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FEATURING

Tête-à-Tête with Dr. Jagbir Singh Kirti

Women in Entomology: Dr. Purnima Das

INDIAN ENTOMOLOGIST

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*Cover page image: Ms. Amrutha V. M (Photo taken at Mallapuram, Kerala,) showing close up shot of robber fly.

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EDITORIAL

It is always a pleasure to pen an editorial for the Indian Entomologist steered by the most hardworking and ingenious team of active and young entomologists. Indian Entomologist is the hallmark of "young entomology" of India, being successfully accomplished in the last few years with absolute passion, and wonderful themes which are current and the most upcoming.

I believe and be delighted that it will be better to make a choice- that this time the editorial shall introspect how the young entomologists are performing in India in its Entomology bastions in the State Agricultural Universities (SAUs)/ in the National Agricultural Research System (NARS) of the Indian Council of Agricultural Research in its deemed universities/ other institutes, and in the few traditional universities with Entomology as a field of specialisation in Zoology. Recently the Entomological Society of India conducted an Entomology Students' Conclave (ESC) 2024 from February 21 to 23, 2024, at the University of Agricultural Sciences (GKVK), Bangalore where these were showcased. This event exclusively meant for students provided a platform for displaying what are tenets of Entomology and what kind of research is going on in India, especially in the hands of the young and current practitioners of Entomology. This also enabled knowledge exchange, collaboration, and professional development, for the students and young entomologists. The celebration of ESI's foundation day with honouring of stalwarts in Entomology added special significance, as it enabled an interface between established excellence and the forthcoming excellence. This event provided snapshots of how Entomology research is progressing in India, and what are its frontiers, and how the performance stands in relation to the global scenario, especially in its expectations and prospects.

Let me detail few salient aspects from the snapshots of the event - The conclave featured addresses by prominent entomologists who emphasized the critical role of entomology in agriculture, biodiversity, and public health, and the stage was set for discussions on the latest trends and challenges in various themes of Entomology. These covered Biodiversity and Taxonomy; Biological Control; Integrated Pest Management; Beneficial Insects; Insect Physiology, Insect Vectors, and Molecular advances in Entomology; Insect Toxicology; Host Plant Resistance; and Insect Ecology; Climate change and insects, Industrial Entomology, and Non-insect pests of crops. There were more than 300 abstracts submitted with nearly 200 of them being presented to showcase the frontlines of research going on in Entomology. These sessions fostered an environment of detailed discussions and exchange of ideas, allowing participants to engage deeply with peers and stalwarts. Awards and Recognitions, celebration of ESI Foundation Day and special lectures which were purposefully held with the Conclave gave an opportunity for the young researchers as to what themes in Entomology provide an appeal and draw accolades, and how the Entomology has been performing to its purposes and needs.

Now let me also get into my sincere observations that I gathered from this event, also allow me to give an absolute inference on how Entomology stands currently with its young practitioners in the NARS of our country. To say very briefly, sadly and in one word, I will say "mediocre" as much of the research is redundant. Let us not blame the young students, those who preach entomology to them in most cases need introspection! Except for a few, which can be easily counted in fingers, many of these are outmoded, the outcome of which are not even appropriate for a research note in standard acclaimed journals of the current day! Yet there is a silver lining with few of the researches standing apart and these received accolades deserving the same, and continue so. Yes, we need to be optimistic with the latter. It is time that we entomologists introspect this deplorable current status and take ameliorative steps. I do not know how many of those who read this will get evoked by this realistic opinion of mine; however wrong or right it might be?

Dr. V.V. Ramamurthy

Editor in Chief, Indian Entomologist

A DIALOGUE WITH DR. JAGBIR SINGH KIRTI

GREAT TAXONOMIST, TEACHER AND ENTOMOLOGIST PAR EXCELLENCE WHO SERVED ENTOMOLOGY FOR 40 GLORIOUS YEARS

D**r. Jagbir Singh Kirti** (Prof. Retd), Department of Zoology and Environmental Sciences, Punjabi University, Patiala did his graduation and post-graduation from Panjab University, Chandigarh and Ph.D from Punjabi University, Patiala. Dr. Kirti is a distinguished entomologist and environmentalist, working in the field of Vector Biology in general and taxonomy and systematics/biodiversity in particular. He is teaching post graduate students of Entomology/Zoology in the Punjabi University, Patiala since Feburary 1986. He remained Head of the Department of Zoology and Environmental Sciences, Punjabi University, Patiala from 1st November, 2012 - 31st October, 2015 and **Director** of the DST-SERB School in Insect Biology from 2015- 2018.

Publications and Projects: He has published **315** research papers in National and International journals besides **9** important books in the discipline of Entomology. He has successfully completed **11** Major Research Projects sanctioned by various funding agencies. He has discovered more than **140** new species of moths and many new genera.

Awards: He was awarded with young scientist award by DST in1990. His contributions have received international acclaim. Prof. Jagbir Singh is a recipient of an **International Award** of Japanese Society of Electron Microscopy and Kochi Medical School, Japan in May 1997. He is also the recipient of an award from National Academy of Vectors and Vector Borne Diseases for his outstanding contributions in the field of vector biology in 2004. Prof. Jagbir Singh received a unique distinction of the **"Roll of Honour"** in Canada from Panjab University Alumni Association, Toronto in 2005. International Vegetable Centre known as **AVRDC**, **Taiwan** selected and sponsored Prof. Singh as a **key resource person and Visiting Professor** for training entomologists in the field of Taxonomy/biosystematics in December, 2010. Indian Academy of Environment Sciences (IAES) has awarded him **Gold Medal** for his contributions to the cause of Environment and human health in general & bioscientific contributions in particular for the year 2011. A **Fellowship** award was presented to him by Indian Society for the advancement of Insect sciences in April 2011 in PAU Ludhiana as a distinguished Entomologist. **Bio-Tech International Award-2011** carrying an amount of rupees **1 lakh** on Vector Biology and Environment was presented to him on 15th Oct. at RMRC, Jabalpur. Prof. Jagbir was bestowed with **'Global Vigyanik Award**-2012, in September 2012 by Global Punjab Foundation.

He was honored with **Rachel Reuben Medal-2012** in October at CRME, Madurai. He received an **Eminent Scientist Award- 2014** at Kolkata in March, 2015. **Life time Achievement Award** by School of Entomology, St John College Agra in 2016 and another **Life time Achievement award** by Ronald Ross institute, Hyderabad in 2016 were conferred on Prof. Jagbir Singh. **Dr. J.S. Yadav oration Award** by Department of Zoology, Kurukshetra University was given to Prof. Jagbir on 24th November, 2016. Third **lifetime achievement** award was bestowed on him at Dehradun in an international conference on taxonomy organized by Zoological Survey of India (ZSI, Dehradun) & Dolphin (PG) Institute of Biomedical & Natural sciences, Dehradun on **28th November, 2019**. 19. He received an award **ISMOCD, 2023** for outstanding work on Vector Biology by Indian society of Malaria and Communicable Diseases. **Best Taxonomist** award was conferred by the organizers of Indian **SOVE- 23** at **VCRC**, Puducherry and presented by Hon'ble Lieutenant Governor of Puducherry and Hon'ble Governor Telangana on **16th March, 2023**. Society of Medical Anthropology **(SOMA)** conferred **'Distinguished Scientist Award – 2023'** during an International Conference held at Kozhikode, Kerala from **December 13th – 15th, 2023**.

He has guided **28** research scholars to Ph.D degree and an equal number of M. Phil students. **Two** more Ph.D scholars are still working under his supervision. He remained an **Expert/Advisory** member of different organizations like DST, ICMR, DRDO and UGC of the country. Presently, he is an expert member of MoEFCC, New Delhi. He has delivered keynote addresses, lead talks and an invited lectures in numerous National and International conferences, symposia, workshops and training programs **throughout the world**. He is a Convener, President, Director, Executive member / life member/ honorary member of many National and International bodies/organizations.

"Indian Entomologist had the privilege of interviewing Prof. (Dr.) Jagbir Singh Kirti, Lepidoptera Taxonomist. Dr. Rahul Joshi, Scientist D, Zoological Survey of India, Kolkata, interacted with Prof. Kirti (JSK) and the excerpts of the discourse are presented below."

Rahul Joshi (RJ): Sir, thank you for speaking to Indian Entomologist magazine. How did you first become interested in Science?

Jagbir Singh Kirti (JSK): There was no one pursuing science in my family. My father was a revenue officer and doing agriculture side by side and my mother is housewife. I was the eldest in my family and all my three brothers are younger than me. I had no inkling that I was going to have interest in science, or even that it could become such an enjoyable and excellent activity to be an entomologist.

RJ: Can you share with us about your initial interests in Entomology during your studies?

JSK: I was very lucky to get admission in B.Sc. (Hons. school) in the department of Zoology at Panjab University, Chandigarh in 1975. Initially I opted for Botany and Biochemistry as two subsidiary subjects in my B.Sc. (Hons. school). After graduating in Zoology, I was selected as M.Sc. (Hons. school) Zoology students with Entomology as my specialization. I was fortunate to get my mentor/supervisor as Prof. Dr. Hans Raj Pajni, a renowned International entomologist my guide for M.Sc. thesis work. During one and half years working on a taxonomic problem on Noctuid moths under his guidance laid strong foundation for my career in the beautiful discipline of entomology.

RJ: What are the driving factors that made you to take Taxonomy? Who is your role model or who you admire in your professional life?

JSK: During my Viva Voce examination of M.Sc. thesis, Prof. Dr. Santokh Singh, a leading taxonomist and entomologist from Saint John's College Agra, advised me to work in North East India on the taxonomy of moths for my future research career. Later on, I completed my doctorate in Punjabi University Patiala and was awarded the Ph.D. degree in March, 1985 on the taxonomy of Pyraustinae subfamily under the supervision of Prof Dr. H.S. Rose who was also the first Ph.D. student of Prof. H.R. Pajni. I honestly admit here that Prof. H.R. Pajni and Prof. Santokh Singh were my role models. It is worth mentioning here that I got a chance to work in entomology research institute (ERI) at Chennai in 1990 for three weeks under the guidance of Prof. T.N. Ananthakrishnan, a doyen of Entomology in India. He was also great role model for my further career.

RJ: Travelling to North eastern states 40 years back was not so easy and that too all alone. What were the challenges you faced during initial stages of your research during surveys in North East? As you have completed many projects in North East, what do you feel have changed in these days? (If you can share some of the pictures of that days, that would be really great)

JSK: As far as Travelling to Northeastern states was concerned almost 43 years back it was a very tough task. I used to conduct collection cum survey tours during 1981 to 1984 in remote areas of seven sister states all alone at night time. Travelling from Punjab to Guwahati and Dibrugarh by one or two trains and crossing Brahmaputra from Dibrugarh to North Lakhimpur/ Arunachal Pradesh was also not very easy. I remember many stories when I interacted with different tribes for example Khasi's, Jaintia's, Naga's, Nocte's and many others. Language was a major problem, besides food and shelter in remote tribal areas. Sometimes, i used to sleep in front of the houses of tribal people in Jatinga in the North Cachar hills. Many times, it was also walking at midnight from Jatinga to haflong (about 9km) for accommodation in inspection bungalow with collection equipment i.e. Light traps, insect storage boxes etc.

RJ: Do you think choosing Taxonomy as a career was the right choice? Or you think you should have opted for some other specialisation?

JSK: I honestly admit that taxonomy was a right choice for me. I was very fond of travelling and staying in the lap of mother nature in beautiful surroundings having dense forest and vegetation. I am a hardcore taxonomist and after guiding thirty Ph.D. students and many M.Phil. students on various taxonomic aspects, I am fully satisfied with my career. I am thankful to the Almighty for bestowing upon me his choicest blessings and fulfilling my wishes to work in this beautiful branch of biological sciences.

RJ: Being a Professor in university, you have attained a high profile in research also. How did you balance both teaching and research?

JSK: Teaching is also one of my passion and I was fortunate to be selected as a curator, lecturer cum Curator, Associate Professor and Professor in Punjabi University, Patiala. During 35 years of my academic career in teaching and research, I could make balance in both the fields. Both these areas i.e. teaching & research gave me an equal opportunity to travel intensively and extensively not only in India but also many other countries.

RJ: Can you elaborate on your research on Lepidoptera taxonomy, specially the Arctiid taxonomy in India?

JSK: I got initial training from my respected guide Prof. (Dr.) H.R. Pajni while working on 60 Noctuid moth species from Chandigarh and surrounding areas. He guided and trained me on the morphology of moths in general and laid stress especially on sensilla, sutures, sclerites, genitalic features and other morphological structures particularly in moth species as a part of my thesis. With this strong base, I selected family Arctiidae as one of the important group of moths for my research work after my selection at Punjabi University, Patiala. I am proud to have worked with many hard working, sincere, dedicated students and all of them helped me to build up one of the best laboratory in lepidoptera taxonomy in India at Punjabi University, Patiala.

