incidence of this beetle was also reported from red gram and green gram from Punjab (Taggar *et al.*, 2012). Recently cotton growing regions of central India became infested with this insect which caused low (0.40%) to moderate (12.92%) damage in Rajkot (Gujarat) and Wardha (Maharashtra), respectively (Naik *et al.*, 2017). Daravath *et al.* (2020) recorded the incidence of flower chafer beetle from Telengana and Southern India, where they found it mainly damaging the cotton. Besides they also noticed some other host plants of this beetle *viz.* brinjal, sesamum, maize, sorghum and *Parthenium hysterophorus* from that region.

It may be concluded that the incidence of flower chafer beetle, *Oxycetonia versicolor* on sunflower as documented above is the first-time report from West Bengal in particular and from Eastern India as a whole as per the existing scientific literatures. In future, further investigations will be needed for assessing the probable population build up of this insect with a pest risk analysis. A comprehensive knowledge on the nature of damages produced by the insect along with its bionomics and way of sustainable management if required should be studied.

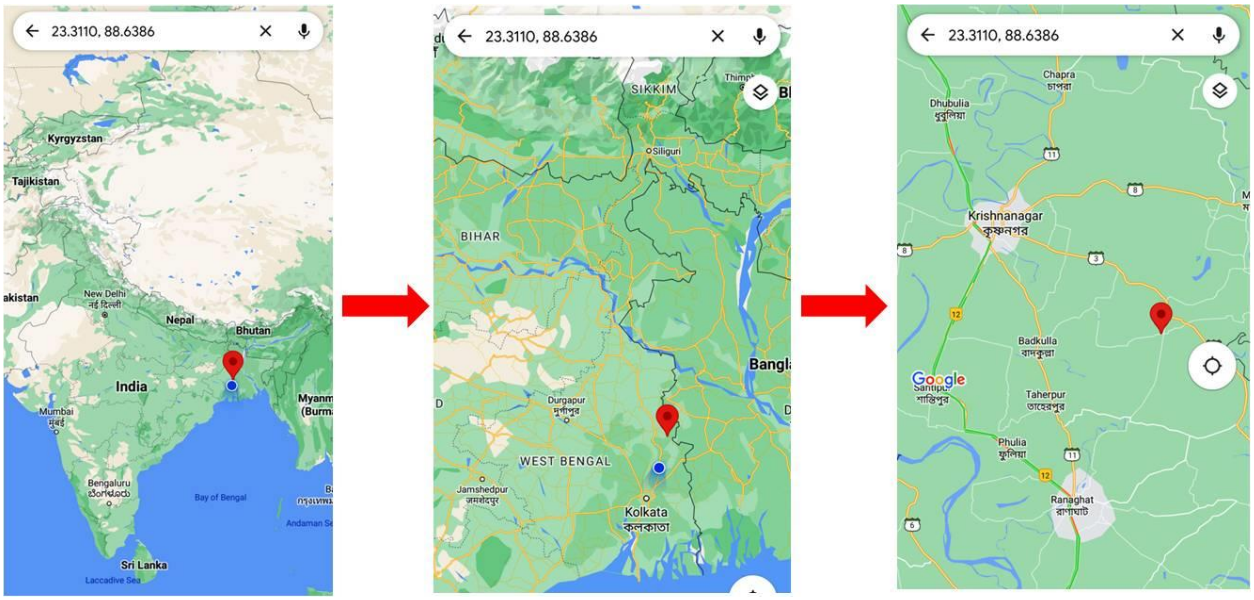


Fig. 1: Place of record as per GPS

Fig. 2: Incidence of flower chafer beetle (*Oxycetonia versicolor* Fab.) on the flower head of sunflower

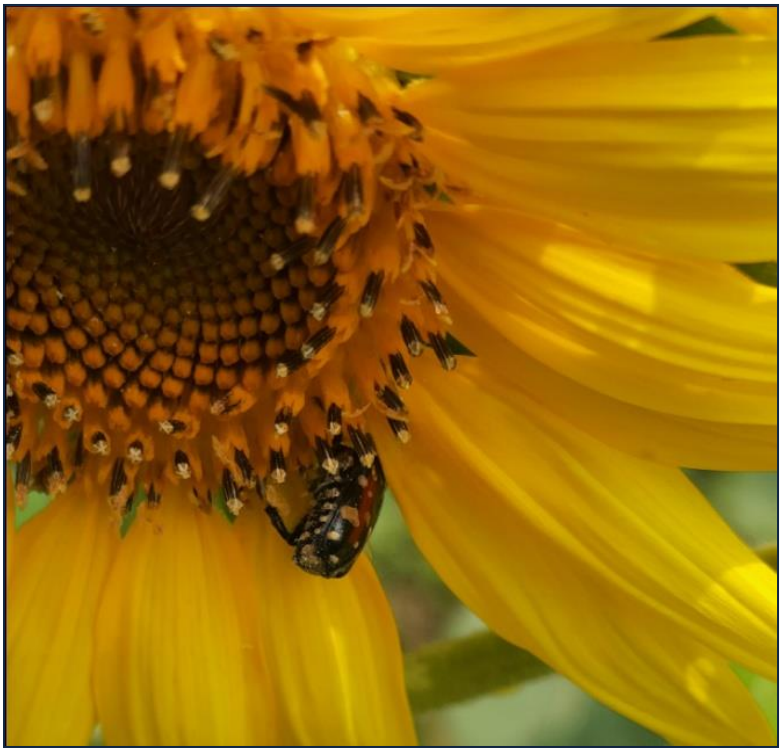


Fig. 3: Flower chafer beetle (*Oxycetonia versicolor* Fab.) feeding on sunflower pollens

References

Ambethgar, V. 2000. Report of cetonid beetle *Oxycetonia versicolor* Fab. on brinjal from Tamil Nadu, India. *Insect Environment*, **5**: 170.

Anonymous. 2005. British Pharmacopoeia Commission (2005). "Ph Eur monograph 1371". British Pharmacopoeia 2005. Norwich, England: The Stationery Office.

Anonymous. 2018. Agricultural Statistics at a Glance. Directorate of Economics and Statistics, Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India.

Anonymous. 2022. Sunflower oilseed production volume in India FY 2016-2021. Statista Research Department, Mar 22, 2022.

Arrow, G.J. 1910. The fauna of British India including Ceylon and Burma, Col. Lamell. I (Cetoniinae and Dynastinae). London, UK: Taylor and Francis.

Bhatnagar, S.P. 1970. Records of new cetonides pests in Rajasthan state. *Labdev Journal of Science and Technology*, **2**: 119-120.

Daravath, V., Kasbe, S.S. and Musapuri, S. 2020. Flower chafer beetle (*Oxycetonia versicolor* Fabricius) on the verge of becoming a major pest on cotton in Telangana region of India: A first report. *Journal of Entomology and Zoology Studies*, **8**(2): 242-246.

Duraimurugan, P. and Srinivasan, T. 2009. Insects and mite assuming status of pests in mungbean. *Pulses Newsletter*, 20, 3. IIPR, Kanpur, India.

Fairmaire, L. 1893. Sur quelques Coléoptères de Séchelles. *Bulletin de la Sociéte Entomologique de France*, **19**: 322-325.

Fletcher, T.B. 1914. Some south Indian insects and other animals of importance. The Superintendent Government Press, Madras.

Fletcher, T.B. 1917. Report of the proceedings of the second entomological meeting. Vol. 2. Calcutta, India: Superintendent Government Printing.

Geetha, S.and Hegde, M.G. 2018. Incidence of insect pests and natural enemies in sunflower. *International Journal of Current Microbiology and Applied Sciences*, **7**(9): 1593-1601.

Hassan, A.M., Mahmood, T. and Ahmad, M. 1984. Insect pests of sunflower at Faisalabad. Proceedings of the National Workshop, April 28-30, Barani Agriculture and Development Project, NARC, pp. 39-42.

Hinckley, A.D. 1967. Associates of the coconut rhinoceros beetle in Western Samoa. *Pacific Insects*, **9**(3): 505-511.

Khan, S., Choudhary, S., Pandey, A., Khan, M.K. and Thomas, G. 2015. Sunflower oil: Efficient oil source for human consumption. *Emergent Life Sciences Research*, **1**: 1-3.

Kumar, S., Sankar, M., Sethuraman, V. and Musthak, A. 2009. Population dynamics of white grubs (Coleoptera: Scarabaeidae) in the rose environment of Northern Bangalore, India. *Indian Journal of Science and Technology*, **2**: 46-52.

Makhdoomi, S. M. A., Bhatti, M.N., Zia, M.A. and Shafiq, M. 1984. Studies on insect pests associated with sunflower crops in Faisalabad. *Journal of Agricultural Research*, **22**: 51-62.

Matot, P. 2000. Note on the flower scarab *Oxycetonia versicolor* (Fabricius, 1775) (Coleoptera: Scarabaeidae) in the Seychelles. *Phelsuma*, **8**: 77-78.

Naik, V.C.B., Giri, N.H., Kumbare, S., Kranthi, S. and Kumar, N. 2017. New report of Oxycetonia versicolor Fabricius, as a pest on cotton from Central India. National Academy Science Letters, **42**: 387-390.

Nwanze, K.F. and Youm, O. 1995. Panicle insect pests of sorghum and pearl millet: Proceedings of an International Consultative Workshop (1993, ICRISAT Sahelian Center, Niamey, Niger).

Reed, W., Lateef, S.S., Sithanantham, S. and Pawar, C.S. 1989. Pigeonpea and chickpea insect identification handbook. Information Bulletin 26. Patancheru, India: ICRISAT.

Sandhu, G.S., Brar, K.S. and Bhalla J.S. 1973. Pests of sunflower and other insects associated with sunflower crop. *Oilseed Journal*, **3**: 19-26.

Satter, A., Karimullah and Yousuf, M. 1984. Insect pests of sunflower in NWFP, Pakistan. *Pakistan Journal of Agricultural Research*, **5**: 239-240.

Shanker, C. and Dhyani, S.K. 2006. Insect pests of *Jatropha curcas* L. and the potential for their management. *Current Science*, **91**: 162-163.

Taggar, G.K., Singh, R., Kumar, R. and Pathania, P.C. 2012. First report of flower chafer beetle, *Oxycetonia versicolor*, on pigeonpea and mungbean from Punjab, India. *Phytoparasitica*, **40**(3): 207-211.

Tremblay, E. 2000. Entomologia applicata. Coleotteri (da Cicindelidi a Lucanidi). *Liguori editore, Napoli*, **4**(1): 1-104.

Viggiani, G. 1926. Alcune notizie sulla morfologia e sulla biologia della Tropinota hirta, con speciale rigurado ai danni da essa recati alle coltivazioni erbacee ed arboree. *Bollettino della Società dei Naturalisti in Napoli*, **37**: 28-53.

Yegorov, B., Turpurova, T., Sharabaeva, E. and Bondar, Y. 2019. Prospects of using by-products of sunflower oil production in compound feed industry. *Journal of Food Science Technology Ukraine*, **13**: 106-113.

MS Received 15 April 2022
MS Accepted 30 April 2022


With best compliments
POLLEN SEEDS PVT LTD
NO. 21, 2ND A CROSS,
BYRAVESHWARA NAGAR,
LAGGERE, BENGALURU -
580058, KARNATAKA,
INDIA
MOBILE:9448165401
Pollen Seeds(TM)
An ISO 9001-2015 Certified Company

Review articles & Short notes

DOI: 10.55278/BWTL7909

Hormesis- a weapon for improving insect natural enemies

Aishwarya Ray[1,2] and Basana Gowda G[2*]
1 Department of Entomology, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chattisgarh,492001, India
2 Crop Protection Division, ICAR-National Rice Research Institute, Cuttack, Odisha,753006, India
Corresponding author e-mail: basanagowda.g@icar.gov.in

Constant pressure to feed the world's growing population has led to development of high-yielding varieties which caused crops to be stressed by various pests (Singh *et al.*, 2014). Although the call for using integrated pest management (IPM) is very sound and clear, still chemical management has been the first preference. This has led to excessive use of non-selective pesticides, thereby resulting in ecological backlash like natural enemies' destruction, resistance and resurgence of pests along with secondary pest outbreaks (Wang *et al.*, 2012; Gowda *et al.*, 2021a). Although pesticides are applied at sufficient concentrations to manage the target insect pests, certain spatio-temporal changes in concentrations due to abiotic and biotic factors lead to altered targeted doses thereby causing lethal as well as sublethal effects in the arthropods exposed (Desneux *et al.*, 2007, Ullah *et al.*, 2019). This biological phenomenon is called hormesis or dose response phenomenon. It is a biphasic dose-response to low doses of stress that can stimulate biological activities (Fig.1) (Cutler and Rix, 2015). This hormesis has been seen in a wide range of organisms including insects (Calabrese, 2005; Cutler and Rix, 2015). In insects, it includes stimulation such as enhancement in longevity, fecundity at any life stage and with any pesticide active ingredient, thereby enhancing the growth of organisms (Cohen, 2006; Cutler, 2013; Ayyanath *et al.*, 2013; Guedes and Cutler, 2014). Because of various ecological backlash and a huge impact on IPM-deciding strategy, the study of insect hormesis has been the center of research for insecticide toxicology with relatively less importance on toxicological impacts in natural enemies. The insecticide-induced insect hormesis is very detrimental whereas for the natural enemies it is a puissant weapon in optimizing mass rearing and enhancing the quality of bio-agents. Due to the high value of bio-agents in IPM, hormetic study or sublethal effect has garnered more attention.

It is very evident that commercial mass rearing and management of beneficial insects is a multi-billion dollar exclusive industry. Insects reared for biological and medical research, sterile insect release program, bio-control and many others have paved way for the money-making industry. The collaboration of rearing with the hormetic principles can elevate the mass culture programs of insects such as by improving insect longevity, fecundity and parasitization rate (Cutler, 2013). The urge to study the insecticide induced hormesis in natural enemies, especially on the predators, started with the lacewing, *Chrysopa californica*, coccinellid beetle and *Habrobracon hebetor* (Fleschner and Scriven, 1957; Atallah and Newson, 1966; Grosch and Vacovic, 1967; Guedes and Cutler, 2013; Gowda *et al*., 2021b). The hormetic effects are more profound in insect predators than in parasitoids. For example, an increase in the reproductive outputs and reduction of the generation time of the predatory bug *Podisus distinctus* was seen with a single exposure to the sublethal dose of permethrin (Guedes *et al*., 2009). A similar trend was observed with the predator *Supputius cincticeps* (Zanuncio *et al*., 2005). In the case of parasitoids, *Trichogramma* which is an effective bioagent against various lepidopteran pests (Orr *et al*., 2000; Cabello *et al*., 2012; Chailleux *et al*., 2013; Gontijo *et al*., 2019; Nozad-Bonab *et al*., 2021; Gowda *et al*., 2021c), the knowhow about the potential of hormesis on the mass rearing and quality has now become a priority. For example, exposure to low lethal concentrations (LC_{30}) of chlorflurazuron and tebufenozide on *Trichogramma chilonis* Ishii increased the adult longevity and female fecundity (Wang *et al*., 2012). Such advancement in rearing programs with hormetic principles can elevate the development of natural enemies.