RJ: How important do you think are National Zoological Collections in India. You have recently donated collections to Zoological Survey of India also. Can your share the thoughts behind that?

JSK: One of the most important duty of a taxonomist is to enrich our National collections lying in our National museums. This is the only way that all the taxonomist working in different animal groups should deposit their collections in National museums so that our future younger taxonomist has not to depend upon collections lying at International museums in foreign countries. Working for more than 35 years and building a huge collection of lepidoptera gave me an opportunity to deposit our lepidoptera collections at ZSI museum Kolkata. All the holotypes and paratypes of new species i.e. more than 140 have been deposited in the lepidoptera section. Some of the collections have also been deposited in the Entomology museum of IARI (Pusa) New Delhi and FRI, Dehradun

RJ: You have worked on taxonomy of other insect groups also. Can you share some light on these studies?

JSK: Besides Lepidoptera, I worked on the taxonomy of mosquitos i.e. family Culicidae. We have worked on the ultrastructures of antennae, mouth parts, legs, genitalia, ciberium etc with the use of scanning electron microscope. Many new taxonomic attributes have been added in the diagnosis of various taxa of family Culicidae. This work has given us International recognition in the field of Culicidae taxonomy. One of my student has also worked on the taxonomy of dragonflies from Northwest India. Some of the M.Phil. and Ph.D. students have completed their studies on the taxonomy of various families of butterflies also.

RJ: Impact factors in taxonomic publications are very low. The common question faced by the young researchers in most of the interviews, your views on this?

JSK: I don't agree with this system of impact factors, Citations and other such criteria as far as work on the taxonomy of various groups is concerned. Taxonomy is a unique science and one can spend his/her whole life on a particular group. We cannot compare taxonomy like this with other branches of sciences. There are very few taxonomists left in our country as well as abroad and the citations are very low in taxonomy. Writing a monograph in taxonomy is much more challenging then the publications of the other branches of biology.

RJ: Being a member of many National/international committees, could you please highlight some of the initiatives to uplift Taxonomic research.

JSK: As part of different committees at National level, I have always worked for the interest of taxonomists. Many new research proposals were sanctioned on taxonomy of different groups during my tenure in National committees of UGC, DST, ICMR, MOEFCC etc. It was with lot of difficulty that we could start the All India coordinated project on taxonomy (AICOPTAX) once again but sadly the funds were not released by the MOEFCC.

RJ: Younger taxonomists are not much more inclined towards classical taxonomy these days. What's your advice to the young researchers in the field of taxonomy?

JSK: In my invited talks I always say Taxonomy is "Tax on me" and I tried my level best to inspire young research fellows to work in this field which is more challenging and need a lot of hard work. We have to inspire and attract young biologists/ taxonomist towards this beautiful science. Now a days ZSI Kolkata has recruited lot of young taxonomist in this field and recently ICMR has also recruited 18 young entomologists at various centres working on vector biology. We should all work to attract young researchers in this area and we have done it by organising three SERB Schools in Insect Biology. As many as 75 young scholars/ researchers have been trained in the discipline of Entomology with emphasis on taxonomy, molecular aspects and some more areas.

RJ: How would you like to see "Lepidoptera Taxonomy" in future?

JSK: I see a very bright future of Lepidoptera taxonomy as some of my students are now working in senior positions at ZSI and some other institutes. They are working tirelessly and with lot of dedication on the taxonomy of this wonderful order. Some other young scientist are also working at IARI and some other institutions.

RJ: What do you do to keep yourself busy these days? I have heard that you are very much engaged in highlighting the Environmental issues and motivating the youth regarding safety of Environment.

JSK: Teaching is one of my passion and I love to talk about Environment, mother nature, conservation with people of all ages. Initially our Department was known as Department of Zoology up to 2011 and its name was changed to Department of Zoology and Environmental sciences in 2012 after I took as HOD of this Department. Actually, it was in 2007 when I started going to schools, colleges and other institutes to inspire the students for protecting their environment and biodiversity. Later on, we started celebrating biodiversity day, environment day, ozone day, wetland day, earth day etc. at various places in north west India. Many programs were arranged in the rural areas for educating farmers regarding planting of trees, organic farming and conservation. It was a pride moment for me when I delivered a keynote address to 700 Scientist/delegates from 50 counties in Turkey during International conference i.e. Ecology 2018. I feel it is the need of the hour to educate students, teachers, and all other people for protecting the environment, biodiversity and for a healthy life on this planet.

Dr. JS Kirti with his mentor Late Prof. H.R. Pajni

Dr. Rahul Joshi completed his Ph.D. on 'Taxonomic studies of Indian Lithosiinae and Ctenuchinae (Lepidoptera)', from Punjabi University Patiala in 2013 under the supervision of Prof. (Dr.) Jagbir Singh. Dr. Joshi joined Zoological Survey of India in 2017 and is presently, working as Scientist 'D' in the Zoological Survey of India, HQ, Kolkata.
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In conversation with North Eastern women Entomologist Dr. Purnima Das who extensively worked on agro based rich heritage of India: The Lac culture.

Dr. Purnima Das hails from Sivasagar district in Assam. She completed her higher secondary education at Govt Higher Secondary School, Sivasagar. She holds a B.Sc. in Agriculture from AAU and earned her M.Sc. in Entomology from the College of Agriculture, AAU. Later, she obtained her Ph.D. in Entomology from Dibrugarh University, Assam.

Currently, Dr. Purnima Das serves as an Associate Professor at the Department of Entomology, AAU, Jorhat. She is also the Principal Investigator of the Network Project "Conservation of Lac Insect Genetic Resources" since September 2017. Previously, she worked as a Subject Matter Specialist (Plant Protection) at Krishi Vigyan Kendra, Chirang, Bongaigaon, AAU.

In her 20 years of service, Dr. Das has supervised 5 Ph.D. and 14 M.Sc. students, focusing on developing human resources. She has been actively involved in teaching undergraduate and postgraduate courses for the past 14 years and has been recognized as a master trainer for teaching excellence programs in collaboration with Sathguru foundation and Cornell University, USA.

Dr. Purnima Das has made significant contributions to Integrated Pest Management (IPM) in rice, tea, and stored grain pests, emphasizing eco-friendly and economically viable methods. Her research, starting from 2014, has been supported by grants from DST, SERB, BRNS, DBT, and ICAR-NISA. She has specialized in biopesticides and lac culture technology, earning accolades such as the Best Center award for lac culture technology in India.

Her pioneering work includes the scientific identification of the lac insect prevalent in Assam, *Kerria chinensis* (Mahdihassan), through morphometric and molecular characterization. Dr. Das has identified new host plants for commercial lac cultivation and focuses on value addition of natural resin from lac insects.

Dr. Purnima Das has received the DST Young Scientist Award in 2015, the Dr. B. Vasantharaj David Women Scientist Award in 2019, and the Dr. Rajendra Prasad Excellence Award in 2020. Her achievements reflect her dedication to advancing agricultural science and sustainable pest management practice.

Dr. Shimanthini B K (SBK): Madam, thank you for speaking to the Indian Entomologist magazine. Could you share the most memorable early career experience?

Purnima Das (PD): I come from a middle-class family, and I'm the youngest child. My elder brother is a doctor and I initially wanted to become a doctor. However, my journey led me to discover a passion for agriculture, particularly entomology. It all began when I attended the classes taught by Dr. S. K. Dutta, a dedicated entomologist. His teaching was captivating, especially when he demonstrated the details of insect morphology, like that of a grasshopper. His passion and skill led me to develop interest in entomology, and I chose it as my elective subject during my studies. Dr. Dutta continued to be a significant influence as my advisor during my M.Sc. studies. His guidance was invaluable, helping me complete my degree. After my B.Sc., I started my career as a Project Assistant under the renowned entomologist Dr. L. K. Hazarika. This job focused on biopesticides and it laid the foundation for my future. Under Dr. Hazarika's mentorship, I pursued a Ph.D. in microbial biopesticides. During this time, I was offered a permanent position as a Subject Matter Specialist in Plant Protection, where I gained valuable experience in extension work. Subsequently, I joined AAU, Jorhat as an Assistant Professor in Entomology. Over the years, I became an Associate Professor within the same institute, marking significant milestones in my career.

SBK: What made you choose Entomology as a subject of interest while pursuing undergraduate degree program in Agriculture and What has inspired you to work on lac culture in particular?

PD: My interest in Entomology began when I had exceptional teachers like Dr. S. K. Dutta, Dr. L. K. Hazarika, and Dr. B. C. Dutta who made the subject fascinating. They taught with such skill that I became deeply interested and wanted to learn more about insects. Initially, it started with remembering scientific names of insects, the joy only entomologists can relate to. Over time, I studied various insects belonging to different groups and made an effort to remember their names and scientific classifications. My mentor had a remarkable ability to remember not just insect names and scientific details, but also the names and addresses of all his students. Those moments have led me deep into the subject and to choose entomology as my area of interest.

In Assam, lac is mostly grown in hilly areas by tribal farmers using traditional methods. However, many of them aren't familiar with modern techniques for lac cultivation. Despite Assam having a lot of potential for lac farming, lack of awareness is a major problem. In 2014, Assam Agricultural University became part of a project "NP-CLIGR". Dr. L. K. Hazarika led this project with a vision to expand lac farming beyond just tribal areas to other parts of Assam. I was involved as a Co-Principal Investigator and became increasingly interested in lac farming. When Dr. Hazarika retired in 2017, I was promoted to Principal Investigator which gave me more responsibility and made me even more committed to improving lac farming practices. In 2019-2020, our center at AAU was recognized as the Best Centre for our work in lac cultivation. This achievement motivated us to continue improving and spreading the benefits of lac farming across Assam.

SBK: What motivated you to pursue Entomology as a profession and Who has inspired you the most in your professional life?

PD: Dealing with insect pests is a significant challenge when it comes to global food security. With insects accounting for over half of the two million known living species, they are a major cause of crop damage. Entomologists play a key role in every aspect of agriculture, serving as important figures who are respected and honored, especially in managing outbreaks or emergency situations has motivated me choose Entomology as a profession.

My family, mentors, and loved ones inspire me to contribute to society. My mother was an ideal lady in my life. Her hard work motivated us to work hard, manage our time, and move forward. Additionally, I was really inspired by my family as they always support and motivate me to achieve my goals. Students are another source of inspiration for me to achieve my desires.

SBK: What are the biggest challenges/hurdles you have faced while working on lac culture?

PD: Lac cultivation in Assam has been limited to hilly areas and practiced using traditional methods. Introducing modern techniques has been a major challenge because farmers are accustomed to their traditional ways. Tribal farmers, who are the main stakeholders, often face difficulties understanding these new methods, especially due to language barriers. In the valley regions where rice farming is predominant, convincing farmers to switch to lac cultivation has been tough for our team. Many farmers are hesitant to adopt modern practices. To tackle this, we adopted a hands-on approach. We demonstrated modern lac cultivation methods directly in farmers' fields, showing them how it can be done effectively. This approach, learning by doing, has been crucial in overcoming resistance and showing the benefits of modern techniques. Reaching remote areas in the hills was another significant challenge. It required extensive effort to connect with farmers in these remote pockets and introduce them to new ways of cultivating lac. Overall, our goal is to bridge the gap between traditional and modern practices, ensuring that farmers can benefit from improved lac cultivation methods while preserving their heritage and livelihood.

SBK: What are the North Eastern research gaps in the field of Entomology and how to narrow down these gaps? Even with all the gaps, how did you made so much notable contributions?

PD: Setting up facilities like insectaries, museums, and well equipped insect labs is difficult in humid regions. Institutions lack collaborations with experts like taxonomists and ecologists, which hinders comprehensive research. Students need more exposure through field visits to cultivate interest. Labs should be specialized for molecular, taxonomy, and ecology studies to boost efficiency. Improving interaction between researchers and advisors is crucial for sharing ideas and solving challenges together. Providing accessible internet and journal resources is essential for staying updated in the field. Addressing these gaps can strengthen entomological research and education.

When it comes to my contributions, throughout my career, I've been fortunate to receive several competitive extramural grants from esteemed agencies such as ICAR, DST, SERB, BRNS, and DBT, which have supported my research endeavors. My work has focused on enhancing Integrated Pest Management (IPM) strategies for essential crops such as rice, tea, and stored grains. I've dedicated myself to developing environmentally friendly and economically feasible pest control methods, including the formulation of biopesticides derived from local fungi. One of the most fulfilling aspects of my career has been leading the Network Project on "Conservation of Lac Insect Genetic Resources" since 2017. It was a humbling experience to receive recognition through the Best Center award from ICAR-NISA for our efforts in this area. Additionally, my involvement in establishing a Lac Museum and Regional Lac Insect Field Gene Bank at AAU. Undergraduate students are highly benefited from these two establishments. A significant achievement has been the scientific identification of the lac insect prevalent in Assam as *Kerria chinensis* (Mahdihassan), achieved through morphometric and molecular characterization. In 2015, I was honored with the DST Young Scientist scheme for developing a talc-based bio-formulation from native Entomopathogenic fungi, demonstrating high efficacy against rice pests. Under the BRNS project, I have contributed to the development of an early duration insect-resistant mutant line of Ranjit Sub 1 against the leaf folder, Cnaphalocrocis medinalis, using physical mutagenesis i.e gamma radiation techniques. These recognitions serve as motivating reminders of the importance of our work in entomological research. They underscore the collective efforts of my team and the steadfast support of our institution. I try to remain dedicated to exploring new avenues in research and continuing to contribute meaningfully to both scientific knowledge and agricultural practice.

SBK: Would you like to share your proudest moment/ achievement?

PD: After working as a Research Fellow for nine years, I got posted as a Subject Matter Specialist (SMS) which was my best achievement. Also in 2011, I have been selected for the post of Assistant Professor, I won the Women Scientist Award, Master trainer of Teaching Excellence program organized by Cornel University USA, and received the European Fellowship for one month of training are the moments that I will cherish.

SBK: How do you balance between professional life and personal life?

PD: Balancing work and personal life is important for any person. I make sure to manage my time effectively by setting clear priorities. This helps me focus on my work at the university and also have quality time with my family and friends. Taking breaks helps me recharge outside of work. I try to communication with my colleagues and family to manage expectations and reduce stress. I am grateful for my husband and children for their never ending support to me in every regard.

SBK: How would you like to see yourself in next 5 years?

PD: As an Associate Professor and Researcher, I wish to make prominent contributions to the University and also to the farming communities through significant work on biopesticides and lac culture. I wish to develop good human resource through the students and to help them in achieving their life endeavors. I hope to see myself as a better teacher, advisor, researcher and motivator for my students. I am committed to the development of the University and look forward to being an integral part of its growth.

SBK: How do you differentiate an Associate Professor and a Researcher/scientist?

PD: As an Associate Professor, my primary responsibilities include teaching, guiding students through their academic endeavors, and actively participating in practical activities. Beyond the classroom, I also engage in various institutional duties that contribute to the University's overall development. My role as a researcher plays a crucial part in enhancing my effectiveness as an educator. It involves conducting in-depth studies and experiments aimed at yielding positive and impactful results. This requires meticulous planning, strategic execution, and a steadfast commitment to staying updated with the latest advancements in my field. When it comes to teaching, my goal is to deliver lectures that are not only informative but also purposeful, ensuring that students grasp the practical applications of the knowledge they acquire. My roles as an Associate Professor and researcher are intertwined, allowing me to contribute meaningfully to both student education and the advancement of knowledge in my field.

SBK: What suggestions/advices do you have for the budding entomologists or early career researchers?

PD: My advice to young entomologist is to prioritize hard work and dedication. It's crucial to cultivate punctuality and sincerity in your work ethic while fostering positive relationships and nurturing a healthy research environment. Stay curious and proactive in learning new concepts. Stay updated with the latest developments in your field. Engage in training programs and collaborate with experts from various allied sciences to broaden your perspective. Actively participate in seminars and conferences to expand your knowledge base and network with peers and mentors. Understanding the fundamentals of entomology and exploring interdisciplinary approaches will enrich your research endeavors. Seek opportunities to secure funding for your projects through relevant agencies, as this not only supports individual growth but also contributes to the advancement of your institution.

SBK: Madam, any specific suggestions/views/ opinion on the Indian Entomologist magazine?

PD: The magazine is already making significant contributions to the research community. It serves as a valuable platform for researchers, academics, and enthusiasts to share their findings, insights, and innovations in the field of Entomology. Furthermore, awarding merit-based rewards to deserving students from all regions of India has the potential to cultivate student interest and enhance their motivation.

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Pesticide residue and food quality analysis laboratory: An overview

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Effective use of pesticides is essential for the better protection of crops from pests and diseases as well as boosting food production. However, the improper use of pesticides causes a wide range of problems in humans and other non-target organisms. It has been observed that pesticide exposures are increasingly linked to immune suppression, hormone disruption, diminished intelligence, reproductive abnormalities and cancer (Abhilash and Singh, 2009). Although the Indian average consumption of pesticides is far lower than many other developed economies, the problem of pesticide residue is very high in India. Pesticide residue in several crops has also affected the export of agricultural commodities in the last few years. In this context, pesticide safety, regulation of pesticide use, proper application technologies, and integrated pest management are some of the key strategies for minimizing human exposure to pesticides

Reports from the National Health and Family Survey, United Nations International Children's Emergency Fund and, WHO have highlighted that rates of malnutrition among adolescent girls, pregnant and lactating women, and children are alarmingly high in India (Narayan et al., 2019). One of the major factors responsible for malnutrition is the nutritional status of food. Working toward the nutritional parameters of food (proximate analysis) is an essential need in India.

Over the last few years, the safety concern relevant to aflatoxin content in spices, nut and nut products has resulted in the rejection of these Indian products by other developed countries like European Union, US etc. Because these products cause hepato-toxicity and carcinogenicity in human beings (IARC, 1993). Similarly, the problem of aflatoxicosis is also reported in livestock animals (Frisvad et al., 2006). Ground and surface water are the major sources of drinking water supply in rural and urban areas of India. Water with high Total Dissolved Salt (TDS) levels becomes difficult to consume and is not acceptable for drinking according to the Bureau of Indian Standards (BIS). Besides, high-soluble salts can directly injure the roots, interfering with water and nutrient uptake causing nutrient deficiencies that compromise plant health. The presence of toxic ions such as lead, nitrate, cadmium and arsenic present in water can also lead to several serious health problems (Jaishankar et al., 2014)

Considering all the above issues, UAS, Raichur established "The Pesticide Residue and Food Quality Analysis Laboratory" (PRFQAL) at main campus. It is a state-of-the-art NABL-accredited laboratory dedicated to testing pesticide residues, heavy metals, food proximate and aflatoxin contaminants in agricultural produce and commodities to cater to the needs of various stakeholders *viz.,* farmers, scientists and, students from different SAUs, ICAR institute and private agencies, food and processing industries, food grain packers and exporters. The laboratory began to function in 2016 and obtained the National Accreditation Board for Testing and Calibration Laboratories (NABL) accreditation as per ISO/IEC 17025:2017. PRFQAL is also a part of two national programs *viz.,* All India Network Project (AINP) in persistence and dissipation of pesticides in different crop ecosystems and Monitoring of Pesticide Residues at National Level (MPRNL) sponsored by the Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare Government of India.

Objectives of PRFQAL

- To standardize analytical methods for pesticide residue, heavy metals and aflatoxins in agricultural and horticultural crops and their commodities
- To study persistence, dissipation and decontamination of selected pesticides in different agroecosystems and food products
- To analyze pesticide residues in different market, farmgate and organic samples (fruits, vegetables, cereals & pulses). This data aids in establishing Maximum Residue Limit (MRL), helping to prevent export rejection.
- To analyze the nutrient quality parameters in

Scope of analysis at PRFQAL

Sl.No	Scope	Parameters	Equipment Used
1	Pesticide Residues	NABL accredited: 74 pesticides non-NABL: 45 pesticides	LC-MS/MS, GC-MS/MS
2	Heavy Metals	NABL acrrediated: 14 heavy metals for fruits & vegetables 07 heavy metals for cereals & pulses 16 heavy metals for water	ICP-MS
3	Food Proximate Composition	NABL accredited: protein, fat, carbohydrate, energy, ash, moisture, fibre and refractions	Protein: Automatic distillation and titration unit Fat: Fat extraction unit Fibre: Fibre extraction unit Ash: Muffle furnance Moisture: Hot air oven Carbohydrate & Energy: By calculation method Refractions: By balance
4	Water Quality Analysis (drinking water, surface water and ground water)	NABL accredited: 12 parameters as per ISO 10500 (2012)	UV Visible Spectrometer, PH meter, Turbidity meter, Conductivity meter
5	Honey Quality Analysis	NABL Accredited- moisture, specific gravity, ash, total reducing sugars, sucrose and acidity non-NABL: fructose glucose ratio, fructose % and glucose %	Ion- Exchange Chromatography
6	Aflatoxin Analysis	NABL accredited: AFG2, AFG1, AFB2 and AFB1	UHPLC
7	Environmental Gas Estimation	Methane (CH_4), carbon dioxide (CO_2) and nitrous oxide (N_2O)	GC-ECD, GC-FID
8	Food Adulterants	non-NABL: curcumin, congo red, metanil yellow and sudan dye	UHPLC

farm and processed products.

➢ To analyze the physio-chemical parameters, heavy metals and pesticide residue in drinking water, groundwater and surface water.

➢ To analyze the aflatoxin in nut & nut products and spices.

➢ To determine honey quality parameters as per FSSAI standards

➢ To analyze pesticide residue in biopesticide samples laced with pesticides, provided by the Government of Karnataka.

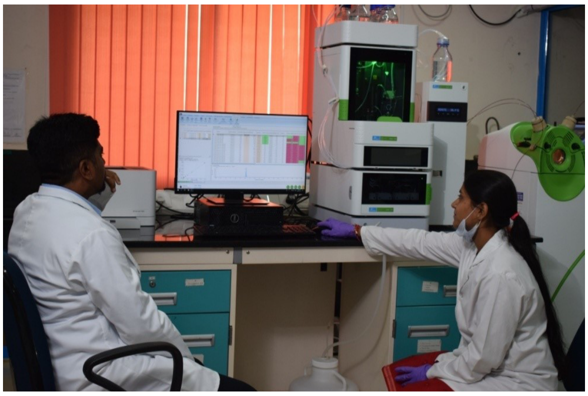
➢ To create awareness among the farmers and general public on the importance of residue-free food, safe and judicious use of pesticides by conducting training programs.

Conclusion

The state-of-the-art laboratory PRFQAL established under UAS, Raichur is catering to the needs of farmers, students, scientists, manufacturers, industrialists and various other stakeholders. It is our privilege to serve the stakeholders for the benefit of the society, state and the country.

Laboratory equipped with advanced equipment

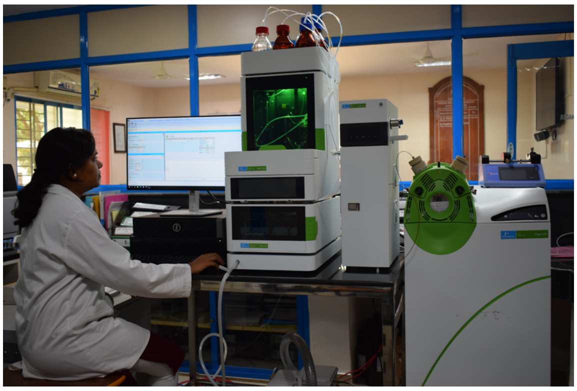
LC-MS/MS (Shimadzu 8040)



LC-MS/MS (Perkin Elmer Qsight 420)

GC-MS/MS (Shimadzu-TQ 8030)

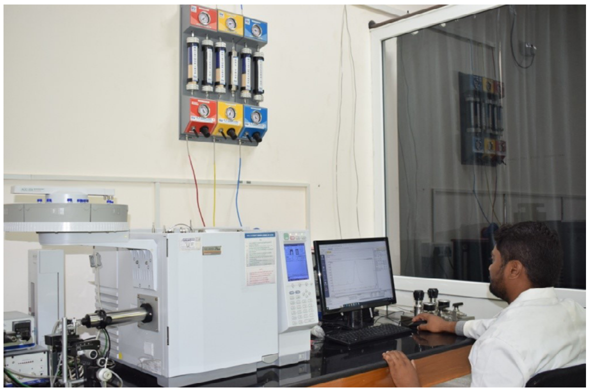
ICP-MS (Perkin Elmer Nexon 350X)



LC-MS/MS (Perkin Elmer Qsight 220)

Ion Exchange Chromatography (Metrohm 930 compact IC

GC-ECD (Agilent Technologies 7820 A



GC-FID & TCD (Shimadzu)

Fat, Fiber and Protein Estimation Unit

Water Quality Testing

UHPLC Shimadzu (Nexera X2)

Sample Extraction Room

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Survival of subordinate in extremes –Story of Cataglyphs

Anna Jose, Renuka Hiremath and Dyamanagouda Poojar

Animals that live in deserts appear to be special as they are adapted in one or the other way to survive in the extremes of temperature and scarcity of water. The most universal behavioral adaptation used by small mammals, reptiles and insects to deal with high temperatures is to avoid heat by staying out of it as much as possible. However, ants in the genus, *Cataglyphis* do not avoid heat and come out during the hottest times of the day to forage. Since they forage at midday in hot deserts, they are also known as furnace ants or mad Englishmen.