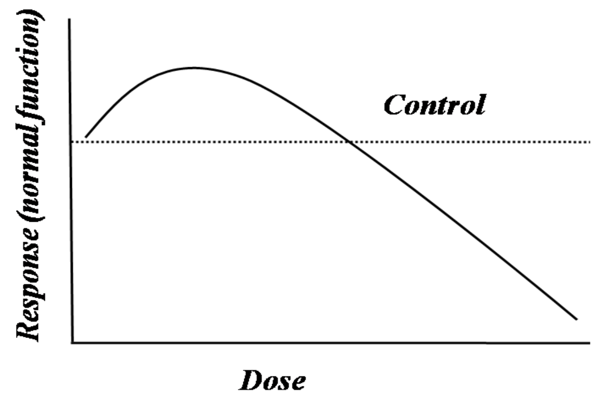


Fig. 1. Hormesis: A biphasic phenomenon (Guedes and Cutler, 2013)

References:

Atallah, Y.H. and Newson, L.L. (1966). Ecological and nutritional studies on *Coleomegilla maculate* De Geer (Coleoptera: Coccinelidae). III. The effects of DDT, toxaphene, and endrin on the reproductive and survival potentials. *J Econ Entomol* 59:1181–1187.

Ayyanath, M.M.; Cutler, G.C.; Scott-Dupree, C.D. and Sibley, P.K. (2013) Transgenerational shifts in reproduction hormesis in green peach aphid exposed to low concentrations of imidacloprid. *Plos one* 8: e74532.

Cabello, T.; Gamez, M.; Varga, Z.; Garay, J.; Carreno, R.; Gallego, J.; Fernandez, F. and Vila, E. (2012) Selection of *Trichogramma* spp. (Hym.:

Trichogrammatidae) for the biological control of *Tuta absoluta* (Lep.: Gelechiidae) in greenhouses by an entomo-ecological simulation model. IOBC/WPRS Bull 80: 171-176

Calabrese, E.J. (2005) Paradigm lost, paradigm found: the re-emergence of hormesis as a fundamental dose response model in the toxicological sciences. *Environ Pollut*, 138:379–411.

Chailleux, A.; Biondi, A.; Han, P.; Tabone, E. and Desneux, N. (2013) Suitability of the pest–plant system *Tuta absoluta* (Lepidoptera: Gelechiidae)–tomato for *Trichogramma* (Hymenoptera: Trichogrammatidae) parasitoids and insights for biological control. *Journal of Economic Entomology*, 106: 2310-2321

Cohen, E. (2006) Pesticide-mediated hemeostatic modulation in arthropods. *Pestic Biochem Physiol* **85**:21–27

Cutler, G.C. (2013) Insects, insecticides and hormesis: evidence and considerations for study. Dose-Response 11: 154-177.

Cutler, G. C. and Rix, R.R. (2015). Can poisons stimulate bees? Appreciating the potential of hormesis in bee–pesticide research. *Pest Manag Sci*, 71: 1368–1370.

Desneux, N.; Decourtye, A. and Delpuech, J.M. (2007) The sublethal effects of pesticides on beneficial arthropods. *Annu. Rev. Entomol*. 52: 81-106

Fleschner, C.A. and Scriven, G.T. (1957). Effect of soil-type and DDT on ovipositional response of *Chrysopa californica* (Coq.). *J Econ Entomol* **50**:221–222.

Gontijo, L.; Cascone, P.; Giorgini, M.; Michelozzi, M.; Rodrigues, H.S.; Spiezia, G.; Iodice, L. and Guerrieri, E. (2019) Relative importance of host and plant semiochemicals in the foraging behavior of *Trichogramma achaeae*, an egg parasitoid of *Tuta absoluta*. *Journal of Pest Science*, 92: 1479-1488.

Gowda, B.; Ray A.; Adak, T.; Sahu, M.; Sahu, N.; Patil, N., Annamalai, M.; and Rath. P.C. (2021a) Non-target effect of pesticides in rice environment. *Oryza*, 58: 194-207. https://doi.org/10.35709/ory.2021.58.spl.8.

Gowda, B.G.; Sahu, M.; Ullah, F.; Patil, N.B.; Pandi, G.P.P.; Adak, T.; Pokhare, S.; Mahendiran, A.; Rath, P.C. (2021b). Insecticide-induced hormesis in a factitious host, *Corcyra cephalonica*, stimulates the development of its gregarious ecto-parasitoid, *Habrobracon hebetor*. *Biol.Control.*

160: https://doi.org/10.1016/j.biocontrol.2021.104680.

Gowda, B.G.; Pandi, G.P.P.; Ullah, F.; Patil, N.B.; Sahu, M.; Adak, T.; Pokhare, S.; Yadav, M.K.; Mahendiran, A.; Mittapelly, P.; Desneux, N.; Rath, P.C. (2021c). Performance of *Trichogramma japonicum* under field conditions as a function of the factitious host species used for mass rearing. PLoS ONE 16(8): e0256246. https://doi.org/10.1371/journal.pone.0256246

Grosch, D.S. and Vacovic, L.R. (1967). Chlorinated hydrocarbon insecticides are not mutagenic in *Bracon hebetor* tests. *J Econ Entomol* **60**:1177–1179

Guedes, R.N.C.; Magalhaes, L.C. and Cosme, L.V. (2009). Stimulatory sublethal response of a generalist predator to permethrin: hormesis, hormoligosis, or homeostatic regulation? *J Econ Entomol*,102:170-176

Guedes, R. and Cutler, C. (2013) Insecticide-induced hormesis and arthropod pest management. *Pest*. *Manag*. *Sci*. 70: 690–697

Guedes, R.N.C. and Cutler, G.C. (2014) Insecticide-induced hormesis and arthropod pest management. *Pest Manag Sci*, **70**:690–697

Nozad-Bonab, Z.; Hejazi, M.J.; Iranipour, S.; Arzanlou, M. and Biondi, A. (2021) Lethal and sublethal effects of synthetic and bio-insecticides on *Trichogramma brassicae* parasitizing *Tuta absoluta*. *Plos one* 16: e0243334.

Orr, D.B.; Suh, C.P.; Mccravy, K.W.; Berisford, C.W. and Debarr, G.L. (2000) Evaluation of inundative releases of *Trichogramma exiguum* (Hymenoptera: Trichogrammatidae) for suppression of Nantucket pine tip moth (Lepidoptera: Tortricidae) in pine (Pinaceae) plantations. *The Canadian Entomologist*, 132: 373-386.

Singh, M., Bentur, J., Tanwar, R.K. and Sharma, O.P. (2014). Integrated Pest Management Package for Rice.

Ullah, F.; Gul, H.; Desneux, N.; Gao, X. and Song, D. (2019) Imidacloprid-induced hormesis effects on demographic traits of the melon aphid, Aphis gossypii. *Entomol Gen* 39: 325-337

Wang, D.S.; He, Y.R.; Guo, X.L. and Luo, Y.L. (2012) Acute toxicities and sublethal effects of some conventional insecticides on *Trichogramma chilonis* (Hymenoptera: Trichogrammatidae). *Journal of Economic Entomology*, 105: 1157-1163.

Zanuncio, T.V.; Zanuncio, J.C.; Serrao, J.E.; Medeiros, R.S.; Pinon, T.B.M. and

Sediyama, C.A. (2005). Fertility and life expectancy of the predator *Supputius cincticeps* (Heteroptera: Pentatomidae) exposed to sublethal doses of permethrin. *Biol Res* 38:31-39.

MS Received 18 April 2022
MS Accepted 03 May 2022

DOI: 10.55278/OILB7950

Immune priming: An overview in insects

Chaitali Banerjee
Assistant Professor in Zoology, Vidyasagar College for Women, 39, Sankar Ghosh Lane Kolkata 700006, West Bengal, India
Corresponding author: chaitali.banerjeeibl@gmail.com

Abstract

A characteristics feature of living systems is the ability to provide protection from different kinds of infection and various toxins. Importantly in insects, innate immune response is the most fascinating phenomenon. Though vertebrates' specific adaptive immune system is lacking in invertebrates including insects, defence priming is integral to many insect species. Immune priming is defined as the improved protection by the host to the same infectious agent upon a second encounter. This protection could be species/strain-specific, may be rendering lifetime protection or can be transgenerational. These attributes hence are effective protective system against a range of pathogens. Transgenerational immune priming can be attained primarily by two ways - direct parental transfer or elevated endogenous offspring immunity. The exact mechanisms for direct parental transfer is poorly understood though ways proposed involves direct transfer of antimicrobial peptides and mediators like lysozymes in the cytoplasm of the egg, epigenetic phenomenon like genomic imprinting or transfer of microbial fragments directly by the parents. Hence immune priming in insects are important line of defence and herein in this article an attempt on the elucidation of this phenomenon in the context of insects is done.

Keywords: Immune, Priming, Transgenerational

Introduction

Class Insecta (Latin *insectum*, “notched or divided body", that implies "cut into”) is the largest representative of Phylum Arthropoda, which in turn are the most predominant phyla (Snodgrass, 1960). They have 3 major divisions of the body – head comprising the mouthparts, eyes, and a pair of antennae; thorax (segmented) and abdomen that involves important systems like excretory and reproductive. They harbour very prominent and primitive innate immune system which exhibit both cellular and humoral immune responses. The insect immune system is known to possess fat bodies that secrete effector molecules into the circulating fluid (hemolymph) and diverse range of hemocytes. The fat body (a substitute of vertebrate liver and adipose tissue) is reported to secrete several soluble factors like antimicrobial peptides into the hemolymph (Lemaitre and Hoffmann, 2007). Hemocytes are versatile in forms and function.

Phagocytosis, encapsulation, nodule formation are some of the important roles worth mentioning. The most prevalent cell types are adipohemocytes, oenocytoids, prohemocytes, spherule cells, granulocytes, secretory, plasmatocytes, crystal cells and lamellocytes (Rosales, 2017).

Immune priming is another important immune mechanism shown by several insect species. It is a defence strategy in which a prior encounter to the pathogen or any of its derived material leads to profound immune response upon further encounter. Hence this strategy protects the insect by rendering it resistant to subsequent infections. This process involves an increase in the density of circulating hemocytes and subsequent enhanced production of antimicrobial peptides (Sheehan *et al*., 2020). Insects have always been an indispensable model to study microbial pathogen infection in human and hence detailed mechanisms of immune priming is integral to assess several parameters.

Immune priming – the detailed aspect

Immune priming is a fascinating aspect of invertebrate immunology which refers to swift, prompt and improved response of immune system to microbial population if they are exposed to the same pathogen previously at a relatively sub-lethal dose. Immune priming can result because of several factors like exposure to anti-microbial agents, different kinds of thermal and physical stress amongst others (Sheehan *et al*., 2020). Immune priming hence bestows insects to counteract potential infections with a history of previous exposure. The armamentarium involved in these process are different components of cellular and humoral immune system. Precisely immune priming is a complicated mechanisms and its effects may vary amongst insects of different species (Cooper and Eleftherianos, 2017).

Various experiments have been performed to demonstrate and understand immune priming. The classical biological model, *Drosophila melanogaster* have served as an integral model to study immune priming. The fruit flies were infected with sub-lethal dose of *Streptococcus pneumoniae* or its heat-killed form and a week later were re-exposed to the lethal dose of same pathogen (Pham *et al*., 2007). It was observed that the flies successfully withstood the infection. Similar observation were also noted with *Beauveria bassiana*, a natural fly pathogen. In another set of experiments with the bumblebee, *Bombus terrestris* were exposed to gram-negative *Pseudomonas fluorescence* or closely related gram-positive bacteria (*Paenibacillus alvei* and *P. larvae*) followed by repeat exposure with either the same bacteria (homologous) or one of the two bacteria (heterologous). The results showed that primed bees significantly withstand the homologous repeat infection than a heterologous repeat infection (Sadd & Schmid-Hempel, 2006).

These and several other infection studies in insects model have suggested and indicated the involvement of immune priming in insects. Further studies exploring the mechanism of priming have established the involvement of important signalling pathways like Toll and Imd in the phenomenon (Tanji *et al*., 2007). Both of these pathways are highly conserved signalling paths and follows similar patterns. The immune deficiency pathway or Imd primarily regulates antimicrobial peptides' expression. The Imd pathway is similar to TNFR and TLR signalling pathways. Precisely TNF-α requires *NF-κB* for the execution of functioning and Imd pathway relies on *Relish* signalling molecule. Relish is reported to contain *Rel* homology domain (that explains the nomenclature *Relish*) and an IkappaB-like domain that has ankyrin repeats (6 in numbers). Thus, Relish is a dual domain protein. This explains similarity of Relish to mammalian NF-kappaB precursors - p100 and p105 (Silverman & Maniatis, 2007). The Figure 1 explains the mechanism executed by Imd and TFNR pathways respectively. The conserved signalling molecules have been highlighted by similar colour and shapes (Myllmaki *et al*., 2014). It is worth mentioning here that *Relish* is typically involved in the humoral immune responses.

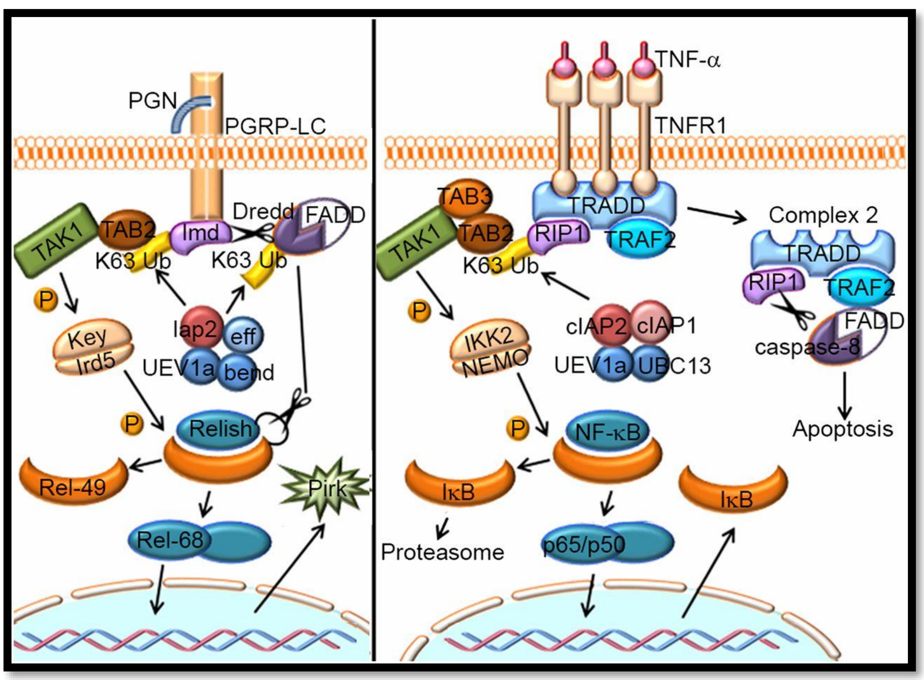


Figure 1: Schematic representation of the Drosophila Imd pathway and human TNFR signaling. Conserved components are indicated by similar shapes and colours (Myllmaki *et al*., 2014).