Cataglyphis

Genus *Cataglyphis* includes around hundred species of ants and are found in arid deserts of Palearctic region. Cataglyphs lives in small colonies that are widely dispersed in desert sand, comprising only few hundred to thousand individuals. They are solitary foragers and strictly diurnal thermophilic scavengers as they forage for insects and other arthropods died due to the environmental stress of their desert habitats. By restricting their foraging times to the hottest times of day and year, which are avoided by the majority of other species, they get two advantages (i) they can escape predation by lizards which are less thermotolerant and hence won't be active when cataglyphs comes out for foraging and (ii) being subordinate species, they will be forced to abandon prey when dominant species are competing for the same resource. Hence foraging during the hottest hours allows them to exploit food resources with reduced competition.

Adaptations to survive in arid environment

(a) Long legs: Most cataglyphs have relatively long legs (Fig.A) that carry their body away from hot sand (Sommer and Wehner, 2012).

(b) Thermal shield: The Saharan silver ant, *Cataglyphis bombycina* Roger has triangular shaped hairs (silver hairs-Fig. B) covering the body that act as thermal shield. Willot et al. (2016) measured the reflectance and temperature on abdomen of both hairy and shaved workers of *C. bomycina* and observed that the reflectance was tenfold higher in the presence of hairs which in turn, resulted in the reduction of the internal temperature by 2^0C.

(c) Thermal refuge: When the temperature increases above 40^0C, ants show a particular kind of respite behaviour in which, they retreat to cooler thermal refuges by climbing up stones or small sticks (Fig.C) of dry vegetation to radiate off excess heat from body (Wehner, 2020).

(d) Improve mobility by raising gaster: While running, Cataglyphs particularly, *Cataglyphis bicolor* Fabricus (Fig.A) and *Cataglyphis fortis* Forel raise their gaster vertically above the body to reduce their moment of inertia so that they can take tighter turns with increased speed without losing balance (McMeeking et al., 2012).

(e) Ultra runners: The most conspicuous behavioural trait of thermophilic desert ants is their extraordinary running speed. At temperatures (50°C–55°C) during which peak foraging activities occur, the ants' running speeds reach 855 mm/s or nearly one meter per second (Pfeffer et al., 2019).

(f) Heat shock proteins: Heat shock genes play a protective role by refolding denatured cellular proteins that have been damaged under heat stress. The more thermophilic ant species were found to have higher constitutive expression and lower induced expression of heat shock protein genes in response to heat stress than the more mesophilic ant species (Willot et al., 2017).

(g) Social hybridogenesis: In addition to the classical reproduction seen in ants, cataglyphs exhibit a special kind of reproduction called social hybridogenesis wherein, males and queens are produced as a result of parthenogenesis, while workers are hybrids and produced as a result of mating with another lineage. This benefits the colony by providing a genetically diverse workforce. This may be particularly relevant for scavengers such as *Cataglyphis* who are at risk from pathogens from dead arthropods (Wehner, 2020).

(h) Colony division: Two different modes of colony foundation *viz*., independent colony foundation (ICF) and dependent colony foundation (DCF) exist in cataglyphs. In ICF, a mature colony produces numerous queens that disperse individually by flight and start new colonies alone. In DCF, a mature colony splits to produce one (or a few) new colonies and is more predominant among cataglyphs. Deserts are patchy environments and it has very limited viable habitats where ants can establish a nest. So, in ICF, there is more chance that they may fail to find a favourable habitat in a desert environment and colony foundation is by queen alone. In contrast, DCF queens disperse on foot and they remain close to mother colony. And here, workers also help in excavating nest and taking care of young ones and hence, mortality will be less and thus, DCF maximize the competitiveness and tolerance of their offspring colony (Wehner, 2020).

Foraging in desert

Cataglyphs are zoonecrophages as they feed on dead bodies of arthropods that succumbed to death because of high temperature in desert. They forage individually and do not use chemical trails or trail pheromones that are used by most of the ants in other genera since at high temperature pheromones will evaporate and degrade. During hottest hours of the day, cataglyphs come out of the nest and take tortuous path in search of sparsely dispersed food. But, after collecting food they take the shortest path towards the nest. This kind of navigation is termed as path integration (PI) or vector navigation. Path integration is a method of determining current position based on knowledge from the previous position, heading, and velocity. Distance and directional information needed for PI are acquired by the ants *via* several methods. For knowing direction, cataglyphs use pattern of polarised light to know the position of sun whereas distance is measured by a combination of methods. Ants estimate distance using ant pedometer, wherein, ants employ a stride meter (pedometer) that counts numbers and measure lengths of the strides to know the distance travelled. Though the actual mechanism remains unclear, it is assumed that the ant might have used proprioceptors on the leg and body to achieve this (Wittlinger et al., 2006). Another technique used to measure distance is self-induced optic flow. If we are moving continuously in one direction looking on an object located far, as we are moving towards it, image of the same object changes constantly with regards to the area of retina it stimulates. This flow of information is known as optic flow. Measuring this rate of optic flow gives ants the distance covered (Ronacher and Wehner, 1995). Cataglyphs are known to memorise landmarks as well to locate their nest (Akesson and Wehner, 2002).

Ecological role

Cataglyphs can be found even in deserts with barely any vegetation. They are known to play a role in nutrient recycling as they feed on heat-stricken arthropods. They are also fed upon by robber flies and spiders during early morning or late evening hours when these ants are sluggish (Wehner, 2020). Few cataglyphs are known to contribute to seed dispersal and help in establishment of pioneer species through seed dispersal (Sharafatmandrad and Mashizi, 2021).

Conclusion

Harsh environments drive unique ecological adaptations, allowing organisms to take advantage of extreme conditions to reduce competition and predation pressure. *Cataglyphis* ants possess several adaptations to increase thermotolerance and overcome the limitations of chemical communication in hot environments. Though these adaptations are not novel or exclusive to *Cataglyphis*, these heat loving ants have succeeded by enhancing a number of individual features and traits that are generally normal to ants.

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Fig. A. *Cataglyphis bicolor* with raised gaster.
(Wehner, 2019 https://link.springer.com/article/10.1007/s00359-019-01333-5)

Fig. B. Thermal shield in *Cataglyphis bombycina*
Willot et al, 2016, http://dx.doi.org/10.1371/journal.pone.0152325

Fig. C. Respite behaviour in *Cataglyphis bombycina*
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Courtship rituals of dance flies: Mating swarms and female ornamentation

Renuka Hiremath, Anna Jose and Dyamanagouda Poojar

Dance flies (balloon flies or dagger flies), known for their captivating mating dance, display some of the most fascinating and unusual courtship behaviors in the insect world. These are predatory dipterans of the family Empididae, whose subfamily Empidinae is divided into three genera *viz., Hilara, Empis* and *Rhamphomyia* with approximately 1,450 species worldwide. Sex role reversal in relation to the usual male and female reproductive behaviour is an important evolutionary behaviour among these dance flies. Males typically provide the female with a nuptial gift at the time of mating and many species form lek-like mating swarms in approximately 28% of the species in the genera *Rhamphomyia* and *Empis*, females have some sort of secondary sexual characteristics/ornaments. These ornaments include inflatable abdomen, pinnate (feathery) leg scales and enlarged or darkened wings (Fig. A). The female ornaments are believed to be a signalling mechanism to attract male mates, either for their gametes or to obtain more prey/nuptial gifts from males to provide for ovarian maturation (Myllyaho, 2022).

Mating behaviour

The Empidinae dance flies display a number of interesting mating traits; males typically provide the female with a nuptial gift at the time of mating, and many species form lek-like mating swarms. The elaborate mating behaviour can be broken down to three distinct stages in adults *i.e.* hunting, swarming, and mating. Mating swarms in the dance flies can vary substantially by species in terms of density, sex ratio and timing. Many species form mating swarms at a 'swarm marker' (puddles, rocks, or distinctive vegetation, or open patches of sky) and return to the same site annually with specific individuals revisiting the swarm for the duration of the mating season.

The preference of female by male could depend on the size of the female or its position in a swarm and several other factors. The effect of female size on male mate choice was experimented by Funk and Tallamy (2000), using two-dimensional models of inflated females. Accurate models were designed by photographing parts of inflated females that had been snap-frozen in flight as they swarmed. The various female parts (wings, legs, head, thorax and abdomen) were combined in the darkroom into black and white composite prints that represented an intact female in flight. Printing was done at several magnifications including life size (*i.e.* actual size of average field-collected females), 0.75X, 1.5X and 2.0X. Then the images from the film were cut and trimmed as closely as possible. Activities were recorded on videotape. Two models of each of the four sizes were used with positions re-randomized each night and the data were collected. It was found that males either accepted or rejected each model as a potential mate after flying beneath it. When given a choice between models of four sizes, males approached the largest model (twice life size) significantly more often than the other sizes (P=0.0002). Several hypotheses were explained for this preference

1. Large females may be more capable of laying larger egg clutches or clutches comprised of larger eggs.
2. Females with the largest inflatable sacs may be preferred because they bear 'good attractiveness' genes and will thus produce

'sexy' daughters.

3. Inflated abdomens may compromise survivorship through lost manoeuvrability and thus convey 'good viability' genes *via* the handicap principle.
4. Females with larger abdomens may be further along in the gonotrophic cycle (process of ovarian development and egg laying) and thus be closer to oviposition than females with smaller abdomens.

Exaggerated sexual traits of *Rhamphomyia longicauda*

Loew were also studied, which revealed that female provide misleading sexual signals to males. Thus, the act of deception does operate in dance flies. Females had bizarre abdominal extensions that might deceive males indicating the incorrect size and particularly, the maturity status of their eggs.

Female swarm position also becomes important to attract the incoming male which was experimentally explained. A total of 1479 male approaches over the course of 10 mating swarms were recorded. Males were more likely to approach and court a female silhouette if it was positioned near the centre, rather than the periphery of the swarm (Murray *et al.,* 2018). Thus, the swarm is stratified according to female size, with the largest females occupying lower positions in the swarm. Indirect female competition plays a role in swarm positioning and mating success. Additional role for female ornaments: that they signal quality not only to choosy males, but also to rival females (Bussiere et al., 2008).

Beautifully flawed!

Everything comes with a cost so does the ornamentation in females of dance flies. Scientifically speaking it's the handicap principle and dance flies are not an exception! The flies and spiders along the banks of the Credit River, for the entire swarming season of the flies, were studied. The number of flies caught in the spider webs was counted. Twenty-one *R. longicauda* prey collected from 11 spider webs containing dance fly prey showed as predicted, significantly more females than males. The reason for female bias in predation according to researchers could be due to secondary sexual structures. Two possibilities for this increased predation were considered. One is that females make swarms near the spider webs or the bias in predation may come from the structural modifications carried by a swarming female which includes mated abdominal pouches, which increase her overall body size, as well as the impediment of possessing legs fringed with pinnate scales. These traits, which are not expressed in males, may either make it more likely that flying females are caught in the first place or more difficult for females to extricate themselves from webs before being immobilized by the spider (Gwynne and Bussiere, 2002).

Conclusion

The remarkable courtship behaviour of Empidinae dance flies has stimulated a renewal of interest in using them as models in studying the evolution of mating systems. However, the progress in studying mating systems in dance flies has been hampered by the fact that dance flies do not behave as expected in lab environments and by the speed of natural swarms.

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Fig. A. Female-specific ornamentation in *Rhamphomyia longicauda* (Murray *et al.* 2022)

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GENERAL ARTICLE

Exploring the fascinating world of insect Orcokinins: A nature's tiny messengers

Alagesan Keerthana, Logeswaran K. and Vinod Kumar Dubey

Insects play a crucial role not just as pollinators and decomposers, but also as subjects of scientific curiosity. One such area that has piqued the interest of researchers is the study of neuropeptides in insects, particularly orcokinins. Orcokinins are a class of neuropeptides that play critical roles in the nervous systems of insects and other arthropods. These small, protein like molecules function as chemical messengers, facilitating communication between neurons and influencing a variety of physiological processes. Initially discovered in the crayfish *Orconectes limosus*, orcokinins have since been identified in a wide range of insect species.

Orcokinins are involved in several key functions, including the regulation of muscle contractions, modulation of heart rate, and coordination of circadian rhythms. They are particularly significant in the neuroendocrine regulation of ecdysis (the process of moulting) and reproduction, making them essential for the growth, development, and reproductive success of insects. Given their diverse roles, orcokinins are of great interest to researchers aiming to understand the complex hormonal and neural networks that govern insect behavior and physiology.

In addition to their biological significance, orcokinins present potential targets for pest control strategies. By disrupting the normal functioning of these neuropeptides, it may be possible to develop novel methods for managing pest populations, thereby reducing the reliance on traditional chemical insecticides. This dual significance in both fundamental research and applied science underscores the importance of studying orcokinins within the broader context of neuroendocrinology and evolutionary biology.

What is Insect Orcokinins?