Drosophila Toll pathway is characterized by around 9 *toll* genes. They are primarily involved in cellular immune responses and act as important signalling molecules during phagocytosis, parasite encircling and nodule formation, encapsulation etc. The pathogen sensing is done by molecules extracellularly placed that triggers proteolytic cascade involving hydrolysis of the Toll receptor like prospatzle to spatzle (Lemaitre *et al*., 1996). The active spatzle binds to Toll receptor for the Toll pathway activation which in turn recruits a cascade of proteins consisting of MyD88, Tube and Pelle. As a consequence, there is a degradation of Cactus, eventually freeing Dorsal, and Dorsal-related immunity factor (DIF) facilitating their entry into nucleus to regulate the expression of AMPs such as drosomycin (Valanne *et al*., 2011).

Besides immune priming, both these pathways in downstream are severely implicated in disease pathogenesis and are the major determinants of immune evasion or protection against microbial infection. They are important initiators of several cascades like apoptosis, autophagy, necrosis to name a few. Howsoever, the Imd pathway is characterized for sensing diaminopimelic acid-containing peptidoglycan (DAP-type PGN) prevalent in Gram-negative bacteria. As mentioned earlier, they mainly regulate the expression of anti-microbial proteins like Diptericin involving Relish, an important transcription factor (Kleino and Silverman, 2014). Toll pathway operates in a different way by sensing lysine-containing peptidoglycan (Lys-type PGN) found in Gram-positive bacteria and by β-glucans characteristic of fungal cell walls. As a result they activate a different set of AMPs like Drosomycin that triggers downstream cascade *via* the involvement of dorsal-related immune factor (DIF), another important transcription factor.

Transgenerational immune priming

Transgenerational immune priming is an important aspect of insect immunology. Here the parental encounter to the pathogen provides protection to the progenies; hence suggesting immune protection persisting across generations. This dynamic phenomenon has been demonstrated by several representatives of different orders of class Insecta (Tetreau *et al*., 2019). A Transgenerational mechanism involves transfer of specific signalling molecules through developing eggs. These molecules could be some bacterial peptides translocated from mother's gut to the egg. Often this signal translocation involves enhanced expression of immune-related genes in the egg. Specifically in case of social insects *Apis mellifera*, vitellogenin is greatly implicated in the process. Vitellogenin is a lipoglycoprotein (egg-yolk precursor). They are synthesized and stored in the fat body but are secreted into the hemolymph. Though they are female specific proteins, in honeybees they are also expressed in the workers. Vitellogenin categorically recognises Pathogen associated molecular pattern like LPS and PGN. This can provide immunization to the progenies through many pathways including social immunization. In this later instance, bacterial fragments from the gut gets transferred to the worker bees' glands involved in producing the royal jelly that the queen bee feeds. This eventually reaches the eggs produced by the queen hence benefitting the colony (Salmella *et al*., 2015). In insect models like *Galleria mellonella* and *Tribolium castaneum*, transfers of specific microbial proteins occur by crossing the midgut epithelium. It is then entrapped into nodules in the haemocoel which is followed by deposition in the eggs (Freitak *et al*., 2014).

In insects there are different types of ovary reported - panoistic ovary, telotrophic ovary and polytrophic meroistic ovary. The later one is characterized by the arrangement of nurse cells and oocytes alternatively along the length of the ovariole whereas telotrophic ovary is characterized by placement of nurse cells at the apex of the ovariole. This facilitates feeding the oocyte through a nutritive cord as it descends down. In both these ovarioles, the trophocytes provides the oocyte with RNA, proteins, and ribosomes through much of their development that are otherwise provided only by the oocyte itself in panoistic ovarioles. Insects exhibiting telotrophic ovary (Orders - Hemiptera and Coleoptera) or polytrophic meroistic ovary (Orders - Hymenoptera, Lepidoptera, and Diptera) involve transferring maternal mRNAs in developing eggs during oogenesis. Many of these mRNAs apart from playing important role in development helps in the early immunological protection to the progenies (Johnstone and Lasko, 2001).

Another important transfer method involved is through epigenetic modifications of the parents like acetylation/deacetylation of histone proteins and/or by the methylation/demethylation of immune-related genes. Besides, females are capable of direct transfer of immune effector proteins to their eggs passively through the diffusion or sequestration into the proteins present in the mother's hemolymph. Also the transfer *via* active process takes place through specialized cells, such as nurse cells that mediates transfer to oocytes (Harwood *et al*., 2019).

Thus these are the different ways of how the developing embryo within the egg gets primed to different microbial patterns from exposure that the parents encountered during their life.

Conclusion and future prospects

Immune response against microbial pathogen is integral to survival of the host. In this respect immune priming is important as it primes the defence machinery and promotes increased protection to further challenges. In insects immune priming has been found as a widespread phenomenon owing to its prevalence in several insect species. This is further elaborated in insects as an event within generation and that persists across generations as well. Transgenerational immunity is a dynamic phenomenon in invertebrates and signifies the memory like response of vertebrates. However, monitoring several successive generations is crucial to establish the sustainability of transgenerational priming. Additionally, detailed mechanisms of immune priming in insects with special reference to transgenerational impact have to be studied. Further the studies has to be substantiated by molecular approaches. An elaborate transcriptomic and proteomic studies could decipher the intricate mechanisms. Several insect species shows metamorphosis of different extent. Hence it is crucial to investigate stage-wise analysis of transgenerational priming.

Equally important is the differentiation of hemocytes. The different sub-population of hemocytes keep circulating in the hemolymph that confers innate immune responses and as required differentiates to counteract the infection. Overall it can be concluded that immune priming is a conserved protective mechanisms though some more critical and elaborate studies may be required for more detailed understanding.

References

Snodgrass, R. E. 1960. Facts and theories concerning the insect head. *Smithsonian Miscellaneous Collections*, **142**:1-61

Lemaitre, B. and Hoffmann, J. 2007. The host defense of *Drosophila melanogaster*. *Annual Review of Immunology*, **25**: 697-743.

Rosales, C. 2017. Cellular and Molecular Mechanisms of Insect Immunity. In: Shields V. D. Editor. *Insect Physiology and Ecology*. London: *IntechOpen*. doi: 10.5772/67107.

Sheehan, G. Farrell, G. Kavanagh, K. 2020. Immune priming: the secret weapon of the insect world. Virulence, **11**: 238-246.

Cooper, D. and Eleftherianos, I. 2017. Memory and specificity in the insect immune system: current perspectives and future challenges. *Frontiers of* Immunology, **8**: 539.

Pham, L. N. Dionne, M. S. Shirasu-Hiza, M. Schneider, D. S. 2007. A specific primed immune response in *Drosophila* is dependent on phagocytes. *PLoS Pathogens*, **3**: p.e26.

Sadd, B. M. and Schmid-Hempel, P. 2006. Insect immunity shows specificity in protection upon secondary pathogen exposure. *Current Biology*, **16**: 1206-1210.

Tanji, T. Hu, X. Weber, A. N. Ip, Y.T. 2007. Toll and IMD pathways synergistically activate an innate immune response in *Drosophila melanogaster*. *Molecular and Cellular Biology*, **27**: 4578-4588.

Silverman, N. and Maniatis, T. 2001. NF-κB signaling pathways in mammalian and insect innate immunity. *Genes & Development*, **15**: 2321-2342.

Myllymaki, H. Valanne, S. Ramet, M. 2014. The *Drosophila* Imd Signaling Pathway. *Journal of Immunology*, **192**: 3455-3462.

Lemaitre, B. Nicolas, E. Michaut, L. Reichhart, J. M. Hoffmann, J. A. 1996. The dorsoventral regulatory gene cassette spatzle/toll/cactus controls the potent antifungal response in *Drosophila* adults. *Cell*, **86**: 973-983.

Valanne, S. Wang, J. H. Ramet, M. 2011. The *Drosophila* Toll signaling pathway. *Journal of Immunology*, **186**: 649-656.

Kleino, A. Silverman, N. 2014. The *Drosophila* IMD pathway in the activation of the humoral immune response. *Developmental and Comparative Immunology*, **42**: 25-35.

Tetreau, G. Dhinait, J. Gourbal, B. Moret, Y. 2019. Transgenerational immune priming in invertebrates: Current knowledge and future prospects. *Frontiers in Immunology*, https://doi.org/10.3389/fimmu.2019.01938.

Salmela, H. Amdam, G.V. Freitak, D. 2015. Transfer of immunity from mother to offspring is mediated via egg-yolk protein vitellogenin. *PLoS Pathogen*, **11**: e1005015.

Freitak, D. Schmidtberg, H. Dickel, F. Lochnit, G. Vogel, H. Vilcinskas, A. 2014. The maternal transfer of bacteria can mediate trans-generational immune priming in insects. *Virulence*, **5**: 547-554.

Johnstone, O. and Lasko, P. 2001. Translational regulation and RNA localization in *Drosophila* oocytes and embryos. *Annual Review of Genetics*, **35**: 365-406.

Harwood, G. Amdam, G. Freitak, F. 2019. The role of vitellogenin in the transfer of immune elicitors from gut to hypopharyngeal glands in honey bees (*Apis mellifera*). *Journal of Insect Physiology*, **112**: 90-100.

MS Received 06 May 2022
MS Accepted 18 May 2022

DOI: 10.55278/TAAS2423

Entomophagy: a step towards food security

Laya A. C. and Haseena Bhaskar
Department of Agricultural Entomology, College of Agriculture, Kerala Agricultural University, Vellanikkara, Thrissur - 680656, Kerala
Corresponding author: layaac.82@gmail.com

The world population surges ahead and is expected to reach nine billion by 2050 (FAO, 2012). Food security becomes a challenge due to growing population and limited resources, necessitating rethinking about food patterns and habits, particularly those relating to meat consumption. The word entomophagy is derived from the Greek word, *Entomon* means 'insect' and *Phagein* means 'to eat.' Thus, the practice of eating insects is known as entomophagy. Insects form a part of the human diet in many tropical countries and the earliest citing of entomophagy can be found in religious literature of Christian, Jewish and Islamic faiths (Huis *et al*., 2013). Loaded with proteins, fats and minerals, insects offer enormous scope as an alternative source of food. About 31 per cent of all edible insects around the world belong to the order Coleoptera followed by Lepidoptera, Hymenoptera, Orthoptera and Hemiptera.

The opportunities of insects as alternate food sources are due to its environmental, nutritional and socio-economic benefits. The major environmental benefits include high feed conversion efficiency, lower emission of greenhouse gases and lower water as well as land requirement (Huis, 2013). Higher feed conversion efficiency as well as lower emission of methane, nitrous oxide and ammonia has been reported in the edible insects *Tenebrio molitor*, *Acheta domesticus*, *Locusta migratoria*, *Pachnoda marginata* and *Blaptica dubia*, when compared to conventional livestock (Oonincx *et al*., 2010).

Fig. 1. Fried silkworm pupae for sale in China

(Source: https://images.app.goo.gl/BLiPwMsYUuA5Lmkc9)

Edible insects are highly nutritious as they are rich in carbohydrates, proteins, amino acids, fatty acids and micronutrients. A comparative study of amino acid content in beef and mealworm larva revealed that mealworms had higher isoleucine, leucine, valine, tyrosine, alanine, glycine and proline content (Huis *et al*., 2013). Harvesting and raising of insects involve low technology and capital investment and provides opportunities for subsistence for both urban and rural population, which makes it socio-economically viable.

Edible insects can be obtained by wild harvesting, semi-domestication and rearing/farming. Ninety two per cent of known species of edible insects are obtained through wild harvesting, six per cent by semi-domestication and two per cent by rearing (Yen, 2009). Rearing and semi domestication are considered to be the most productive method as they have huge potential to provide a more stable supply. Bamboo caterpillar, *Omphisa fuscidentalis* and weaver ant, *Oecophylla smaragdina* are collected from the wild, while the palm weevil, *Rhynchophorus palmarum* serve as a classical example of semi-domestication (Govorushko, 2019). Rearing of insects in captivity, isolated from their natural populations and provided with controlled living conditions and diet is referred as insect farming. House crickets, palm weevils and mealworms are being successfully farmed in Thailand (Hanboonsong *et al*., 2013).

After being harvested, the insects are processed and consumed as whole insects, in ground or paste form or as extracted protein. Blanching and drying are the common processing techniques followed, which minimizes the microbial risk and increases the shelf life of edible insect products. The effect of processing technology and storage conditions on the microbial characteristics of mealworm larva, field cricket nymph and migratory locust adult revealed that storage after drying at 103^{0}C for 12 hours reduced the total microbial count, as well as counts of enterobacteria, yeast and mould significantly (Adamek *et al*., 2018).

Fig. 2. Insect food product

(Source: https://images.app.goo.gl/px3ErwK6KjgKx1Co6)

Even though use of insects as food confers many advantages, not all insects are safe to eat. Microbial, chemical, physical and allergic risk should be considered while selecting insects for human consumption. In future, meat centric diets will become increasingly expensive and grain-livestock systems environmentally unsustainable. Though entomophagy is still in its early stages, given due support, it can play a significant role in assuring global food security.

References

Adamek, M., Mlcek, J., Adamkova, A., Suchankova, J., Janalikova, M., Borkovcova, M., and Bednarova, M. 2018. Effect of different storage conditions on the microbiological characteristics of insect. *Potr. S. J. Food Sci*. 12: 248-253.

FAO [Food and Agriculture Organisation]. 2012. Water and poverty, an issue of life & livelihoods. Available: hppt://www.fao.org/nr/water/issues/scarcity.html. [Accessed 24 Oct. 2019].

Govorushko, S. 2019. Global status of insects as food and feed source: a review. *Trends Food Sci. Technol.* 91: 436-445.

Hanboonsong, Y., Jamjanya, T., and Durst, P. B. 2013. *Six-legged Livestock: Edible Insect Farming, Collection and Marketing in Thailand.* RAP publishers, Bankok, 57p.

Huis, A. 2013. Potential of insects as food and feed in assuring food security. *Annu. Rev. Entomol*. 58: 563-83.

Huis, A., Itterbeeck, J., Klunder, H., Mertens, E., Halloran, A., Muir, G., and Vantomme, P. 2013. Edible insects: future prospects for food and feed security. *Int. Forestry Rev.* 16(1): 1-187.

Oonincx, D. G. A. B., van Itterbeeck, J., Heetkamp, M. J. W., van den Brand, H., van Loon, J., and Huis, A. 2010. An exploration on greenhouse gas and ammonia production by insect species suitable for animal or human consumption. *PLoS One* 5(12): e14445. Available: http://doi:10.1371/journal.pone.0014445 [Accessed 20 Oct. 2019].

Yen, A. L. 2009. Entomophagy and insect conservation: some thoughts for digestion. *J. Insect Conserv.* 13: 667–670.

MS Received 06 May 2022
MS Accepted 18 May 2022

DOI: 10.55278/NTXX8021

Occurrence of the red spider mite, *Tetranychus* sp on red amaranthus in terrace garden in Bangalore

Abraham Verghese [1*] and Rashmi. M. A[2]

[1*]*Former Director ICAR-National Bureau of Agricultural Insect Resources Bangalore,560024 and Former Head, ICAR-Indian Institute of Horticultural Research, Hesaraghatta, Bangalore,560089, India*

[2] *Regional Plant Quarantine Station, Directorate of Plant Protection Quarantine & Storage, Bengaluru 560024 India*

Corresponding author: abraham.avergis@gmail.com

Red amaranthus is a delicious leafy vegetable. It is becoming popular in kitchen gardens and in pots on terraces in urban Bangalore city (12.9784° N, 77.6408° E). The mite *Tetranychus* sp which had attacked Moringa (Verghese *et al.*, 2022) in the same area migrated to the amaranthus. The plants showed white to brown discoloration on the leaves (Fig 2). The leaves showed downward curling (Fig 3) with presence of mites and web on the ventral sides (Fig 2,) as compared to an unifested plant (Fig.1). As these were organic, no sprays were given and affected plants were uprooted and destroyed.

Fig. 1 Uninfested plant

Fig. 2 White to brown discoloration on the leaves, downward curling

Fig. 3 Downward curling with presence of mites

Verghese, A., Rashmi. M. A and Deepak. S, Liquid pongamia soap unsettles *Tetranychus* sp. on Moringa DOI: 10.55278/UWFK9862, *Insect Environment*, 25 (1): 89-91.

MS Received 4 May 2022
MS Accepted 30 May 2022

DOI: 10.55278/ASLB3554

A report on positive phototaxis exhibited by newly emerged bagworm caterpillars (Lepidoptera: Psychidae)

Ashirwad Tripathy[1*], and Shuvangi Panda[2]

[1]*Entomology Branch, Forest Protection Division, Forest Research Institute, P.O. New Forest, Dehradun, Uttarakhand 248006, India.*

[2]*Department of Forest Policy and Law, College of Forestry, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha 751003, India*

[*]***Corresponding author: ashirwadresearch101@gmail.com***

Abstract

The bagworm, *Thyridopteryx ephemeraeformis* (Haworth) (Lepidoptera: Psychidae) is a polyphagous moth that defoliates ornamental shrubs and trees. It has been reported as an emerging pest in the coastal agroecosystem of Odisha, India. A small experiment demonstrated that bagworm's newly emerged larva (NEL) was positively phototactic under white and UV light. After emerging in the rearing box, the larva was exposed to 3 volts of LED white and UV lights. After which, its phototactic behaviour was observed. Considering this report, light traps can be used to catch this nuisance species, which may now be more manageable. Hanging light sources on infested plant branches may be one technique, and when larvae congregate on that area of the branch, it may be easy to remove and kill them.

Keywords: *Thyridopteryx ephemeraeformis*, bagworm, phototaxis, Psychidae, Lepidoptera

Introduction

The bagworm, *Thyridopteryx ephemeraeformis* (Haworth), is a polyphagous moth that defoliates ornamental shrubs and trees. (Jones and Parks 1928). The adult female of this species has vestigial appendages and mouthparts, small eyes, apterous with no antenna. She spends her entire life upside-down inside the bag constructed by the larva during developmental stages (Kaufmann 1968; Neal 1982). On the other hand, males have wings and are diurnal and get attracted to females with a sex-pheromone scent they emit. Females deposit 1-methyl butyl decanoate in the cocoon at the bottom of their larval sack until they mate (Leonhardt et al. 1983, Klun et al. 1986). After reaching the female bag, the male inseminates the female by pneumatically stretching his abdomen inside her pupal shell, past the length of her body, to reach her caudal genitalia. The female oviposits inside her pupal shell and then falls from the bag. The eggs overwinter, and the larvae emerge in the spring. Young larvae typically make a silk thread and drift away on the breeze. (Jones and Parks 1928). This action is most likely one of the most important ways of distribution in the environment. On the other hand, late instar larvae have been seen to crawl away from their host plant shortly before pupation. Extensive research was done by Kaufmann (1968) on the *T. ephemeraeformis* and observed its biology and behaviour.

Over 50 families of deciduous and evergreen trees and shrubs can be targeted by *T. ephemeraeformis* (also known as the evergreen bagworm, common bagworm, eastern bagworm, and common basket worm) (Rhainds *et al*., 2009) and have been reported as an emerging pest in coastal agroecosystem of Odisha, India (Srivastva and Attri 2004). Still, research on its behaviour and other Psychidae is poorly known (Kaufmann 1968).

Insects use a variety of methods to find their way around. Bees' utilisation of the sun and polarised light for detecting food sources and reorienting to the hive is widely documented. Apart from chemical trails, ants have been observed using the sun for orienting (Romoser 1973). Dung beetles (Smolka *et al*., 2016), aphids (Hajong and Varman 2002) are known to be phototactic as well. However, artificial light at night (ALAN) strongly impacts the insect population (Grubisic *et al*., 2018). Luminosity, exposure time, and wavelengths of light-emitting diodes (LEDs) affect agricultural insects and stored-product insects. Agricultural insects are particularly attracted to green or blue LEDs because of their phototactic tendencies, and they are the most effective entrapment methods for these pesky pests (Park and Lee 2017).

Reports on adult lepidopteran attraction towards light are many (Park and Lee 2017). However, there are only a few observations of positive phototactic movements of lepidopteran caterpillars recorded, which is again used to trap the pest (Rao *et al*., 2016). ALAN was tested in a deciduous forest by Welbers et al. (2017), who used street lamps that emitted various colours of light to modify the lighting conditions. Caterpillar abundance peaked substantially higher in trees illuminated with green or white light than it did in trees illuminated with red light or in the absence of light, according to this study. In addition, male caterpillars exposed to green and white light had lower body mass and pupated quicker than those exposed to red or dark treatments, according to Van Geffen *et al*. (2014). Another research by Gotthard (2000) indicated that the length of the illumination could also influence the abundance of caterpillars because of its effect on the level of predation by predatory insects.

A small experiment confirmed the positive phototactic behaviour of the bag worm *Thyridopteryx ephemeraeformis* (Haworth), which was earlier doubtful by Kaufmann (1968) in his study. He observed that the newly emerged larva of the bagworm emerge out of the bag but did not confirm whether it is a positive phototactic response or not.

The bags were collected from the host *Ziziphus jujuba* shrubs from different localities in the agronomy field of Orissa University of

Agriculture and Technology, Bhubaneswar, Odisha (20°15'54.9"N 85°48'25.3"E), in the year 2017. The bags were chosen according to the indications provided by Kaufmann (1968). The matured bag (having the last instar larva) were collected by seeing the moulted head on the outer surface of the bag. This caterpillar moults seven times and becomes an adult (Kaufmann 1968). So the bag whose outer case had around 5-6 moulted head attached were chosen. Total 5-10 bags were collected and kept in a box of size 15cm x 15cm x 15 cm so that after the emergence of the adult winged male, it will find the female bagworm case and try to fertilise it. After copulation, the female bag cases were separated out and each one was kept in a small cylindrical box of 6cm (ht.) x 7cm (dia). Each small box was marked with A (left), B (middle), C (right), D (back) (as shown in figure 1). 3V white and UV LED lights were used to study the behaviour of the newly emerged larva (NEL).

Observations and Discussions

The female, after fertilisation, oviposits eggs inside the pupal case, which is held inside the bag case. After NEL comes out from the bags, it gets scattered all over the box by spinning a thin layer of silk on the inner surface of the box. The NEL move from one place to another by lifting its soft abdomen. Soon after emergence, within minutes, they start to build their bags with the help of the silk formed inside the inner layer of the box. After that, the LEDs were used to study the phototactic response. When the LEDs were switched off, all the larva were found to be scattered evenly all over the box in every marked position, i.e., A, B, C, and D (Fig 1.1). Soon after ‘switching on’ of the LED at different box positions (Fig 1.2, 1.3, 1.4, 1.5), the 100s of larvae tend to aggregate on the focus point of the light intensity. The shift in the LED's position tends to shift the aggregation of the bagworm larva. Then after the LED were ‘switched off’ the larvae get evenly scattered in the whole box again (Fig. 1.1; 2. a-f). This result was accurate for both the LED lights white and UV. Welbers et al. (2017) observed the same results by using green or white lights, increasing the caterpillar abundance. Also, UV light does the same Rao et al. (2016).

An opening cut in the bag's midsection prompted a larva's head to travel toward this opening, where it penned its skin and emerged as a pupa. The same results were produced when the posterior end was left open and the new centre aperture was created larger than the posterior one. Because the larvae oriented their heads toward the opening that provided the bag with the most light, these findings suggest they were positively phototropic (Kaufmann 1968).

According to this report, using light traps to catch this nuisance species may now be more manageable. Hanging light sources on infested plant branches may be one technique, and when larvae congregate on that area of the branch, it is easy to remove and kill them all.

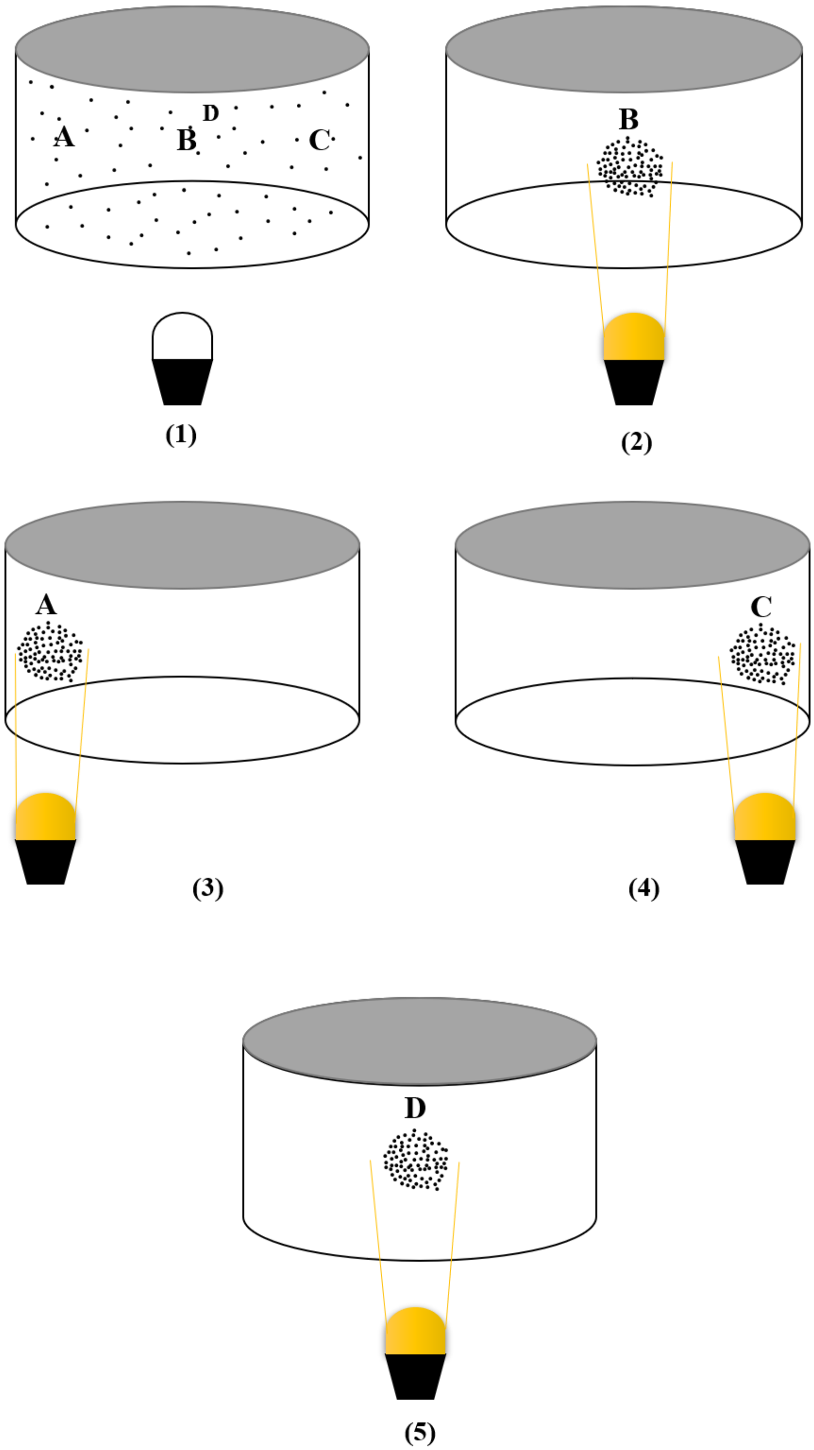


Fig. 1. (1) Evenly scattered bagworm larva when no light intensity was present (2) Aggregation of larva in 'B' (3) Relocation to 'A' (4) Again relocation to 'C' (5) Again aggregation of the larva after placing the light on the back of the box in 'D' position

Conflicts of Interests

The authors have no conflict of interest

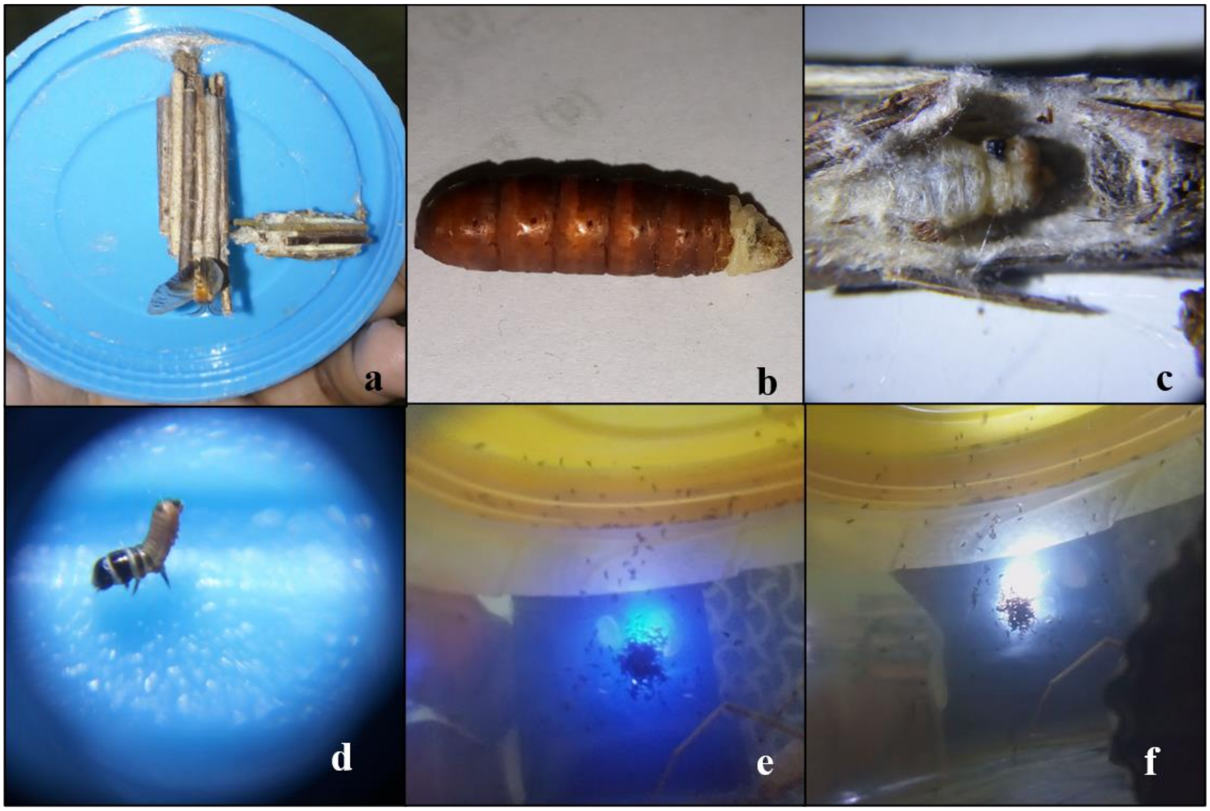


Fig. 2. **(a)** Mating of *Thyridopteryx ephemeraeformis*; (**b**) Adult female with the pupal case attached; (**c**) Adult female inside the bag without the pupal case; (**d**) Newly emerged larva (NEL) moving with its raised abdomen; (**e**) Aggregation of NEL under UV light; (**f**) Aggregation of NEL under white light

References

Gotthard K (2000) Increased risk of predation as a cost of high growth rate: an experimental test in a butterfly. J Anim Ecol 69:896-902.