The term "orcokinin" is derived from two Greek words "orcos" (pulse) and "kinein" (to move). Orcokinins (OKs) are neuropeptides found in insects. They were initially identified in crustaceans due to their myotropic activity. In insects, the OK gene gives rise to two distinct families of conserved mature neuropeptides: OKA and OKB. Although orcokinins are well-conserved across insect species, their precise physiological role remains elusive. These peptides are synthesized in the nervous tissues and act on specific receptors, influencing various physiological processes such as energy metabolism, osmoregulation, and mating behaviour in insects as summarized in (Table 1 and Fig.1). These peptides are characterized by a conserved N-terminal motif Asn-Phe-Asp-Glu-Ile-Asp-Arg (NFDEIDR). The C-terminal sequences are divergent among the isoforms.

Significance of Orcokinins in Pest Management

The study of orcokinins is not merely an academic interest; it holds practical implications for pest management and eco-friendly agriculture. By understanding the roles of these neuropeptides, researchers can aim to develop targeted strategies for pest control that minimize the environmental impact. Modulating orcokinin pathways could potentially disrupt essential physiological processes in pests, offering a more sustainable and eco-friendly approach to pest management.

Challenges and Future Directions

1. The diversity of insect species adds another layer of complexity, requiring a detailed understanding of orcokinins across different taxa.

Table 1: Roles of Orcokinins in Insect Physiology

Insect Species		**Role of Orcokinin in Insect Physiology**	**References**
Common Name	Scientific Name		
Fruit fly	*Drosophila mela-nogaster* Meigen	Involvement in the control of reproductive processes	Silva et al., 2021
		Regulation of mating behaviours	
Mosquito	*Anopheles albimanus* Wiedemann	Regulation of ecdysis	Alvarado-Delgado et al., 2018
		Involvement in the control of reproductive processes	
Cockroach	*Leucophaea maderae* Korchi	Regulation of circadian locomotor activity	Wei and stengl, 2011
Silkworm	*Bombyx mori* Linnaeus	Involvement in neuronal regulation of ecdystero-dogenesis	Tanaka, 2021
Kissing bug	*Rhodnius prolixus* Stal	Regulation of ecdysis	Wulff et al., 2018
Red flour beetle	*Tribolium castaneum* Herbst	Involvement in awak-ening activities and controlling circadian rhythms.	Jiang et al., 2015

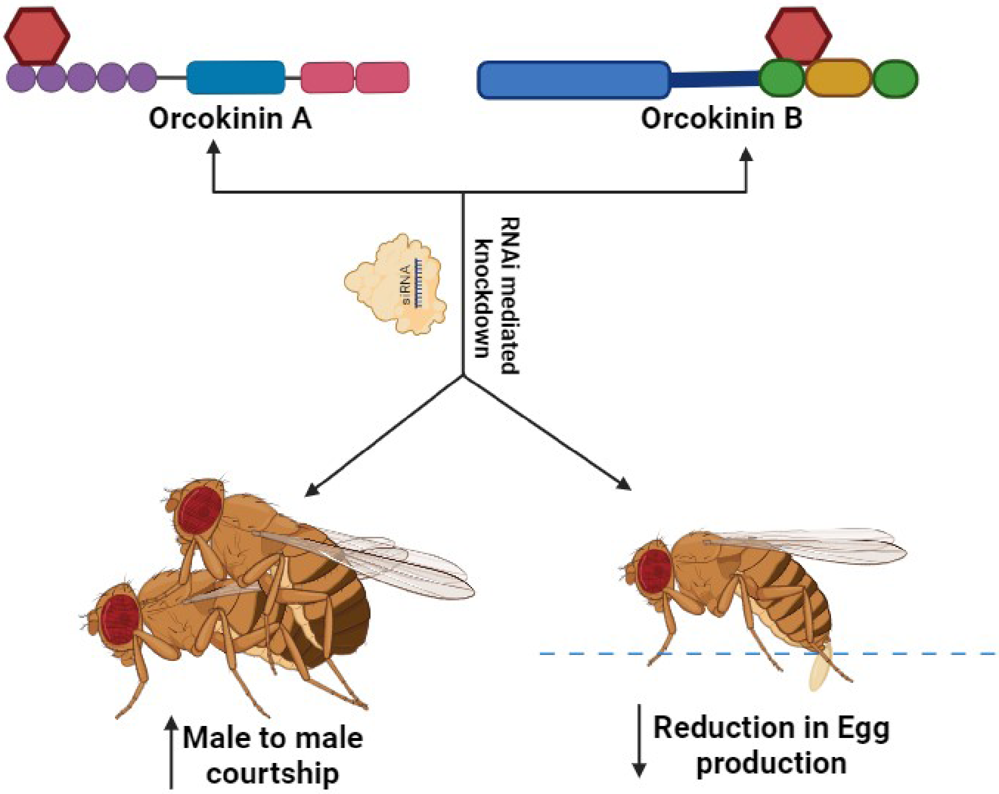

Fig. 1: Regulation of mating behaviours in ***D. melanogaster***

2. Researchers also face challenges in unravelling the complexity of neuropeptide signalling and its integration into broader physiological networks

The future of orcokinin research holds promising outcomes as scientists delve deeper into the molecular and physiological intricacies of these neuropeptides. Advancements in genomics, proteomics, and neuroimaging techniques will likely contribute to a more comprehensive understanding of orcokinins and their roles in insect biology.

Conclusion

Insect orcokinins represent a captivating avenue of scientific inquiry, offering insights into the intricate web of molecular signalling that governs insect physiology. As researchers continue to unlock the secrets of these tiny messengers, the potential applications in pest management and agriculture underscore the importance of understanding the roles these neuropeptides play in the lives of insects. The world of orcokinins is undoubtedly complex, but its exploration promises a deeper understanding of insect biology and novel practical solutions for the sustainable management of insect pests.

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Hypoxia in insects

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All living beings require a minimal amount of oxygen for their daily survival and to ensure proper functioning of all their body parts. Hypoxia is described as a phenomenon where there is a deficit in sustainable amounts of oxygen at tissue levels, required for carrying out normal physiological actions. Hypoxia occurs when there is less than normal levels of oxygen pressure (as opposed to normoxia or normal conditions). Like almost all other living beings, insects regulate their uptake of oxygen by carefully balancing out oxygen toxicity and deprivation. An increase or decrease in ambient oxygen levels results in suspension of homeostasis, activity and growth. This in turn incites physiological responses in the insect body. When response mechanisms are unable to keep up with the growing demand of the tissues, it results in either hypoxemia (excess amounts of oxygen) or hypoxia (insufficient amount so oxygen). When faced with hypoxia, insects often try to counteract by activating both short and long-term mechanisms. It is a common belief amongst many scientists that the mass extinction of insect species during the late Permian period came about due to induced hypoxic stress as a result of low atmospheric oxygen and rising temperatures in the environment.

Types of hypoxia in insects

Hypoxia in insects manifests itself in two forms, *i.e.,* functional and environmental hypoxia. In functional hypoxia, the supply of oxygen falls short to meet the oxygen demand. The occurrence of this type of hypoxia is normal early insect development and is a factor in mediating life-history trade-offs. When oxygen levels drop below the ambient oxygen level of 21 kPa is known as environmental hypoxia (Harrison et al., 2018). Hypoxia in insects have been observed in different types of habitats, ranging from aquatic, terrestrial, subterranean and high altitudes. A key observation in insects when exposed to hypoxia is decrease in ATP production which results from a decrease in oxygen in the living tissues. Hypoxia also manifests itself in the form of protein unfolding, inflammation and immune response. In order to deal with the drop in ambient oxygen levels, insects often try to increase the oxygen supply by opening their spiracles and increasing abdominal pumping. The effects of hypoxia can be seen in insects in the form of reduced body size, decreased growth and survival in *Drosophila melanogaster*, decreased egg production and reduced adult emergence in *Callosobruchus maculates*, and developmental abnormalities at ecdysis (*Manduca sexta*) (Harrison et al., 2006). In certain instances, hypoxia has also induced susceptibility in *Tribolium castaneum* to microbial infection *Beauveria bassiana* (Lord, 2009).

Response of insects to hypoxia

Insects have developed remarkable ways to deal with hypoxia, these changes may be morphological, physiological or behavioural in nature and may vary based on the severity of hypoxia and habitat of the insect.

Exposure to hypoxia typically brings about a slew of behavioural changes, this often starts with an immediate increase in frequency of spiracular openings, ventilatory movements and activity. Terrestrial insects like American bird grasshopper (*Schistocerca americana*) respond to hypoxia by increasing tracheal conductance and entering quiescence. Insects also adopt escape measures like damsel fly nymphs have shown an increase in their rate of ventilatory movements. Aquatic insects survive hypoxic waters by spreading their gills and exposing their respiratory structures to the surface air. The latter are less tolerant to hypoxic conditions than terrestrial insects (Hoback et al., 2001). Insects often reside in unusual microhabitats, to avoid excess competition and predators. These microhabitats may be severely hypoxic or anoxic, which results in the development of several physiological adaptations. The adult scarab dung beetles show quiescence at lower oxygen concentrations (<1-2% oxygen). The beetles are capable of movement and seem to measure hypoxia and even move to oxygen-rich areas of the ding pat, when necessary (Holter and Spangenberg, 1997). Similar behaviour has also been observed in calliphorid flies, *Phormia regina* and *Calliphora vomitoria*, where the larvae move from anoxic to oxygenated areas of decaying tissues while feeding (Brand, 1946).

Insect tracheal systems are highly efficient due to Fick's law of diffusion, according to which the rate of diffusion within tracheal systems is linearly at par with the cross-sectional volume. This aids in the maintenance of the rate of oxygen uptake by insects between 1-2%. Hypoxic conditions interrupt the movement of oxygen, halting its flow to the tissues. Morphological changes in the respiratory system of developmental stages helps insects accommodate hypoxic conditions. For example, enlargement of the cross- sectional tracheal volume allows greater intake of air into the tissues. Yellow mealworms (*Tenebrio molitor*), displayed a 40% increase in the cross-sectional volume when reared in 15% oxygen (Loudon, 1988). An increase in the number and frequency of tracheoles and tracheal branches has also been observed in fruit flies, where tracheolar branching seems to be induced due to the secretion of fibroblast growth factor from oxygen starved tissue (Wingrove and O'Farell, 1999). Intertidal species like *Pemphigus treherni* maintain low metabolic rates which are supported by cuticular gas exchange, when submerged (Forster and Treherne, 1976). However, *Anurida maritima,* survives submergence by trapping air-bubbles, which allow respiration for at least three hours (Zinkler et al., 1999). Nitric oxide/cyclic GMP pathway are mostly responsible for tracheole growth (Wingrove and O'Farell, 1999). Over-expression of nitric oxide synthase results in greater hypoxia response while its inhibition decreases such responses. In many instances, insects have also been reported to depend upon biochemical mechanisms to develop a suitable mechanism to withstand hypoxia. Long-term responses of hypoxia include activation of hypoxia-inducible factor (HIF) pathway in insects. Although the consequences of the induction of HIF have been poorly studied, HIF has been linked to induction of a homologue of fibroblast growth factor (FGF), which stimulates production of new branches in local tracheoles (Maxwell, 2004).

Schistocerca americana showed an increase in pH values of hemolymph which might be a result of intracellular pH regulation activities. Low oxygen supply often results in oxidative damage in insects, tiger beetle larvae prevent oxidative stress by lowering their metabolism while goldenrod gall insects, *Eurosta solidaginis* and *Epiblema scudderiana* accommodate ruperfusion (Harrison et al., 2018). Under anoxic conditions, a broad spectrum of metabolic events may take place which inhibit key aerobic pathways. Insects then switch to anaerobic metabolism to continue the production of ATP. This switch is often regulated by cellular signalling pathways that sense oxygen levels and trigger metabolic changes. In *Chironomus thummi* for example, exposure to anoxia led to severe decline in ATP levels, on the other hand ADP, AMP and IMP increased rapidly (Redecker and Zebe, 1988). In some cases, anoxic conditions in aquatic insects have led to accumulation of glycerol or conversion of carbohydrate to lactic acid, providing results similar to cold-acclimation (Heslop et al., 1963).

Role in insect pest management

Gaseous fumigants are often used as insecticides in storage conditions. Since the gases enter the body of the insect through the respiratory system, factors affecting respiration such as concentration of O_2, CO_2 and other gases play a potential role in efficiency of the fumigant toxicity (Lu et al., 2009). Modified or controlled atmospheres (MAs or CAs), which involve increasing or lowering the levels of atmospheric gases such as oxygen (O_2), carbon dioxide (CO_2), ozone (O_3), and nitric oxide (NO), offer a cost-efficient way to eliminate specific pests and safeguard stored products. Aerobic organisms depend on specific levels of oxygen for their survival. Manipulation of the level of oxygen present for utilization by the insects can greatly impact their normal physiological and biological conditions, resulting in high mortality rates. Insect tolerance to hypoxia has a crucial role to play in insect control (Cui et al., 2017). In case of *Sitophilus zeamais,* reduction of oxygen levels to 0% in 6–9 days in hermetic conditions, led to a significant decrease in the number of offspring when compared to weevils in non-hermetic conditions (Moreno-Martinez et al., 2000).