Grubisic M, Grunsven RHA, Kyba CCM, Manfrin A, Holker F (2018) Insect declines and agroecosystems: does light pollution matter? Annals of Applied Biology 173(2): 180-189.

Hajong SR, Varman AR (2002) A report on positive phototaxis exhibited by polymorphic forms of an aphid. Journal of Insect Behavior 15(2): 295-298.

Jones FH, Parks H (1928) The bagworms of Texas. Texas Agr Exp Sta Bull 382: 1-26.

Jones FM (1927) The mating of the Psychidae. Trans Amer Entomol Soc 53: 293-312.

Kaufmann T (1968) Observations on the Biology and Behavior of the evergreen bagworm moth, *Thyridopteryx ephemeraeformis* (Lepidoptera: Psychidae). Annals of the Entomological Society of America 61(1): 38-44.

Klun JA, Neal JW, Leonhardt BA, Schwarz M (1986) Suppression of female bagworm, *Thyridopteryx ephemeraeformis* reproduction potential with its sex pheromone, 1-methylbutyl decanoate. Entomol Exp Appl 40(3): 231-238.

Leonhardt BA, Neal JW Jr, Klun JA, Schwarz M, Plimmer JR (1983) An unusual lepidopteran sex pheromone system in the bagworm moth. Science 219: 314-316.

Neal JW Jr (1982) Significance of opposing abdominal tergal spine on the pupae of the bagworm, *Thyridopteryx ephemeraeformis* (Lepidoptera: Psychidae). J Kansas Entomol Soc 53: 605-616.

Park JH, Lee HS (2017) Phototactic behavioral response of agricultural insects and stored-product insects to light-emitting diodes (LEDs). Appl Biol Chem 60: 137-144.

Rao NBVC, Snehalatharani A, Ramanandam G, Maheswarappa HP (2016) Management of coconut slug caterpillar (*Macroplectra nararia*) with light traps. Journal of Plantation Crops 44(1): 57-61.

Rhainds M, Davis DR, Price PW (2009). Bionomics of bagworms (Lepidoptera: Psychidae). Annual Review of Entomology 54: 209-226.

Romoser WS (1973) The Science of Entomology, Macmillan, New York

Smolka J, Baird E, el Jundi B, Reber T, Byrne MJ, Dacke M (2016) Night sky orientation with diurnal and nocturnal eyes: dim-light adaptations are critical when the moon is out of sight. Anim Behav 111: 127-146.

Srivastva SK, Attri BL (2004) Bag worm (*Thyridopteryx ephemeraeformis* (Haworth)), an emerging pest in coastal agro ecosystem of Orissa. Insect Environment 10(2): 70-71.

Van Geffen KG, Van Grunsven RHA, Van Ruijven J et al (2014) Artificial light at night causes diapause inhibition and sex-specific life history changes in a moth. Ecol Evol 4:2082-2089.

Welbers AAMH, van Dis NE, Kolvoort AM, Ouyang J, Visser ME, Spoelstra K, Dominoni DM (2017) Artificial light at night reduces daily energy expenditure in breeding great tits (Parus major). Front Ecol Evol 5:20170530.

MS Received 18 April 2022
MS Accepted 01 May 2022

DOI: 10.55278/KNWC5805

Parasite on Asian rice gall midge - *Orseolia oryzae* (Wood-Mason) in light trap collection

A Sunny Rao[1,2], A.P. Padmakumari [1*]and Gajendra Chandrarkar[2]
[1]ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad, Telangana 500030 India.
[2] Indira Gandhi Krishi Vishwa Vidyalaya, Raipur, Chhattisgarh. 492012, India.
***Corresponding author: E mail: padmakumariento@gmail.com**

Adult rice gall midge, *Orseolia oryzae* (Wood mason) (Diptera: Cecidomyiidae) insects were collected from light traps during September 2021and brought to the laboratory. On observation it was found that many insects were dead. While observing the dead adults under a microscope, a peculiar structure was observed to be attached to the female adult on the ventral side. Further microscopic examination revealed that an organism was attached to the intersegmental area between the thorax and abdomen and was feeding on the adult gall fly (Fig1**).** We were not sure where and how the parasite had attacked the adult insect. It had devoured only the gall midge insect tissues but not the eggs which were in the abdomen. Two days after feeding it had detached itself from the host tissues. Since it was feeding from outside we presume it be an external parasite.

The parasite was observed to possess an oval shaped body having projections on the dorsal surface (Fig 2). On the ventral surface it had a longitudinal groove running from one end to another end (Fig 3) and possessed a mouth.

This is the first report. Perusal of available literature could not throw light on the external parasites of gall midge.

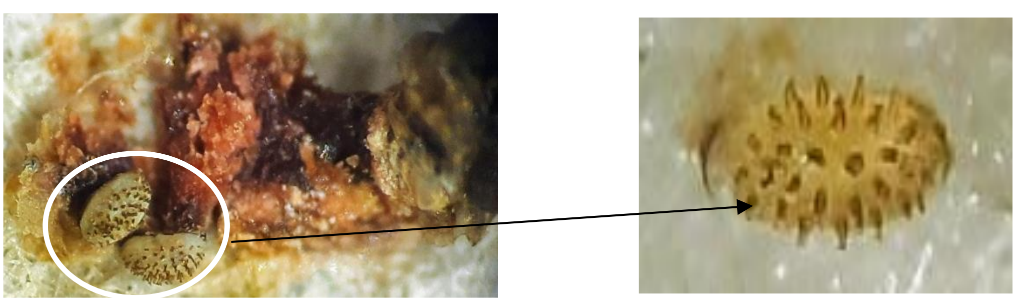


Fig. 1: Parasites feeding on the gall midge adult

Fig. 2: Dorsal view of the parasite.

Fig. 3: Ventral view of the parasite

MS Received 06 May 2022
MS Accepted 28 May 2022

DOI: 10.55278/PZHN7910

Foraging and influence of season on *Apis dorsata* in an urban garden

Anitha A Abraham
Department of Life Science, Bangalore University, Bangalore -560004, India.
Corresponding author: abrahamanitha@yahoo.com

The Asian honeybee *Apis dorsata* Fabricus (Apidae, Apinae) is known for its ecosystem service. Foraging is an important aspect of insect life. In the case of *A. dorsata*, searching for suitable floral resources is essential for the sustenance of the honeybee. This honeybee is an important crop pollinator known to visit several plants for its food source mainly nectar and pollen (Robinson, 2012). The honeybee is also found foraging on flowers in urban gardens.

An observational study was made in the year 2017-2018 at the nursery in Lalbagh Botanical garden (12.95°N 77.59°E) in Bangalore. The bee was observed from January to June in the garden. It visited many native and non-native plants in the garden. The foraging choices made by this bee are dependent on the seasonal availability of plant resources. It was observed that they visited a wide variety of plants from January to June. The flowers of the plants they foraged on were *Pentas lanceolate*, *Hibiscus rosa sinensis* (Anitha *et al*., 2017). It was seen foraging on *Nymphae* sp. They were seen foraging in large numbers during February and March. The seasonal availability of nectar and pollen was important in their foraging choices. Its body size and large hives demand high energy. Their foraging decisions are based on these factors. Many ornamental trees were foraged by *A. dorsata* during early summer like *Tabebuia argentea*, *Samanea saman*, and *Pongamia*. The abundance of floral resources seems to be a reason for higher foraging in summer and the seasonal availability of floral resources. Observations over a temporal scale showed floral fidelity in *A. dorsata*. This shows it can learn complex floral colors and odors of flowers of various plants ((Mogily *et al*., 2020). This ability enables them to forage on the same floral patch seasonally over a temporal scale.

Reference

Anitha A, A. Soumya, C.B. Subramanyam, M. & Verghese, A. 2017. *Pentas lanceolata* and H*ibiscus rosa sinensis* as bee flora for urban conservation of *Apis dorsata* (Fab.)(Hymenoptera: Apidae) Pest Management in Horticultural Ecosystems **23** (2), 138-141

Mogily, S. VijayKumar, M. Sethy, S.K. & Joseph, J. 2020. Characterization of the olfactory system of the giant honey bee, *Apis dorsata*. *Cell Tissue Res*,

379:131-145 doi: 10.1007/s00441-019-03078-8

Robinson, W. S. 2012. Migrating Giant Honey Bees (*Apis dorsata*) Congregate Annually at Stopover Site in Thailand. *PLOS ONE* doi/org/10.1371/journal.pone.0044976.

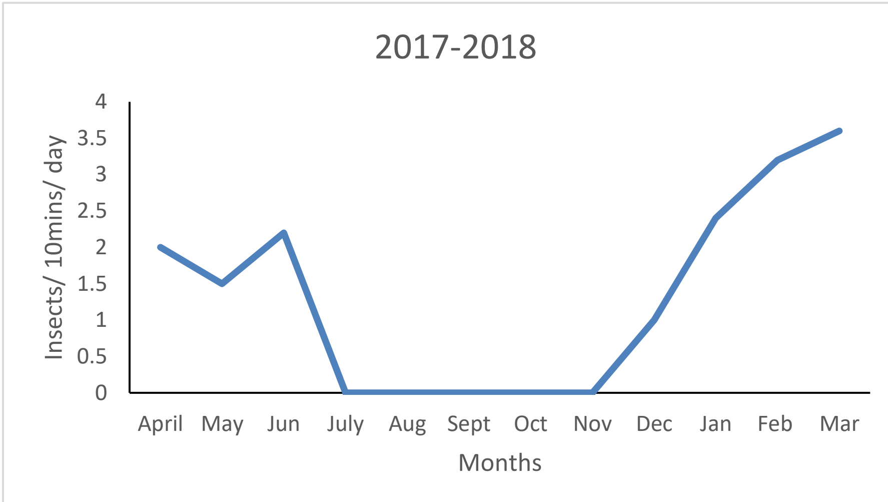


Fig 1: Population of *Apis dorsata* in the year 2017-2018

Fig 2: *Apis dorsata* on *Nymphae* sp, with hind leg showing pollen collected

MS Received 28 April 2022
MS Accepted 13 May 2022

DOI: 10.55278/IUOS6719

Diversity of silk production in insects

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**

Silk is one of the earliest natural fibres discovered by man. Silks are fibrous proteins containing highly repetitive sequences of amino acids stored in the animal as a liquid, and configure into fibres when sheared or spun at secretion (Craig, 1997). The cocoon silk of domesticated silkworm, *Bombyx mori* (Lepidoptera: Bombycidae) is prized over millennia for textiles, and most of our understanding about silk production is from this species. However, silk is known to occur in many arthropod classes, and a few molluscs and fishes also.

Fig 1: Spider silk

(Source: natural-japan.net)

Fig 2: Embioptera silk

(Source:https://smbasblog.com/2020/07/05/the-curious-webspinner-insect-knits-a-cozy-home-deep-look-video/)

Fig 3: Insect silk

(Source:https://uwm.edu/field-station/the-wonders-of-webs-ii-insect-silk/)

Among the class Insecta, 16 out of 30 orders produce silk for a variety of purposes, which include reproduction, shelter, protection from predators, *etc.* (Walker *et al*., 2012). Study conducted by Gurr and Fletcher (2011) revealed that the silk produced by Australian endemic leafhopper, *Kahaono montana* Evans (Cicadellidae: Typhlocybinae) provided protection from the lacewing predator, *Mallada signata* (Schneider) (Neuroptera: Chrysopidae).

In insects, silk is produced and stored in dedicated glands. On the basis of location, Sehnal and Akai (1990) classified silk glands into labial glands, Malpighian silk glands and dermal glands. Labial gland accounts for most silks and is the prominent feature in caterpillar and pupal biology of Lepidoptera. Antlions, mayflies and thrips produce silk from, their Malpighian glands whereas, some water beetles and lacewings synthesize silk from dermal glands.

Insect silks have high levels of amino acids like glycine, alanine and serine. The abundance of these amino acids is most likely due to their non-essential character and intermediate hydrophobicity. Insect silks are semi-crystalline materials whose structure differs from species to species in molecular organization. Hydrogen bonds within and between the structures contribute to the mechanical strength and stability of silk fibres. Accordingly, five different structures have been identified *viz.*, extended β-sheets, cross beta, α-helices, collagen helices and polyglycine-II (Rudall and Kenchington, 1971).

Fig. 7: Silk refuges produced by *K. montana*
(Source: Gurr and Fletcher, 2011)

Sutherland *et al*. (2007) identified a silk gene, *DFibroin* from highly expressed mRNA extracted from the prothoracic basitarsus of male hilarine flies (Diptera: Empididae). The silk gene from the basitarsi cDNA library matched an approximately 220 kDa protein from the silk-producing basitarsus. The hilarine silk protein is high in glycine and asparagine, and adopts an extended β-sheet conformation.

Fig 8: Silk produced by Hilarine fly
(Source: https://bugguide.net/node/view/1049683/bgimage)

Insect silk possesses extraordinary mechanical properties in terms of strength, extensibility and stiffness. The obvious example of the use for silk is cloth, which also takes up the highest proportion of silk consumption. Scientists from Khan Koen University, Thailand, invented a silk bicycle using silk with resin at one third the cost of carbon-fiber or aluminium frame. The silk frame can take fives time the pressure and eight times the tension of an aluminium frame. As the silk frame has 30 times more elasticity, it also serves as a natural shock absorber. The versatility and sustainability of silk-based materials attract its use in food packaging, medicine, automobile industry, dietary and cosmetic supplements, optics, art, craft, *etc.* (Huang *et al.*, 2018).

Though the term 'silk' encompasses a wide range of distinct materials, it is remarkable that certain features are common among silk production systems in insects. Today, insect silk has taken on new importance to society beyond fabric. Mechanically enhanced silk is expected to open up possibilities for numerous novel applications.

References

Craig, C. L. 1997. Evolution of arthropod silks. *Annu. Rev. Entomol.* 42: 231-267.

Gurr, G. M. and Fletcher, M. J. 2011. Silk production by the Australian endemic leafhopper *Kahaono montana* Evans (Cicadellidae: Typhlocybinae: Dikraneurini) provides protection from predators. *Aus. J. Entomol.* 50: 231-233.

Huang, W. H., Ling, S., Li, C., Omenetto, H. G., and Kaplan, D. L. 2018. Silkworm silk-based materials and devices generated using bio-nanotechnology. *Chem. Soc. Rev.* **47**: 6486-6504.

Rudall, K. M. and Kenchington, W. 1971. Arthropod silks: the problem of fibrous proteins in animal tissues. *Annu. Rev. Entomol.* 16: 73-96.

Sehnal, F. and Akai, H. 1990. Insect silk glands: their types, development and function, and effects of environmental factors and morphogenetic hormones on them. *Int. J. Insect Morphol. Embryol.* 19: 79-132.

Walker, A. A., Weisman, S., Kameda, T., and Sutherland, T. D. 2012. Natural templates for coiled-coil biomaterials from praying mantis egg-cases. *Biomacromolecules* 13: 4264-4272.Sutherland, T. D., Young, J. H., Sriskantha, A., Weisman, S., Okada, S., and Haritos, V. S. 2007. An independently evolved dipteran silk with features common to lepidopteran silks. *Insect Biochem. Mol. Biol.* 37(10): 1036-1043.

MS Received 20 April 2022
MS Accepted 05 May 2022

DOI: 10.55278/VKNO7046

Armoring maize from invasive fall armyworm

R. Beulah Bhakiya Sherlin, N. Balakrisnan and G. Ravi
Department of Agricultural Entomology, Agricultural College and Research Institute, Killikulam, Tuticorin (628252, India)
* ***Corresponding author: sherlinento@gmail.com***

Introduction

In India the invasive pest, maize fall armyworm (FAW) (*Spodoptera frugiperda* J. E. Smith; Noctuidae, Lepidoptera) was first recorded in May 2018 (Sharanabasappa *et al.*, 2018). It is the second most destructive agricultural pest, native to tropical and subtropical America (CABI, 2018). Due to its migratory behavior, high dispersal capacity and fast multiplication rate the pest spread quickly to many countries worldwide. The insect is capable of migrating 500 km to 1,000 km during its lifetime. Fall armyworm is a polyphagous pest, It is reported on 353 host plant that belongs to 76 plant families (Montezano *et al.*, 2018). Among them, maize is highly favorite host plant. Fall armyworm attacks the maize crop from the first week of germination till maturity and causes severe damage throughout the year. In maize it causes 70-100% yield loss (Acharya *et al.*, 2020). It also causes economic damage in other cereals and millets.

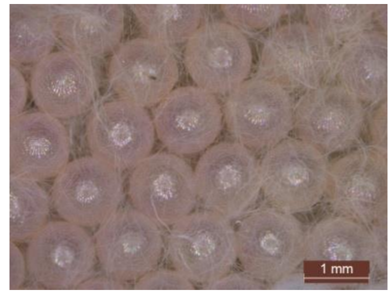
Life cycle

The life cycle (30 days) of the fall armyworm is mostly influenced by climatic factors. In hot climatic condition fall army worm undergoes 12 generation per year. Its life cycle comprises of eggs, larvae, pupae, and adult stages. Images of several life stages of FAW were collected from mass culture in our laboratory, AC&RI, Killikulam. As an egg laying substrate, nerium plants were used. The institute is located at an altitude of 40 metres above mean sea level, at 8^{o} 46' North Latitude and 77^{o} 42' East Latitude, in the Semi-Arid Tropics, with mean temperatures ranging from 21 to 37 degrees Celsius and an annual rainfall of 786 mm.

Egg

The female moth often deposits her egg masses on the under surface of the two to third leaves of seedlings or inner side of the tender central whorl. It lays egg masses in a single layer or a few layers (2-3 layers) and then covers them with scales. A single egg mass includes 100- 200 eggs. A female lays 1500 to 2000 eggs in her lifetime. The egg period lasts between 2 to 3 days.





Egg mass covered with scales

Egg mass



Eggs ready to hatch

Neonate emergence

Larva (Caterpillar)

The larval stage is the destructive stage on crop plants. After the egg hatches, masses of neonate start to disperse on leaf surface. The neonate used to be white in colour with black head. There are six larval instars. The larval group spread to the surrounding plants by hanging off from the silken thread secreted by them, due to ballooning effect caused by wind force larvae carried over to numerous plants from a single egg mass. Cannibalistic behavior has been documented from third instar, therefore from the third instar onwards each plant occupied by single larva rarely we can observe two larvae at different region of the same plant. The FAW larva can be easily identified by its morphological features such as 'Y' shape inverted pale marking on its head. On every segment of the larval body, there is a symmetrical distribution of dark black colour raised dots (2 dorsal pairs and lateral pairs). Each spot consist of single hair. The terminal segment has four dark dots that are distributed evenly and in a square form. The larval body has longitudinal pale and dark bands on the dorsal and lateral sides. Larval period is for 14 to 22 days.

First instar

Second instar

Third instar

Fourth instar

Fifth instar

Sixth instar

Larval stages

Pupa

The mature larvae forms earthen cocoon inside the soil at a depth of 2 to 8 cm. Sometimes it pupates within the plant itself. Pupa is reddish brown in color. The pupa measures 2-3 cm in length and 4.5 mm in width. During the summer, the pupal stage lasts for 7 to 13 days.

Adult

Similar to other noctuid moths it possess scaly wings with variegated colours such as black, light to dark brown, grey and straw colour. The forewing of male moth has different markings. The terminal end of the wing contains white inverted triangular marking. At one third portion of the forewing from thorax has golden yellow colour oval/ kidney shape marking. The female moths forewing is uniformly grey in colour. Adult moth is nocturnal, hiding under vegetation or inner side of the leaf whorl during the morning hours. The hind wing of both male and female moths used to be small and silvery in appearance. Female moths begin to lay eggs 3 to 4 days after mating (pre oviposition period). Moths can live for about 7-15 days.

Male moth

Female moth

Damage symptoms

- The first and second instar larvae feeds on leaf surface epidermal tissue by scrapping chlorophyll and makes the leaf surface papery in nature.
- The third to six instar larvae are voracious defoliator, they mainly feeds and damages the tender developing central whorl and makes small to big size holes, it also feeds on tassel and immature cob.
- Because of the damage to the unopened whorl, it makes parallel circular window holes and random irregular holes on leaves. The holes expands in size as the plant grows.
- Heavy whorl damage causes ragged, torn or shredded appearance to newly opened top most leaves.
- FAW infestation can be easily identifiable by the presence of mass larval dropping on leaf surface and central whorls.
- During vegetative stage, larvae hide inside the leaf whorl and causes whorl damage.At the time of tassel and cob emergence, larvae hide between stem and leaf base.
- Fall armyworm damage to tassel has an impact on pollination.
- Larvae affects the tip and inner side of the cob and feeds on developing kernels during milky stage, affecting seed development and reducing crop productivity and nutritional status.
- FAW infestation on maize cob invites secondary fungus infection, resulting in aflatoxins production, which reduces grain quality and quantity.

		
Leaf chlorophyll scraped by the neonates		Leaf holes
		
Whorl damage	Whorl covered by insect excreta	
		
Shredding of leaves	Tasel damage	Silk damage
		
Cob damage		
Crop damages		

Scouting: 'W' pattern of scouting from early seedling stage helps to find FAW

Economical Threshold Limit for FAW damage: 10% whorl and cob damage

Integrated fall armyworm management

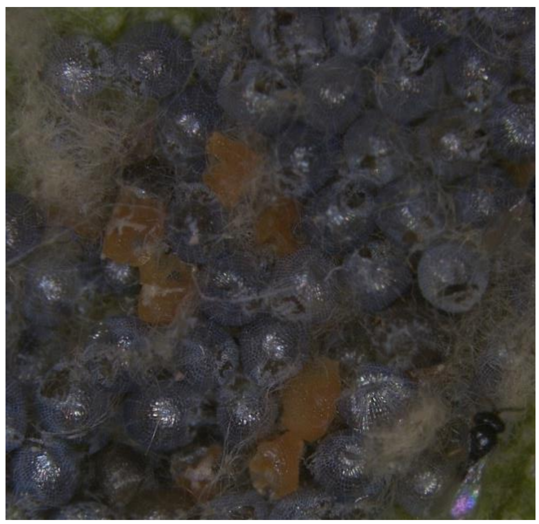
The Tamil Nadu Agricultural University has conducted a wide range of research and has recommended the following strategies to control the maize fall armyworm.

- Deep summer plouging to expose FAW pupa to predators and to kill by scorching sun.
- In the last ploughing, apply neem cake at the rate of 100 Kg / acre and plough well for providing pest resistance to plants.
- Avoid staggered sowing; timely and uniform sowing over large area reduces FAW insidence.
- Seed treatment: Seed treatment should be done with the mixture of Cyantroniliprol 19.8% and Thiamithoxam 19.8% FS at the rate of 4 ml per kg of maize seed. This will reduce the damage caused by fall armyworm as soon as the crop germinates.
- In irrigated condition, cowpea, sesame, sunflower and redgram should be cultivated as border crop, grow the fodder sorghum as in case of rainfed maize cultivation. Thus increasing the number of natural enemies.
- Installing sex pheromone traps at the rate of 5 traps per acre can be used to monitor the movement of fall army worm.
- Regular hand picking and destroying of FAW egg masses and larvae prevents severe damage.
- Augmentative release of egg parasitoid *Telenomus remus* @ 50,000 per acre based on pheromone trap catches prevents FAW multiplication.
- Crop spacing: Irrigated condition- 60x25 cm, Rainfed condition- 45x20 cm.
- Biopesticide such as *Metarhizium anisopliae, Nomuraraea rileyi, Beauveria bassiana* and *Bacillus thuringiensis* also controls fall armyworm growth and development.
- Recommended chemical pesticides only recommended pesticides should be used at the respective time. Doing so may reduce the insect resistance to the pesticides.
- Recommended insecticides should be sprayed at the recommended rate. The entire whorl region should be sprayed properly.

Crop age	**Recommended pesticides**	**Hand sprayer**	**Power sprayer**	**Pesticide Per acre**
15-20 Days after emergence	Chlorantraniliprole 18.5 SC	0.4 ml/lit	1.2 ml/lit	80 ml/acre
	Flubendiamide 480 SC	0.5 ml/lit	1.5 ml/lit	100 ml/acre
30-35 Days after emergence	Azadirachtin 1500 ppm (If necessary, when FAW damage crosses the ETL 10% level)	5 ml/lit	15 ml/lit	1 lit/acre
40-45 Days after emergence	Emamectin benzoate 5 SG	0.4 g/lit	1.2 g/lit	80 g/acre
	Spinetoram 11.7 SC	0.5 ml/lit	1.5 ml/lit	100 ml/acre
	Novaluraon 10 EC	1 ml/lit	3 ml/lit	200 ml/acre

- 60 DAE: Any one of the insecticides which is not sprayed previously, Emamectin benzoate 5 SG @ 0.4 g/lit or Spinetoram 11.7 SC @ 0.5 ml/lit or Novaluraon 10 EC @ 1ml /lit

Telenomus remus - egg parasite



FAW egg mass parasitized by *Telenomus remus*

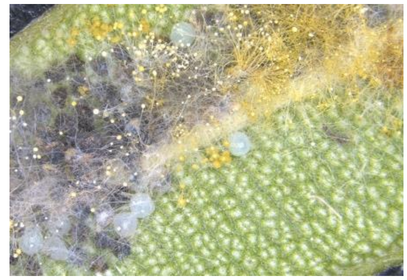
Pulses as border crop

Pheromone trap

Fall armyworm naturally infected by some beneficial microbes

Bt infected FAW larva

Metarhizium infected FAW larva



Fungus infected FAW egg mass

Note: Field photoes were taken from AC&RI, Killikulam research plot.

Acknowledgements:

We would like to acknowledge Government of Tamil Nadu -Sponsored Research Scheme on "Developing Integrated Pest Management Module for Maize Fall Armyworm and validation under Area wide Integrated Pest Management (AWIPM) through Farmer Participatory Approach in Tamil Nadu" (F36OT) for proviinge us this opportunity to work and gain knowledge about this invasive pest.

References

Acharya, S., Kaphle, S., Upadhayay, J., Pokhrel A. and Paudel, S. 2020. Damaging Nature of Fall Armyworm and Its Management Practices In Maize: A Review. *Tropical Agrobiodiversity (TRAB)*. 1(2): 82-85.

CABI. 2018. Invasives species compendium. URL: www.cabi.org/isc/fallarmyworm [accessed 2018 Aug 15].

Montezano, D.G., Specht, A., Sosa-Gómez, D.R., Roque-Specht, V.F., Sousa-Silva, J.C., Paula-Moraes, S.V., Peterson, J.A. and Hunt, T.E. 2018. Host plants of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in the Americas. *African Entomology*, 26, 286–301.

Sharanabasappa, Kalleshwaraswamy, C.M., Maruthi, M.S. and Pavithra, H.B. 2018. Biology of invasive fall army worm *Spodoptera frugiperda* (JE Smith) (Lepidoptera: Noctuidae) on maize. *Indian journal of entomology*. 80(3): 540-543.

MS Received 16 April 2022
MS Accepted 29 April 2022

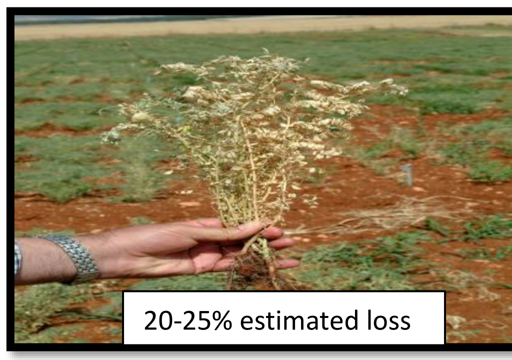

TANISHA LOGISTICS
R R NAGAR
BANGALORE 560098
FOR IMPORT AND EXPORT
RELATED QUERIES
Contact us
SANTHOSH KUMAR T.R
PROPRIETOR
Mobile: 98454 71273

DOI: 10.55278/CSVG8009

Molecular approach towards resistance to chickpea pod borer : *Helicoverpa armigera*

Smitha S.
Department of Plant Biotechnology
University of Agricultural Sciences, GKVK, Bengaluru-560065 Karnataka, India
***Corresponding author: smithaswathickm@gmail.com**

Chickpea (*Cicer arietinum* L.) is a rabi season legume crop and third most extensively cultivated pulse crop globally. *Helicoverpa armigera* is considered as one of the most devastating key pest severely affecting chickpea, due to its high rate of reproduction with short life span (Kumar and Singh, 2014). It is a vigorously feeding, polyphagous pest and is also called as corn ear worm, American cotton boll worm, tobacco bud worm, fruit borer of tomato, carnation worm *etc*. The prime reason for the lower yield of chickpea is infestation by pod borer (*Helicoverpa armigera*) from the vegetative phase to pod formation period (Dhingra *et al*., 2003). Single larva of the *Helicoverpa* damages 30-40 pods prior to its maturity. Yearly pod damage caused by *Helicoverpa* alone is about 150 to 200 million tonnes. With the predictable yield loss only due to gram pod borer is 10-90 per cent.



Even though efforts have been made towards developing resistant genotypes through conventional method, especially conferring pod borer resistance it has not been successful up to requisite level due to the lack of genetic resource conferring resistance to chickpea pod borer. This is the similar case in cotton boll worm also where successfully genetic engineering was used to transfer genes from bacteria, *Bacillus thurengiensis* known to produce proteins toxic to *Helicoverpa armigera*. Now, in the world more than 95 per cent of the commercial cotton growing area is covered with genetically modified cotton, called as *Bt* cotton, resistant to boll worms. Similar efforts have been made in chickpea at Assam Agricultural University, Jorhat.