Conclusion

Continuous dearth of oxygen in living tissues leads to severe hypoxia or anoxia, conditions where there is a complete lack of oxygen. Insects, unlike vertebrates have a much developed although obscure, mechanism which enables them to recover from such conditions. Hypoxia is a well-studied phenomenon, with applications in various fields ranging from basic and comparative biology to biomedical sciences. Given their efficient tracheal system and their ability to escape hypoxic conditions through multiple developmental, physiological and ecological aspects, insects have become model organisms in the study of hypoxia. Hypoxia is a common occurrence in insect development and is a crucial factor in life-history trade-offs but the various mechanisms of functional hypoxia still remain an enigma. Despite all the research in this area of interest, many questions pertaining to species-specific adaptations to hypoxia still remain unanswered. Studies on the role of oxygen signalling in insect development and effects of hypoxia would provide a good insight to insect life support system. Additionally, by leveraging modified oxygen levels, pest management becomes a more sustainable and effective practice, providing long-term protection for stored products and reducing reliance on chemical pesticides.

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The meat-eating bees

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In the intricate web of the natural world, dietary habits play a crucial role in shaping the behaviour, physiology and ecological interactions of species. Among the myriad of dietary specializations, the phenomenon of meat-eating in bees presents a fascinating deviation from the norm. While most bees are renowned for their role in pollination and their diet of nectar and pollen, a unique subset of stingless bees, commonly referred to as vulture bees, has evolved to consume carrion. The existence of vulture bees, particularly within the genus Trigona, challenges conventional perceptions of bee behavior and ecology. These bees have developed specialized adaptations that enable them to thrive on a diet primarily composed of decaying meat, a stark contrast to the floral resources utilized by their pollen-collecting relatives.

Necrophagy in bees

Necrophagy is feeding on carrion or feeding on liquids exuded from carrion. There are two types of necrophagy in bees viz., facultative and obligate necrophagy. Facultative necrophagous bees primarily feed on nectar and pollen and sporadically on fresh animal carcasses for supplementing their floral diets (Dorian and Bonoan, 2021) which is seen in bumble bees like Bombus terrestris (L.), Bo*mbus ephippiatus* Sayand in many stingless bee genera *Partamona, Scaptotrigona*, and *Oxytrigona*. Whereas, obligate necrophagous bees are never found visiting flowers, instead they feed on fruits and extrafloral nectaries for their carbohydrate requirement and fresh animal carrion for protein and has been found only in three closely related *Trigona* species: *Trigona hypogea* Silvestri, *T. necrophaga* Camargo & Roubik and *T. Crassipes* (Fabricius) (Hymenoptera: Meliponinae).

Distribution and nesting behaviour of obligate necrophagous bees

Trigona hypogea and *T. crassipes* are found in Amazon basin and Guianas, while, *T. necrophaga* is endemic to Panama (Camargo and Roubik, 1990). Trigona hypogea is the smallest among these three and has hypogeous or ground nesting habit whereas, *T. crassipes*,the largest among these, construct nests within cavities of living tress at 2 – 10 m height and T. *necrophaga*, construct nests within cavities of living trees of 46-70 cm diameter, with their entrances 1.2-8.0 m above ground level. Just like pollinivorous stingless bees, necrophagous bees are eusocial, live in perennial colonies, exhibit social organisation and divides the task among themselves. Nest structure is basically same like that of any other meliponine bee. Inside a bee colony, there will be a queen, thousands of workers, and hundreds of males (Camargo and Roubik, 1990).

Adaptations in bees for necrophagy

There are few morphological adaptations that allowed the bees to forage on carcass.

(a) Toothed mandibles: Obligate necrophagous stingless bees have toothed mandibles i.e., they have five teeth in the mandible including three teeth in the apical region. Mandibles of pollinivorous stingless bees lacks apical tooth and have a blunt apical region. The teeth allowed the stingless bees to tear open the skin and to feed within.

(b) Reduced corbicula: Corbicula is a structure on hind tibia of bees that enables bees to collect pollen and in order to collect pollen, corbicula should have a concave surface on its outer side with hairs and bristles. Hind tibia of necrophagous bees is very slightly expanded toward its apex and not concave on its outer surface and the reduced corbicula makes them inefficient to forage on flowers and collect pollen.

(c) Lack of setae in labial palpi of workers: All other species of *Trigona* have giant setae or long, wavy hairs that are used to gather pollen from tubular anthers, which is greatly reduced in these three necrophagous *Trigona* spp. (Roubik, 1982).

(d) Specialised gut microbiome: Figueroa et al. (2021) found that pollinivorous stingless bee species harboured specialised gut microbiome that helped the bees in necrophagy. Microbes including A*cetobacter, Commensalibacter, Apilactobacillus* and other *Lactobacilli* were abundant in the gut of necrophagous bees and these microbes are believed to have a role ingut acidification as an important adaptation for carrion feeders. Further, lactic acid bacteria are known to prevent spoilage and growth of pathogenic bacteria in preserved meats via acidification, bacteriocins, and H_2O_2.

Food sources and maturation of honey by necrophagous bees

Trigona hypogea has two different food sources: (i) protein source - flesh from carcass and (ii) carbohydrate source - fruits and extrafloral nectaries. Bees remove flesh with the mandibles, cooperatively excavate holes in the bodies, and then move within the body cavity. Each feeding site appears wet and the bees masticate one spot for many minutes, imbibing liquid. Forager bees deposit animal protein into storage pots without involving the receptor bees. They also collect juice from fruits and extrafloral nectaries and deposit them in honey pots. These bees never visit flowers. Protein collected from animal carcasses deposited in special pots is mixed with honey and these pots remain open for about 19 h. They were then filled, capped, and allowed to mature for about two weeks. During this period, the animal-derived materials degraded into simple compounds and was ready for use by the bees. The stored substance was paste-like when placed in the pots and had the same colour as that of source from which it was collected. In the later days, the material became viscous, and after maturation it is honey-like, yellowish and homogeneous. The level of free amino acids increase as the level of soluble protein decreases during maturation. Simultaneously, sugars (total and reducing) increased as the bees added honey to the carrion-based mixture in the pots (Noll et al., 1996).

Predatory behaviour

Predatory nature of *T. hypogea* on living brood of social wasps was documented by Mateus and Noll (2004). They observed that bees removed immatures (larvae and pupae) from their cells by opening capped cells, chewed using their mandibles and, after the larval tissues were completely macerated, they were swallowed and the bees left behind only some brood remains (exoskeleton) that were probably impossible to macerate. This shows that *T. hypogea* is not only necrophagic but also takes advantage of living animal protein opportunistically and the predatory nature might not be an aberrant behaviour, but merely a lesser-known part of the bees' normal repertoire.

Conclusion

Meat eating bees or vulture bees feed on carrion for protein and on extrafloral nectaries and fruits for carbohydrate. It is still controversial if the honey they produce is from the meat they eat or from extrafloral nectaries. Bees are evolved from carnivorous wasps during cretaceous period and pollinivory paved way for their huge diversity. However, vulture bees have switched back to their ancestral lifestyle to tap the advantages of animal protein over pollen and may help them to survive competition by partitioning and repartitioning niche space.

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Giant willow aphid, *Tuberolachnus salignus* (Gmelin) (Hemiptera:Aphididae) : Biology, nature of damage and management

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The giant willow aphid, *Tuberolachnus salignus* (Gmelin) (Hemiptera: Aphididae: Lachninae), is a cosmopolitan pest that sucks sap from the stems of willow plants (*Salix* spp.) and has also been reported from poplar trees (*Populus* spp.) (Sopow et al., 2017). The origin of the giant willow aphid is considered to be Asia but has now spread to the regions where suitable hosts are present (Blackman and Eastop, 1994). This aphid spreads in spring, summer and autumn in its winged form whereas the wingless forms increase in spring and summer, peak in autumn and decrease in winter (Jones et al., 2021). When the infestation of giant willow aphids is high, a significant amount of honeydew can be witnessed on the affected branches of trees. They predominantly feed on stems and often appear in extensive colonies, covering over half of the bark surface (Collins et al., 2001). The infested tree can be observed from a distance due to conspicuous black-coloured sooty mould on twigs, branches and trunk of the tree. Although, this aphid is considered a major pest of willow, a forest tree, there have been records where it has been observed in fruit crops like apple and quince (Le Baron, 1972; Salisbury et al., 2022) which underscores its ability of being a potential pest to fruit crops.

Host range and distribution

Host range of giant willow aphid varies from forest trees like S*alix* spp. (*Populus* spp.) (Sopow et al., 2017) to fruit crops including apple and quince (Le Baron, 1972; Salisbury et al., 2022). Black Poplar tree (*Populus nigra* L.) and a shrub called *Coprosoma macrocarpa* was also recorded as its host (Charles et al., 2014; Sopow et al.,2017). Though the origin of giant willow aphid is Asia but it was also recorded in Auckland (New Zealand) on *Salix* × *fragilis* L. after which it was recorded in north and south islands of New Zealand (Gunawardana et al, 2014; Sopow et al., 2014). It was also recorded from Australia in early 2014 in New South Wales by State Government Victoria Department of Environment and Primary Industries. In India, the giant willow aphid was recorded on *Salix tetrasperma*, *Salix viminalis* and *Salix alba* in Karnataka, Spiti valley and Ladakh, respectively (Joshi, 1980; Sharma and Thakur; 1993; Hussain et al., 2021).

Nature of damage

Giant willow aphids have specialized mouthparts for piercing and sucking, particularly the stylet, consisting of food and salivary canal. This insect, known for its sap-sucking behaviour, forms colonies on the tender stems and branches of host trees, mainly targeting the phloem for feeding. The extraction of sap by giant willow aphids primarily occurs from recently developed phloem sieve tubes in proximity to the cambium (Mittler, 1957).

Among the affected trees, the colonies of giant willow aphids can be observed on twigs, branches and even the trunk, particularly near the tree basin. When the colonies of this insect are brushed off, there is the presence of distinctive marks caused by their feeding on the tree branches. In areas of extensive aphid infestation, one can readily observe a continuous release of honeydew due to which there is the development of characteristic black sooty mould on trees and basins of trees. Such infested trees can be observed from a distance due to their distinct black colouration. The honeydew oozing out of the affected trees attracts many honeydew-loving insects including bees and wasps. The buzzing sound of these insects around peach trees is an indicator of giant willow aphid infestation.

Morphology, biology and life cycle

T. salignus is a large, dark greyish to black coloured aphid having a size in the range of 5 to 5.8 mm (Blackman and Eastop, 1994). A distinctive feature of this aphid that differentiates it from other aphids is the presence of a greyish-golden abdomen with a characteristic black dorsal tubercle, measuring 0.2–0.3 mm in height, especially prominent in wingless adults. The antennae are shorter than the body. Winged forms have unpigmented forewing membranes with dark brown markings. A notable behaviour of the giant willow aphid colony is the collective lifting of hind legs while waving a hand over them (Hussain et al., 2021).

T. salignus reproduces parthenogenetically i.e. embryo development takes place without fertilization (Aradottir et al., 2012). The oviparous females, eggs and females are absent in *T. salignus* (Dhatwalia and Gautam, 2009). The colonies consist only of nymphs and adult parthenogenetic females. The nymphs undergo four developmental stages, with the youngest appearing light brown. As eggs are not produced, it is presumed that viviparous females overwinter and start emerging the following year (Aradottir et al., 2012). Martin (2017) suggested that the ability to overwinter is exclusive to the winged form, in contrast to Szelegiewicz (1962) who proposed that even younger nymphs can withstand winter conditions. Fang et al. (2016) observed aphids concealing themselves in the cracks of willow trunk bark, indicating a potential strategy for surviving harsh winter conditions. *T. salignus* has a mean generation time of 2–3 weeks when exposed to temperatures ranging between 17.5 and 22.5°C, with the most favourable development occurring at 20°C (Özder and Sağlam, 2008).

Uses of honeydew of giant willow aphid

Honeydew secreted by giant willow aphids has been utilized for various purposes in different regions of the world, for example, in the indigenous tribal community of Spiti Valley of Himachal Pradesh honeydew is collected and skillfully utilized to prepare a sweet delicacy known as Dungsee (Sharma et al., 1995) whereas, in some region of the world, it has been used as a dyeing agent for military uniforms (Charles et al. 2014). The secretion of honeydew from the giant willow aphid leads to an elevation in the C: N ratio in the affected soil (Tun et al., 2020). The honeydew contains a trisaccharide called melezitose which resists breakdown upon hydrolysis. Therefore, it acts as a potential prebiotic that supports the growth of beneficial gut bacteria in the human digestive system (Swears and Manley-Harris, 2021).