Although the potential productivity of chickpea has been scientifically or experimentally proved to be 20 – 22 quintals per hectare, farmers are harvesting only 5 – 10 quintals per hectare. This low and variable productivity level of chickpea in farmers' field is due to loss of crop because of incidence of pod borer and *Fusarium* wilt disease. If these two biotic stresses are not managed, then the extent of loss will be 80 – 90 per cent. To decrease the cost of cultivation and reducing environmental pollution by limiting the application of pesticides and fungicides to manage these two biotic stress problems, developing genotypes tolerant or resistant to pod borer (*Helioverpa armigera*) and *Fusarium* wilt (*Fusarium oxysporum* f. sp. *ciceri*) is the best alternate option.

Thus it was planned to introgress pod borer and *Fusarium* wilt resistance in Chickpea by involving *Bt* event of Chickpea (Acharjee *et al.*, 2010) and wilt resistant Super Annigeri-1 genotypes by using Simple Sequence Repeats (SSR markers for screening specific to SA-1).

An overview of experimental site

Hybridization experiment was conducted at transgenic green house during rabi season, when donor parents (Bt events having Cry genes resistance to pod borer pest) and recipient parent (Super Annigeri-1) were sown. Crossing for artificial hybridization was carried out using recipient parent as female parent. F_1 seeds obtained from these crosses were harvested. The harvested F_1 seeds were sown in pots during late kharif season then checked for the presence of Cry genes in the hybrids.

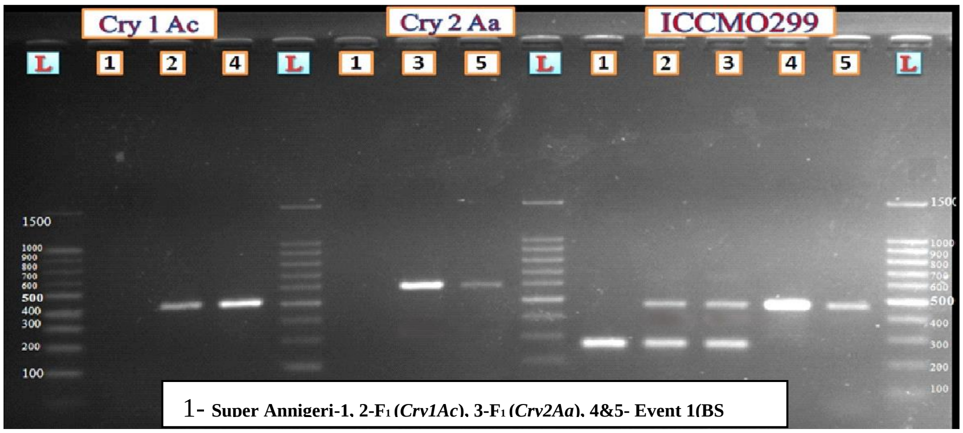
The genomic DNA was extracted from young leaves of 20 days old seedlings of both parents and hybrids using CTAB method and quality of DNA for each sample was assessed on agarose gel. DNA amplification was carried out using pair of 177 SSR primers developed by Nayak *et al*. (2010) in polymerase chain reaction (PCR). Whereas, *Cry* genes specific markers namely *Cry1Ac* and *Cry2Aa* were also involved in the study in order to confirm the presence of cry genes in hybrids. The hybridity of F1 plants was confirmed when they showed presence of both male and female parent alleles with the help of parental polymorphic markers along with cry gene specific markers.

Donor parents (1 and 2) having cry genes resistance to pod borer pest, recipient parent Super annigeri-1

F_1 hybrid plant crossed between Super annigeri-1 × Bt event BS 100B (having cry gene resistance to pod borer)

The presence of both the parental alleles in hybrid plants confirmed their origin from the two parents used in the present study, as well as genuineness of hybrid plants. Plants were confirmed as true hybrids on the basis of amplification pattern of SSR marker. Results of the present study are in agreement with the conclusions of Hipi *et al.,* (2013) in maize. Sharma *et al*. (2018) confirmed the hybridity of Indian mustard (*Brassica juncea* L.) using SSR markers. Out of 20 random SSR primers used for the screening of parental polymorphism, 5 primers were found polymorphic. BR_A04_9627743 and

BR_A01_13393871 were identified as the specific markers for parents RSPR-01 and Donskaja-IV which enable to distinguish and identify hybrid form their parental lines.



Confirmation of true F_1 using gene specific primers (cry genes)

F_1 hybrid was confirmed with both donor gene and recipient gene through one of the parental polymorphic marker ICCM0299

This study showed that SSR markers are more reliable and robust for assessing genetic purity as compared to morphological marker. The results of study are expected to be useful in the verification of genetic purity of hybrid seeds in chickpea accurately. Identified polymorphic markers between parents are good source for recovering recurrent parent genome in early backcross generations.

References

Acharjee, S., Sarmah, B. K., Kumar, P. A., Olsen, K., Mohan, R., Moar, W. J., Moore, A. and Higgins, T. J. V., 2010, Transgenic chickpeas (*Cicer arietinum* L.) expressing a sequence-modified *cry2Aa* gene. *Plant Sci*., 178: 333-339.

Nayak, S. N., Varshney, R. K. and Kishor, P. B. K., 2010, Identification of QTLs and genes for drought tolerance using linkage mapping and association mapping approaches in chickpea (*Cicer arietinum*), Phd thesis, Osmania University, Hyderabad, 85-110.

Sharma, M., Dolkar, D., Salgotra, R. K., Sharma, D., Punya, Singh, A. and Gupta, S. K., 2018, Molecular marker assisted confirmation of hybridity in Indian mustard (*Brassica juncea* L.). *Int. J. Curr. Microbiol. App. Sci*., 7(9): 894-900.

Kumar, J. and Singh, S. K., 2014, Insect pests and diseases dynamics in chickpea (*Cicer arietinum* L.). *The Ecoscan,* 6: 217-220.

Dhingra, S., Kodandaram, R. S., Hegde, S. and Srivastava, C., 2003, Evaluation of different insecticide mixture against third instar larvae of *Helicoverpa armigera*. *Ann. Plant Prot. Sci.*, 11: 274-276.

Hipi A, Surahman M, Ilyas S and Giyanto, 2013, Seed genetic purity assessment of maize hybrid using microsatellite markers. *International Journal of Applied Science and Technology,* 3(5): 66-71.

MS Received 15 April 2022
MS Accepted 30 April 2022

DOI: 10.55278/ZWFL5947

Insect Navigation - en route to the goal

Kattumulla Tejaswee and Ranjith M. T.
Department of Agricultural Entomology
Kerala Agricultural University, College of Agriculture, Vellanikkara 680656, Thrissur, kerala
Corresponding author: tejasweekattumulla@gmail.com

Insect navigation refers to the ability of insects to find their way accurately to a specific location. Insects, just like many other moving animals, have evolved navigational abilities to move around their environment accurately and to exploit the resources available (Schultheiss et al., 2015). The three major navigational strategies recognized primarily in social insects are route following/visual piloting, path integration and map like spatial distribution.

Route following is the most straight forward mode of navigation found in the majority of ants, bees and termites, which follow a pheromone trail deposited on the surface by a conspecific and do not require previous knowledge on the path (Wolf, 2011). Similarly, they also employ terrestrial objects as navigational landmarks (Collett, 1996).

Path integration sums the vectors of distance and direction travelled from a starting point to calculate the current position and, thus, the path back to the start. Social insects such as bees, wasps and ants **employ different inputs like odometry, compass and optical flow to find their target in this strategy. In odometry, the insect calculates the distance travelled based on the number of steps taken to reach the target site. The compass input, on the other hand, includes celestial cues such as the sun, moon, magnetic field, and wind direction**. The honey bee uses sunlight to find food and communicate this information to other members of the hive through various dances and Karl von Frisch was awarded the Nobel Prize in Physiology and Medicine in 1973 for deciphering the bee dance. Fleishmann et al. (2018) demonstrated that in ants, a geomagnetic compass cue is both necessary and sufficient for accomplishing a well defined navigational task. Many insects use optic flow to measure the distance of objects from themselves based on the velocity of movements relative to nearby objects.

The assembly of landmarks, local and global, vectors into a two-dimensional spatial arrangement that yields a true map (mental map) in bees. Though location and mode of memory storage of maps remain elusive, the central complex of the brain in insects is considered to plays a vital role in forming the mental map (Menzel *et al*., 2005).

Insect navigation plays a significant role in insect survival such as to chart food bound routes, locate mate and ovipositional site, survive under adverse conditions, communicate among nestmates and escape from the predatory pressure (Cohen, 2019)). The basic information about navigational strategies in insect pests also helps to employ different pest management tactics such as trap crops, light traps, pheromone traps and repellents. Integrated Vector Management (IVM) programme proposed by WHO in 2020 uses semiochemicals to redirect the movement of mosquitoes from human habitation (Woodling et al., 2020). The navigational strategies in insects are also employed in modelling of robots used in surveillance programmes (Lambrinos *et al*., 2000).

The basic strategies of insect navigation is well explicitly studied in social insects, but their importance in the host plant selection process needs to be explored in detail. Though the navigational strategies in insects are employed in various fields, it is imperative to have a multi-dimensional understanding of navigation in insect pests to formulate various strategies to minimize their incidence.

References

Cohen, Y. 2019. Navigation towards the source through chemosensory strategies and mechanisms. Oxford Res. Encyclopedia of Neurosci. [e-journal]. Available: https://oxfordre.com/neuroscience/view/10.1093/acrefore/9780190264086.001.0001/acrefore-9780190264086-e-315. [31 Oct. 2021].

Collett, T. S. and Zeil, J. 1996. Flights of learning. Curr. Dir. Phsycol. Sci. 5: 149- 155.

Fleischmann, P. N., Grob, R., Muller, V. L., Wehner, R. and Rossler, W. 2018. The geomagnetic field is a compass cue in *Cataglyphis* ant navigation. Curr. Biol. 28(9): 1440-1444.

Lambrinos, D., Moller, R., Labhart, R., Pfeifer, R. and Wehner, R. 2000. A mobile robot employing insect strategies for navigation. Robotics Autonomous Syst. 30: 39-64.

Menzel, R., Greggers, U., Smith, A., Berger, S., Brandt. R., Brunke, S., Bundrock, G., Hulse, S., Plumpe, T. and Schaupp, F. 2005. Honey bees navigate according to a map-like spatial memory. Proc. Natl Acad. Sci. USA, 102: 3040-3045.

Schultheiss, P., Cheng, K., and Reynolds, A. M. 2015. Searching behavior in social Hymenoptera. Learn. Motiv. 50: 59–67.

Wolf, H. 2011. Odometry and insect navigation J. Exp. Biol. 214 (10): 1629-1641.

Wooding, M., Naude, Y., and Rohwer, E. 2020. Controlling mosquitoes with semiochemicals: a review. Parasites Vectors 13: 1-20.

DOI: 10.55278/VSNP3781

Observations on the Indian Wax Scale on *Michelia champaka* avenue trees in Bengaluru

Chetan S, Allan Britto and Jayashankar M*
Department of Zoology, School of Life Sciences,
St. Joseph's College (Autonomous), Bengaluru-560027, Karnataka, India
Corresponding author: jayashankar.m@sjc.ac.in

The Indian wax scale, *Ceroplates ceriferus* (Fabricus) (Homoptera: Coccidae) an invasive polyphagous pest of economic importance to many ornamentals is a soft scale insect with a characteristic thick wax test covering the body of the adult female (https://www.cabi.org/isc/datasheet/12342).
Infestations weaken the infested plants, with reduced growth; also deposits of honeydew from these sucking pests enable sooty mold growth hampering growth of plants. Observations on the incidence *C. ceriferus* (Fabricus) on *Michelia champaka* (Linneus) avenue trees on the Museum Road, Bengaluru was undertaken during April 2022. The method used in the current survey involved manual counting. The scales present at different heights on each tree were counted. The data is restricted to 14 feet height of the trees considering the visual feasibility. Of the 32 trees observed, 21 had the presence of the scale insect and a *Terminalia catappa* tree adjacent to the *M. champaka* had the scale (Figs. 1 & 2). The wax scales were observed on the branches compared to the main stem. The trees infested by a large number of scale insects were observed to be malnourished, with thinning of branches. It was also noticed that the plant part where the wax scales were most prevalent was in the height range of 6-8 feet (Fig. 3). Proper care in terms of monitoring the spread and impact of the pest needs to be initiated.

Fig. 1: Indian wax scale (Star stage) infestation on *M. champaka* in the location

Fig. 2: Spread of wax scale from *M. champaka* to adjacent *T. catappa*

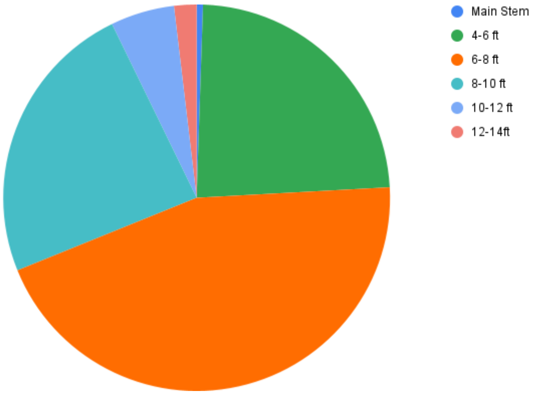


Fig. 3: Graph showing wax scales at different heights

Reference

https://www.cabi.org/isc/datasheet/12342

MS Received 18 May 2022
MS Accepted 28 May 2022

INSECT LENS

Leaf rolling weevil, Parapoderus submarginatus (Coleoptera: Attelabidae)

Parapoderus submarginatus are small beetles of size 2-8 mm and easily recognisable by their square elytra, that does not cover the last abdominal segment. They are slow moving, but good flyers. Adults feed on leaves and buds and they develop either in leaf rolls or leaf mines, stems or flower heads.

Author: Dr. *Sevgan Subramanian, International Centre of Insect Physiology and Ecology, Kenya*

Location: *Karura Forest, Nairobi, Kenya.*

Email:*ssubramania@icipe.org*

Mud wasp (Hymenoptera)

Here wasp is bringing a caterpillar for its progeny as mass provisional feeding behaviour.

Author: *Dr. Thirupam Reddy B., Scientist-B, Basic Seed Multiplication and Training Centre, Central Silk Board, Kharsawan*

Location: *Basic Seed Multiplication and Training Centre, Central Silk Board, Kharsawan Jharkhand, India*

Email: *entomophily@gmail.com*

Leaf webber, Eretmocera impactella (Scythrididae: Lepidoptera)

Leaf webber is sporadic pest of various Amaranthaceae and other food plants distributed in the Indian subcontinent. Caterpillars web leaves with white silken threads and remain hidden in folds feeding from inside.

Author: Dr. D N Nagaraj,

Location: *Bengaluru,Karnataka, India*

Email: nasoteya@yahoo.co.in

Fulgorid Bug (Fulgoridae: Hemiptera)

The family Fulgoridae is a large group of hemipteran insects, sometimes referred to as lanternflies or lanthorn flies, though they do not emit light.

Author: *Dr. Thirupam Reddy B., Scientist-B, Basic Seed Multiplication and Training Centre, Central Silk Board, Kharsawan*

Location: *Basic Seed Multiplication and Training Centre, Central Silk Board, Kharsawan, Jharkhand, India*

Email: *entomophily@gmail.com*

Cuckoo wasp, Chrysis angolensis (Chrysididae: Hymenoptera)

Like the cuckoo bird, cuckoo wasps will infiltrate the nests of other wasps and bees and lay their eggs alongside their hosts' offspring. Once these eggs hatch, the young cuckoo wasp's larvae will feed on food stored in the nest for the host's offspring, such as a paralysed spider or caterpillar.