Management

There can be many management alternatives to control giant willow aphids but biological control is most appropriate since it is eco-friendly and carries low risks to ecosystems in contrast to chemical pesticides. Biological control agents, like natural predators or parasites, focus on specific pests without causing harm to other non-target organisms. Additionally, it diminishes reliance on synthetic chemicals, which may adversely affect human health, wildlife and the environment. Biological control methods present a more sustainable and ecologically harmonious strategy for handling aphid populations. Furthermore, biological control tends to be self-sustaining, as natural predators and parasites can establish and sustain themselves in the ecosystem, ensuring prolonged control without the necessity for repeated pesticide applications.

The coccinellid predator, *Harmonia axyridis* Pallas was identified as a potential predator of giant willow aphid in New Zealand (Sopow et al., 2017). Nevertheless, the efficacy of *H. axyridis* as a biocontrol agent remained uncertain, as it was unclear whether the aphid served as a preferred food source and supported the predator's development and reproduction. Other coccinellid predators like *Adalia bipunctata* L., *Coccinella undecimpunctata* L. and *Harmonia conformis* (Boisduval) has also been recorded on this aphid as a generalist predator. In Israel, a predatory midge, *Aphidoletes aphidimyza* (Rondani) was recorded on the colonies of this aphid. The parasitoid, *Pauesia nigrovaria* Provancher has proven to be highly effective, attributed to its specificity towards hosts and minimal associated risks (Sopow et al., 2021). Another parasitoid *Pauesia salignae* Watanabe is exclusively recorded on giant willow aphid and has been observed in various regions, including India, Japan, Korea, Taiwan, and the United States. *Dendrocerus carpentri* (Curtis) and *D. ramicornis* (Boheman) are the two hyperparasitoids recorded on giant willow aphids out of which *D. carpentri* was recorded in New Zealand (Takada, 1973; Walker and Cameron, 1981). However, their field efficacy has still not been explored. *Neozygites turbinatus* (R.G. Kenneth) Remaud and Keller, identified as the fungal parasite of giant willow aphid, have been recorded in Europe and Israel (Keller, 1997). Particularly during giant willow outbreaks in willow plantations, a significant infestation of willow aphids by this fungus has been observed. Barta and Cagáň (2006) conducted research indicating that this infestation has the potential to lead to the destruction of the aphid population.

The utilization of insecticides to combat giant willow aphid-infested trees is considered unsuitable for widespread or prolonged control due to the potential harm it poses to non-target bees. However, chemical control might be deemed a viable short-term solution in specific locations where an elevated presence of wasps attracted to honeydew poses a risk to human health, such as instances of stinging incidents (Sopow et al., 2017). Additionally, targeted methods can be employed to safely manage wasps, regardless of aphid populations.

Conclusion

The giant willow aphid, *T. salignus*, represents a significant challenge for both natural and horticultural systems due to its widespread distribution and ability to infest a variety of hosts, including willow trees and fruit crops. Its impact on affected trees is multifaceted, ranging from direct damage through sap-sucking to indirect effects such as the production of honeydew and the growth of sooty mould. Understanding the biology and life cycle of the giant willow aphid is crucial for implementing effective management strategies. While chemical control methods exist, they pose risks to non-target organisms and are not considered sustainable in the long term. Biological control methods, on the other hand, offer a more eco-friendly and sustainable approach, utilizing natural predators and parasites to regulate aphid populations. Research into the economic importance of giant willow aphid honeydew has revealed its potential utility in various applications, including as a drink, a dyeing agent, and even as a prebiotic. However, its impact on affected trees and ecosystems must be carefully managed to prevent widespread damage. In conclusion, addressing the challenges posed by the giant willow aphid requires a comprehensive approach that integrates biological, chemical, and cultural control methods while considering the economic and ecological implications of each strategy. By doing so, we can strive towards sustainable management practices that mitigate the impact of this cosmopolitan pest on both natural and agricultural environments.

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Unmanned aerial vehicle (UAV) assisted insecticide application in crop management

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Ensuring the efficient and prompt application of plant protection measures is crucial in agriculture. Unmanned aerial vehicles offer advantages in this regard, such as increased efficiency, decreased labour demands, time and energy savings, swift response times, extensive area coverage, and enhanced environmental safety (Subramanian et al., 2021). The Central and state agriculture departments, research institutions, and manufacturing companies have focused on developing and manufacturing drones to meet the needs of Indian agriculture. The most recent standard operating procedure (SOP) regarding the UAV assisted application of insecticides in India was published in the year 2023 (https://farmech.dac.gov.in/New_Folder/TTC_SOP_2023-4.pdf). It is a significant development in agricultural technology that makes accurate chemical administration at the field level. This SOP guarantees effective, safe, and ecologically responsible insecticide application under a variety of agro-climatic situations by simplifying processes and attending to crop-specific requirements. This comprehensive manual provides farmers with adequate information and resources to maximize their crop management techniques. It was developed cooperatively by specialists from various sectors, including the Ministry of Agriculture, ICAR institutes, state agricultural universities (SAUs), and drone industries. This SOP signifies a new era of precision farming by embracing the transformational potential of UAV technology, which will help in increasing agricultural output, profitability, and sustainability.

Evolution of Drones

Amid the enigmatic skies of innovation, the story about drones is unfolded. In 1907, the Brequet brothers debuted the Gyroplane No.1, a quadcopter that flew a few feet above the ground. The Kettering Bug appeared in 1915 during World War I, capable of attacking targets up to 120 km away. In 1920, Etienne Oehmichen's No.2 quadcopter defied critics by hovering smoothly. The 1980s saw the development of covert military prototypes for reconnaissance. In the 2000s, consumer drones such as quadcopters and hexacopters were used to capture landscapes and memories. The 2010s saw a revolution, with drones changing agriculture, filmmaking, and delivery. Abe Karem is considered as the founder of drone technology, where he built the first fully functional drone for Israel in 1974, but not meant for agriculture. Drones have witnessed fast development and increased use since 1991, beginning with continuous deployment during the Gulf War. The Predator drone, introduced in 1996, revolutionised weaponized drones. Following Hurricane Katrina, UAVs were allowed in US civilian airspace for disaster relief in 2006, boosting the consumer drone business. In 2010, Parrot introduced the AR Drone, which can be controlled via smartphone. DJI's Phantom series, which debuted in 2013, helped popularise consumer drones. The same year, firms like FedEx and Amazon began investigating drone delivery. Since 2014, drone use has increased dramatically across industries, with the market expected to reach $92 billion by 2030. In 2020, drones played an important part in pandemic response, prompting regulatory adjustments and new applications in India as well as in other parts of the world. Drones are now-a-days ubiquitous, monitoring electricity lines and, recording epic sagas, weaving tales over the skies (Consortiq- https://consortiq.com/uas-resources/short-history-unmanned-aerial-vehicles-uavs).

Application of UAVs in Agriculture

UAV, which stands for unmanned aerial vehicle, often referred to as Drone is an aircraft without a human pilot on board. UAVs may fly either under remote control by a human operator or, if so designed and equipped, autonomously via onboard sensors, navigation systems, and computers (Advanced Navigation-https://www.advancednavigation.com/glossary/uav). Unmanned aerial vehicles were first utilised in agriculture in 1921, when the USDA and US Army used them to dust crops. Thurling was the first to utilise a camera on a drone, capturing vertical shots of weeds back in 1985. Yamaha launched the R-50, the first UAV for crop dusting, in 1987 and commercialised it in 1989.

In modern precision agriculture, UAVs (drones) are critical for proactive monitoring and quick response to difficulties. They undertake duties such as agro-spraying, which can cover up to 10 acres per hour (Ukhurebor et al., 2022), decreasing labour and lowering health hazards associated with chemical exposure. UAVs capture real-time photos and videos, allowing for faster agricultural interventions and improved farm security. They are less expensive than other sensing technologies, particularly for medium- and large-scale farms (Norasma et al., 2021). UAVs provide noninvasiveness, adaptability, and efficiency. They enable remote surveying and analysis of soil properties, facilitating informed decision-making. Tailored SOPs optimise drone use according to climate and terrain, increasing efficiency and sustainability. Overall, UAVs revolutionise agriculture by improving precision, efficiency, and sustainability.

Techniques for creating SOPs for drone-assisted insecticide application in crops

It involves thorough data collection *via* online survey schedules and rigorous scientific debates. Committee members held multiple discussions with industry representatives in order to ascertain what experimental data was needed in order to formulate the SOP. A survey schedule was carefully designed, covering a range of topics including pesticide formulas, drone specifications, and environmental conditions. This schedule, which allows for both traditional and online submission, was distributed to ICAR Institutes, SAUs, and the private sector. Seventy-seven replies in all, encompassing a variety of experimental data on drone-assisted pesticide application across ten key crops, were received. Using this information, particular SOPs were created, concentrating on important factors including crop canopy volume, development stages, pesticide dosage and concentration, and operating circumstances to guarantee accuracy and effectiveness in pesticides application *via* drones.

SOPs (Standard Operating Procedure) of some chosen crops

Ten crops (rice, maize, cotton, groundnut, pigeon pea, safflower, sesame, soybean, sugarcane, and wheat) were the subjects of the data collection. SOPs were customized to ensure maximum bio-efficacy and absence of phytotoxicity based on drone, sprayer, crop, and weather data. We assumed a conventional drone, under 25 kg in weight, with a 10-liter tank. To minimise drift and crop damage, the drone's height above the crop canopy and speed of flight were optimised. Across the range of pesticide doses evaluated, no phytotoxicity was seen. The Southern Plateau and Hills, Trans-Gangetic Plains Agro-climatic areas, were the sites of the experiments. During spraying, drone flying speed varies between 4-5 m/s on average. In the case of sugarcane and soybeans, it may be lowered to 2-4 m/s. Drone height above the canopy can be maintained at 1.5–2.0 m, but for sugarcane and wheat, it is more than 3 m. On average, water volume is maintained at 20 l/ha in the early stage and 25 l/ha in the later stages of the crop. Anti-drift flat fan nozzles are used where the droplet size for insecticides is maintained at 250–350 μm with a 0.3–0.6 litre/minute discharge rate and a 60–120° angle for spraying. Pressure is maintained at 2–3 bars. Most preferably, <35°C temperature is maintained along with >50% humidity. Spraying is strictly prohibited during rainy, foggy, or misty conditions (Crop Specific Standard Operating Procedure (SOP) for the Application of Pesticides with Drones, Ministry of Agriculture and Farmers Welfare Department of Agriculture and Farmers Welfare, 2023).

General instructions for pest management in crops

1. Avoid spraying if heavy rain is forecast in the next 1-2 days.
2. Choose targeted insecticides over broad-spectrum insecticides, ideally those with green labels.
3. Rotate insecticides to prevent using the same one again or those with similar modes of action.
4. Use insecticides only as a last resort, particularly when the pest to damage ratio is high.
5. Use bio-pesticides or chemicals sparingly, according to package recommendations, and target susceptible pest life phases.
6. When working with insecticides, always wear protective gear such as masks and gloves.
7. Wait 48 hours after spraying before visiting the field, and allow at least 30 days before harvesting maize corn following chemical application.

Recent government initiatives for facilitating the use of drones in agriculture

The Indian government has offered a series of drone purchasing incentives in order to make drones cheaper to farmers and other stakeholders, as well as to promote drone use. To encourage the usage of Kisan Drones, the Indian Agriculture Ministry is

Table 1. Crop wise list of insecticides tested for crop safety using UAVs

Sl. NO	Insecticide	Formulation	Crop
1.	Chlorantraniliprole	18.5SC	Rice
2.	Triflumezopyrim	10SC	
3.	Pymetrozine	50WG	
4.	Dinotefuran	50SG	
5.	Cartap hydrochloride	50SP	
6.	Flonicamid	50WG	Cotton
7.	Spinetoram	11.7SC	
8.	Fipronil	5SC	
9.	Diafenthiuron	50WP	
10.	Imidacloprid	17.8SL	
11.	Chlorantraniliprole	18.5SC	Redgram
12.	Flubendiamide	39.35SC	
13.	Indoxacarb	14.50SC	
14.	Spinosad	45SC	Redgram
15.	Emamectin Benzoate	5SG	
16.	Chlorantraniliprole	18.5SC	Groundnut
17.	Chlorantraniliprole	18.5SC	Soybean

(Source: SOP for the application of insecticides with Drones, Ministry of Agriculture and Farmers Welfare Department of Agriculture and Farmers Welfare, 2023) granting a 50% or maximum INR 0.5 million subsidy to SC-ST, small and marginal farmers, women, and farmers in the northeastern states to purchase drones. Other farmers will receive financial help up to 40%, or a maximum of INR 0.4 million. Farm Machinery Training & Testing Institutes, ICAR institutions, KVKs, and SAUs are eligible to get full financing for drones from the central government for demonstration purposes.