Author: *Dr. Thirupam Reddy B., Scientist-B, Basic Seed Multiplication and Training Centre, Central Silk Board, Kharsawan, Jharkhand, India*

Location: *Basic Seed Multiplication and Training Centre, Central Silk Board, Kharsawan*

Email: entomophily@gmail.com

Giant scales

Monophlebids (Monophlebidae: Hemiptera)

Monophlebids is a family of scale insects commonly known as the giant scales or monophlebids. They occur in most parts of the world but more genera are found in the tropics than elsewhere.

Author: *Dr. Thirupam Reddy B., Scientist-B, Basic Seed Multiplication and Training Centre, Central Silk Board, Kharsawan, Jharkhand, India*

Location: *Basic Seed Multiplication and Training Centre, Central Silk Board, Kharsawan*

Email: *entomophily@gmail.com*

Oleander hawk moth, Daphnis nerii (Sphingidae: Lepidoptera)

Oleander hawk moth was basking in the sun on turmeric leaf stalks. Its larvae are notably green with blue eyespots, often seen munching on nerium leaves.

***Author:* Dr.** *B. Sailaja Jayasekharan, Scientist, ICAR-CTRI, Rajahmundry, Andhra Pradesh.*

Location: *ICAR-Central Tobacco Research Institute, Rajahmundry, Andhra Pradesh.*

Email: *sailaja8489@gmail.com*

Red lanternfly, Kalidasa lantana (Fulgoridae: Hemiptera)

The red lanternfly is identified by a slender and flexible stalk-like outgrowth arising from above the tip of its snout.

Author: *Dr. Thirupam Reddy B., Scientist-B, Basic Seed Multiplication and Training Centre, Central Silk Board, Kharsawan*

Location: *Basic Seed Multiplication and Training Centre, Central Silk Board, Kharsawan Jharkhand, India*

Email: *entomophily@gmail.com*

Red spider mite: Tetranychus sp. (Tetranychidae: Acari)

The red spider mites (Tetranychus sp.) spin the three-dimensional webs to protect themselves from biotic and abiotic factors and it is called as 'ballooning'. This mechanism also aids in their dispersal from plant to plant. The host plant is garden pea, Pisum sativum.

Author*: Dr. Abhishek Shukla, Senior Acarologist, Department of Entomology, Navsari Agricultural University, Navsari, Gujarat, India.*

Location*: Eru Char Rasta, Navsari, Gujarat, India.*

Email*: abhishekshukla@nau.in*

Gynandromorph of tasar silk moth, Antheraea mylitta (Saturniidae: Lepidoptera)

In the environment, gynandromorphphenomenon is very rare. Here in the Tasar silk moth, left side represents female (gyn) characters whereas, male (andro) characters in the right side. Gynandromorphy is thought to occur when female egg cells develop with two nuclei- so that one nucleus contains a single Z chromosome and the other contains a single W.

Author: *Dr. Thirupam Reddy B., Scientist-B, Basic Seed Multiplication and Training Centre, Central Silk Board, Kharsawan, Jharkhand, India*

Location: *Basic Seed Multiplication and Training Centre, , Central Silk Board, Kharsawan*

Email: *entomophily@gmail.com*

Rock bee, Apis dorsata (Apidae: Hymenoptera)

Apis dorsata is one of the most dangerous animals of the south east Asian jungles due to their threatening defensive behaviours. However, the bees are not managed for pollination, many crops throughout southern Asia depend on rock beesfor pollination viz., cotton, mango, coconut, coffee, pepper, star fruit, and macadamia.

Author: *Dr. M. Mathialagan, Assistant Professor (Agrl. Entomology), Sethu Bhaskara Agricultural College and Research Foundation, Karaikudi, Tamil Nadu, India.*

Location: *Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India.*

Email: *mathialagan08637@gmail.com*

Indian common club-tail dragonfly, Ictinogomphus rapax (Gomphidae: Odonata)

Indian common club-tail dragonfly usually perches on a bare twig facing the water, commonly found in ponds, tanks and rivers. It breeds in running and still water.

Author: *Dr. M. Mathialagan, Assistant Professor (Agrl. Entomology), Sethu Bhaskara Agricultural College and Research Foundation, Karaikudi, Tamil Nadu, India.*

Location: *Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India.*

Email: *mathialagan08637@gmail.com*

The African Fig fly (AFF), Zaprionus indianus (Drosophillidae: Diptera)

Z. indianus is considered as cosmopolitan and measures approximately 2.5 to 3.0 mm with red eyes. Z. indianus is a generalist that breeds on fallen fruit and fruit on the tree, but does not attack unripe and undamaged fruits.

Author: Dr. *Sevgan Subramanian, International Centre of Insect Physiology and Ecology, Kenya*

Location: *Parklands, Nairobi, Kenya*

Email: *ssubramania@icipe.org*

Blister beetle, Mylabris pustulata (Meloidae: Coleoptera)

The beetle gets its name from its defensive secretion of Cantharidin, a blistering agent used in the treatment of warts, unwanted tattoos and the papules of Molluscum Contagiosum.

Author: *Dr. M. Mathialagan, Assistant Professor (Agrl. Entomology), Sethu Bhaskara Agricultural College and Research Foundation, Karaikudi, Tamil Nadu, India.*

Location: *Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India.*

Email: *mathialagan08637@gmail.com*

Stalked eggs of Green Lace wing, Chrysoperla carnea

Single female of lace wing can produce 100–200 eggs. Eggs are laid on plants, usually near where aphids are present in more numbers. Each egg is hung on a slender stalk about 1 cm long, usually on the underside of a leaf. Eggs are distributed as they are highly aggressive and cannibalistic. Gardeners can attract these lacewings by growing companion plants viz., calliopsis (Coreopsis), cosmos (Cosmos), sunflowers (Helianthus)and dandelion (Taraxacum) dill (Anethum) and angelica (Angelica).

Author: *D. Guruva Reddy*

Location: *Nalgonda, Telangana, India.*

Email: *guruvareddy.d@gmail.com*

Brinjal Epilachna beetle, Henosepilachna vigintioctopunctata (Coleoptera: Coccinellidae)

*Henosepilachna vigintioctopunctata is commonly known as the 28-spotted potato ladybird*https://en.wikipedia.org/wiki/Henosepilachna_vigintioctopunctata - cite_note-1 *or the Hadda beetle. It feeds on the foliage of potatoes and other solanaceous crops. The larvae and adults feed on the leaves by scraping the leaf cuticle, reducing the leaf surface by skeletonising the surface area, resulting in russet browning of the leaves.*

Author: Author: *D. Guruva Reddy*

***Location**: Narsapur of Medak, Telangana, India.*

***Email:** guruvareddy.d@gmail.com*

Leaf mining buprestid beetle, Trachys sp. (Buprestidae: Coleoptera)

'Trachys sp. is a beetle of the small size of 3 to 3.5 milli meters. The tiny jewel beetle mines host leaves as a larva, creating large blotches. The female lays eggs on the leaves of deciduous trees, especially elm. The larvae eat the green tissue between the upper and lower layer of the leaves making cavities called mines.

Author: Dr. Thirupam Reddy B., Scientist-B, Basic Seed Multiplication and Training Centre, Central Silk Board, Kharsawan

Location: Basic Seed Multiplication and Training Centre, Central Silk Board, Kharsawan

Email: entomophily@gmail.com

Red-tailed spider wasp, Tachypompilus analis (Pompilidae: Hymenoptera)

Red-tailed spider wasp found in most of tropical and subtropical partsof Asia. They prey on spiders from the families Sparassidae, Agelenidae, and Amaurobiidae.

Author: *Dr. Thirupam Reddy B., Scientist-B, Basic Seed Multiplication and Training Centre, Central Silk Board, Kharsawan*

Location: *Basic Seed Multiplication and Training Centre, Central Silk Board, Kharsawan*

Email: *entomophily@gmail.com*

Crimson Marsh Glider, Trithemis aurora (Libellulidae: Odonata)

A very common dragonfly, yet beautiful in every way is Trithemis aurora.They are widely distributed species and found throughout the year across the Indiansubcontinent and Southeast Asia. Common habitat of this marsh glider are weedy tanks and ponds, marshes, channels, and slow flowing streams and rivers in the lowlands and mid-hills.

Author: Dr. *Rushikesh Rajendra Sankpal, Dept. of Environmental Sciences, Savitribai Phule Pune University, Pune, Maharashtra, India.*

Location: *Warananagar, Kolhapur, Maharashtra, India.*

Email address: *prof.sankpal@gmail.com*

Varroa Mite, Varroa jacobsoni (Varroidae: Acari)

Varroa mite is a natural ecto-parasite of honeybee, Apis cerana. However, after having recently jumped from its natural host to the European honeybee, Apis mellifera and has emerged as a potential serious pest causing bee colony losses.

Author: *Dr. M. Mathialagan, Assistant Professor (Agrl. Entomology), Sethu Bhaskara Agricultural College and Research Foundation, Karaikudi, Tamil Nadu, India.*

Location: *Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India.*

Email: *mathialagan08637@gmail.com*

Rock Bee, Apis dorsata (Apidae: Hymenoptera)

Apis dorsata build a single, large and exposed comb under tree branches or under cliffs, instead of in cavities. They form dense aggregations at one nesting site, sometimes with up to 200colonies in one tree.Each colony can have up to 100,000 bees and is separated by only a few centimetres from the other colonies in an aggregation.

Author: *Dr. P. Roopa Sowjanya, Scientist (Genetics and Plant Breeding)*

Location: *Hiraj Research Farm, ICAR –NRC on Pomegranate, Solapur, Maharashtra, India.*

Email: *2010rupasowjanya@gmail.com*

***Mango Stem Borer, Batocera rufomaculata* (*Cerambycidae: Coleoptera*)**

Mango Stem Borer is a serious pest of fig, mango, guava, jackfruit, pomegranate and walnut in different parts of the world. Infestation may lead to yield losses and even to the death of trees. Most damage is caused by the larvae that initially bore in the tree's sub-cortex and later move deeper into the tree.

Author: *Dr. P. Roopa Sowjanya, Scientist (Genetics and Plant Breeding)*

Location: *Hiraj Research Farm, ICAR –NRC on Pomegranate, Solapur, Maharashtra, India.*

Email: *2010rupasowjanya@gmail.com*

Larva of Fruit Sucking Moth Eudocimaphalonia (Erebidae: Lepidoptera)

The adult is an agricultural pest feed on many fruit crops by piercing its proboscis into fruits and sucks the juice. The larvae tend to feed on foliage of wild host plants of the family Menispermaceae and Fabaceae.

Author: *Dr. M. Mathialagan, Assistant Professor (Agrl. Entomology), Sethu Bhaskara Agricultural College and Research Foundation, Karaikudi, Tamil Nadu, India.*

Location: *Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India.*

Email: *mathialagan08637@gmail.com*

Blister beetle, Mylabris pustulata **Thunberg** ***(Meloidae:Coleoptera)***

Blister beetle, as the name are known for their defensive secretion of blistering agent, cantharidin, used in folk medicine as vesicant for treating warts.

Author: *Dr. Ranjith M, Regional Central Integrated Pest Management Centre, Bangalore*

Location: *Vikramangalam, Madurai district, Tamil Nadu*

E-mail: *entoranjith@gmail.com*

Obituary

Dr Balwinder Singh (01/06/1956- 29/05/2022)

The entomology fraternity mourns the demise of India's pesticide residue and biosafety expert

Dr Balwinder Singh, an eminent entomologist (insect toxicologist) who made notable contributions to Punjab agriculture and especially Punjab Agricultural University (PAU), Ludhiana passed away on May 29, 2022. Dr Balwinder Singh was a bright student, an outstanding teacher, a distinguished researcher in the field of pesticide residue analysis and biosafety, an inspiring mentor, an able administrator, and an academician with impeccable credentials.

Dr Balwinder Singh was born in the village Behman Jassa Singh, Tehsil Talwandi Sabo, District Bathinda, Punjab on 1st June 1956 in a traditional farming family. After graduation from Punjabi University, Patiala in 1975, he moved to the Punjab Agricultural University, Ludhiana. He distinguished himself during his Master's (1978) and Doctorate (1984) programmes in Entomology under the watchful eyes of his major advisor and renowned insect toxicologist, Dr R.L. Kalra. Starting as a research associate in 1979, he moved up to become the Senior Residue Analyst in 1998. He was largely instrumental in upgrading the Pesticide Residue Analysis Laboratory with the latest modern analytical instruments to set up a 'Centre of Excellence in Pesticide Residues' at PAU, Ludhiana. The laboratory was the first such laboratory at any State Agricultural University (SAU) to be accredited by the NABL. The laboratory is acting as a 'core laboratory' under the Central Sector Scheme, 'Monitoring of Pesticide Residue Analysis at National Level' and as a 'referral laboratory' under the 'All India Network Project on Pesticide Residues'. Besides, the laboratory is engaged in providing regular training to the participating laboratories. He continued to head the laboratory till 2014.

Dr Singh was elevated to the position of the Head of the department of entomology in August 2011 and Director of Research, PAU, Ludhiana in October 2014. He distinguished himself in both these positions. After his superannuation at the end of May 2016, he joined as Consultant, Monitoring of Pesticide Residues at the National Level, Ministry of Agriculture and Farmers Welfare, Government of India and continued in this position till his sad and untimely demise.

Dr Singh contributed 40 recommendations in the university Package of Practices, 91 research papers in international journals and 70 in national journals besides 6 books. He was conferred Fellowship by the Indian Society for the Advancement of Insect Science and was Vice president, of the Society of Pesticide Science India and President of the Indian Society for the Advancement of Insect Science.

Dr Singh was a Member-FAD-14, Pesticide Residue Committee, Bureau of Indian Standards, New Delhi; Member-Food Safety Panel, BIS, New Delhi; Member Secretary-Committee constituted by Govt. of India to shortlist NABL accredited private laboratories for pesticide residue analysis in food and Member-Task force constituted by Ministry of Agriculture under the project "Monitoring of Pesticide Residues at National Level. He was also a member of the Board of Management of PAU, Ludhiana.

Dr Balwinder Singh is survived by his wife, Mrs Rupinder Kaur, daughter Sonia and son Gagandeep. With his sudden demise, the country has lost an esteemed teacher/ scientist/mentor, administrator, and a wonderful human being.

Dr Manmeet B. Bhullar
Department of Entomology
Punjab Agricultural University
Ludhiana-141004

Dr Ramesh Arora
Faculty of Agriculture
Sri Guru Granth Sahib World University
Fatehgarh Sahib-140407

Dr Balwinder Singh was an outstanding scientist and always had very pleasing manners. As a close friend I will miss him. Condolences from INSECT ENVIRONMENT to his family members.

–Abraham Verghese.

From L to R: Dr Balwinder Singh, Dr BS Dhillon, Dr SP Bhardwaj and Dr HC Sharma, at the 4th Congress on Insect Science, April 16, 2015, PAU, Ludhiana

From L to R: Dr PK Chakrabarty, Dr KK Sharma, Sh. UK Singh, Dr Balwinder Singh and Dr BS Dhillon at the Annual workshop on monitoring of pesticide residues at national level, May 25, 2016, PAU, Ludhiana