The followings are key government initiatives to promote the usage of drones:

1. The Liberal Drone Rules, 2021, are one of the main government initiatives to encourage the use of drones.
2. Drone Airspace Map, which opens 400 feet to 90% of the airspace.
3. The drone production-linked incentive programme, or PLI.
4. Policy Framework for UAS Traffic Management (UTM).
5. A simpler procedure for drone certification under "Drone Certification Scheme 2022".
6. Mission 'Drone Shakti' (launched on 1st February, 2022) which aims to assist drone related startups.
7. Import restrictions on foreign drones but the ease in importing parts of drones from abroad was notified under the Drone import policy in February 2022.
8. The Ministry of Agriculture launched a financial subsidy programme in January 2022 with the goal of making it easier for people to buy agricultural drones etc.

Bharat Drone Mahotsav 2022, held on 27th and 28th May in New Delhi, was India's biggest drone festival till date. Prime Minister Narendra Modi opened the event, spoke with kisan drone pilots, and saw drone displays. Over 70 exhibitors demonstrated a variety of drone applications, including a Made in India drone taxi prototype. The festival highlighted the government's efforts to advance the drone sector, particularly in the field of agriculture (Beriya, 2022).

Conclusion

A notable achievement in agricultural technology is the creation of an Advanced Standard Operating Procedure (SOP) for Accurate Drone Assisted Insecticide Application in Crop Management. This all-inclusive manual, which was created by professionals from several fields working together, leverages the revolutionary potential of drone technology to guarantee accurate, secure, and environmentally responsible pesticide application. This method, which ushers in a new era of precision farming, maximizes productivity and sustainability by customizing SOPs to particular crops and environmental conditions. The focus on pesticide compounds relevant to certain crops and general pest management guidelines emphasizes the dedication to efficient and ethical farming techniques. As technology progresses and costs decline, drones are becoming increasingly affordable and accessible for agricultural purposes. This affordability and accessibility have spurred greater adoption among farmers, especially small-scale ones who previously lacked access to such technology.

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Lac ecosystem: Complex yet fascinating

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Lac insects belonging to the genus *Kerria*, family Tachardiidae, and order Hemiptera are commercially harnessed for resin, dye, and wax. Owing to their nontoxic and harmless nature lac products find an incredibly wide range of applications in food, pharmaceuticals, cosmetics, paints, varnishes, surface coating industry, confectionery industry, postal department, fruit and vegetable coating, soft drinks, *etc*. Due to its great demand in the international market, a significant portion of lac (7293.47 tonnes) in different forms was exported to foreign nations and earned foreign exchange of Rs. 405.51 crores during 2019-20 (Yogi et al., 2021). Shellac, a refined lac product, has been permitted as a food additive by the European Union (EU) with E number E904 and has also received a GRAS (Generally Recognized as Safe) status from the U.S. FDA (Srivastava and Thombare, 2017). Since lac resins represent a significant part of raw lac, they can be hydrolyzed into their constituent acids. One of the constituent acids, aleuritic acid is used as a precursor for the production of a variety of high value chemicals such as isoambrettolide. Another product, lac dye, which is poly hydroxy anthraquinone derivatives has brilliance and fastness and is used for dying silk and wool.

The lac insect is a unique species of scale insect that feeds on a particular class of plants called lac hosts. These host plants together with the lac insect make up an ecosystem that is a complex multitrophic web of flora and fauna. The flora and fauna of this lac environment are part of a complex, multi-trophic network that displays a great variety of biodiversity. In addition to the lac insects, it also includes host plants, several lac insect predators and parasitoids secondary parasitoids microbes, and a variety of host plant pests. The first trophic level in this ecosystem is made up of the host plants for lac insects, followed by the second by lac insects, pests of host plants, the third by primary parasitoids and predators of lac insects, and the fourth by hyperparasitoids of lac insect pests and the fifth by microbes inhabiting these flora and fauna and even soil.

Trophic level 1: Lac host plants

Lac insects thrive by sucking phloem sap from the delicate branches of the host plant. Lac insects can live on over 400 plant species that grow naturally in forests (Kapur et al.,1954). Lac production and quality are mainly dependent on the host plant and lac insect strain. As lac insect is immobile almost throughout its life (except for crawlers and adult males) and attaches to the host plant where it can obtain nourishment efficiently and with a greater affiliation, the host plant plays a critical role in the production and regulation of lac. The quality of lac pigment (erythrolaccin) present in the resin also relies upon the lac insect and the host plant on which the insect is growing (Mishra et al., 1999).

Lac host plants can be divided into numerous categories based on the degree of preference of lac insects for specific hosts and the quantity and quality of lac obtained by inoculating the host. Firstly, some species make notable hosts throughout the year and anywhere they exist. Secondly, some species are good hosts in certain restricted areas of the country, while in other areas these species are not suitable for lac cultivation. Thirdly, there are hosts which are major hosts for positive precise functions in certain specified seasons. Again, at the same time as one sole or sort of host species is a good host, another (which might be botanically indistinguishable from the first) may be a non-host (Sharma et al., 2024 under publication). Based on lac cultivation and use possibilities for domestic distribution, lac host plants are grouped into

3 categories (Srivastava, 2011) common host plant, occasional host plant, and rare host plant. Out of 400 identified lac hosts, few are of commercial importance. The traditional lac hosts in this country are *Schleichera oleosa* (*kusum*) (Fig. 1a), *Butea monosperma* (*palas*) (Fig. 1b) and *Ziziphus mauritiana* (*ber*) (Fig. 1c). *Flemingia semialata* (Fig. 1d) has gained popularity as a lac host due to its bushy nature, facilitating cultural operations easily. There are a few endemic hosts and recently diagnosed as potential hosts. Those include *Ficus* spp*., Samanea saman, Cajanus cajan* (pigeon pea), *Malvaviscus penduliflorus*, *Calliandra calothyrsus*, and *Calliandra surinamensis*. *Ficus* spp. generally act as broodlac savers during summer.

Trophic level 2

A. Lac insects

Out of the reported nine lac insect genera and 101 species in the world, two genera and 28 species are found in our country, representing 27.7% of the known lac-insect species diversity (Sharma et al., 2024 under publication). Under the *Kerria* genera 24 species are found in India (Garcia et al. 2016). *Kerria lacca* is the most important and widely cultivated commercial lac insect in India. *Kerria chinensis* and *Kerria sharda* are also cultivated to some extent. Based on the life cycle, lac insects are particularly divided into two strains, *rangeeni* and *kusmi*. Both the strains are categorized into two crops each i.e., for *kusmi*,theyare *aghani*(from June/July to January/February) and *jethwi* (from January/February to June/July) and its main host plant is *S. oleosa*, and for *rangeeni*, they are *katki* (from May/June to October/November) and *baisakhi* (from October/November to May/June) and its main host plant is *B. monosperma*. *Kusmi* strain secretes superior quality resin compared to *rangeeni* and it is indigenous to India.

Life cycle of lac insects: Lac insects are ovoviviparous insects that produce juveniles after hatching within the mature female cell. Biologically, lac insect's life cycle is divided into three stages: nymph, pupa and adult and practically as crawler, settled nymph and adult. Crawlers are tiny boat-shaped nymphswith three pairs of legs and a pair of antennae, as they come out of the female insects and crawl throughout the tree branch in search of soft branch to get settled so that they can feed by piercing the shoot with their long proboscis and do not move afterward.

Following one to two days of settlement, settled nymphs begin secreting resin through resin glands that are located throughout the cuticle region. They gradually transform into males and females through three moultings although in distinct ways of metamorphosis. For example, only males go through complete metamorphosis, whereas females do not go through the pupal stage. After the first moult, both of them lose legs, eyes, and antennae and transform into second instar. Then second instar male lac insects get transformed into pre-pupa and later undergo metamorphosis into pupa where they stop feeding where the degeneration of internal organs from larval stage starts and histogenesis begins. Male and female can now be distinguished at this moult stage as the male is elongated or cigar-shaped while the female is round-shaped. After that, those who get transformed into males (both winged and wingless) come out from the encrustation sacrificing their piercing mouth part. Then males fertilize female lac insects which cost them their life as without nutrition they survive for a few days and die. After fertilization, females secrete more resin and continue to grow bigger to accommodate the young ones. After attaining maturity, eggs are laid in the cavity by shrinking of the female cells, which are identified by yellow dots on the lac encrustations. Each female is capable of laying 200–500 eggs which hatch immediately inside the encrustation and emerge out of the female. This is called swarming, and the life cycle goes on (Fig. 2).

B. Lac host associated fauna

Like other plants, lac host plants are also subjected to attack by hordes of insect pests. There are different types of lac host plant pests available which are also components of the second trophic level. They include sap sucking insects, defoliators, pod borers, seed borers *etc*. which damage host plants. Since the productivity of lac depends on the availability of healthy shoots on host plants, damage done by insect pests has direct bearing on it. According to reports, significant lac host plants are infested by 61 sporadic and minor pests, including roughly 19 major pests (Sharma and Ramani, 2001). A pest complex of about 32 insect pests belonging to six orders and 20 families has been recorded on *Flemingia semialata* (Meena et al*.,* 2014). Egyptian cottony cushion scale, *Icerya aegyptiaca*, scale insect, *Aulacaspis* sp., leafhopper, *Amrasca biguttulla*, weevils, *Amblyrrhinus poricollis* Schoenherr and *Peltotrachelus* sp., sweet potato bug, *Physomerus grossipes* Fabricius, soapberry bug, *Leptocoris augur* (F.) have been reported as pests on *kusum* (Singh et al., 2014).

Trophic level 3

Lac crop is destroyed by a number of major and minor pests, which not only dramatically reduces the yield but also has an impact on the quality of the lac. Since lac insects are sedentary, they are more vulnerable to predators and parasitoids. Predators include both vertebrate and invertebrate species, while the parasitoids are all insects. On average, loss to the lac crops by these predators and parasitoids results in 35-40% of the damage annually. Twenty species of lac insect predators, 30 species of primary parasitoids, 45 species of secondary parasitoids are known (Das, 1990).

A. Predators

The lepidopteran predator makes a tunnel inside the lac and makes a hole while adult emergence damaging the resin cover. On lac, there are three main predators *Eublemma amabilis* (Fig. 3a)*, Syncola* sp. (Jadhav et al., 2020; Fig. 3b)*, Chrysopa* sp. (Fig. 3c); the first two cause severe damage compared to *Chrysopa* sp. (Bhattacharya et al., 2005). Relative abundance of the major lac predators differs with the strains of lac insects. The number of *E. amabilis* is higher than that of *Syncola* sp. on *rangeeni* lac insects, whereas it was just the reverse on *kusmi* insects. Another predator, *Chrysopa* sp. was recorded only from *kusmi* lac insects casually and in low numbers. The abundance of lac predators is very much dependent upon the availability of food as their number increases in the growth of lac insects which finally attain a size 6-8 times that of larva at birth. Predators are more numerous during the summer crops (*baisakhi* and *jethwi*) than in those passing through rainy seasons (*katki* and *aghani*). There are a few vertebrate predators of lac insects, including monkeys, squirrels, rats, woodpeckers, and birds (Lalita, 2020). These vertebrate predators indirectly help in carrying the lac insects to newer locations.

B. Parasitoids

Parasitoids harm the lac insect by laying their eggs inside the lac cell and larvae hatch from the eggs, feed on the lac insect and destroy the whole crop. *Aprostocetus purpureus* (Fig. 3d) is the most abundant species followed by *Tachardiaephagus tachardiae* (Fig. 3e) and these together constitute 84.19% of the lac pest population (Sharma et al., 1997). The numbers of other parasitoids particularly *Parechthrodryinus clavicornis*, *Coccophagus tschirchii, Eupelmus tachardiae* are low and do not differ much among themselves within the crop. *Rangeen*i strain crops are more damaged during the damp season (*katki* crop) because they are more susceptible to pest attack rather than *kusmi*. In *kusmi* and *rangeen*i strains, the amount of resin was reduced by 17.92% and 17.44%, while fecundity was reduced by 32.55% and 34.71%, respectively due to parasitoids (Sharma and Ramani, 2001). Damage caused by parasitoids varies depending upon the virulence of outbreak and the stage of development of lac insect at which damage is inflicted.

Trophic level 4: Hyperparasitoids

Hyper parasitism is the development of secondary insect parasitoid at the expense of primary insect parasitoid. Insect hyperparasitoids, the most diverse members of insect food web therefore attack another insect developing or developed in or on another insect host, which can affect the biological control of the pest. There are two types: i. True hyperparasitoids which parasitize the larvae of their hosts (parasitoids), reaching these larvae with their ovipositor through the herbivore that hosts the parasitoid larva. ii. Pseudohyperparasitoids which attack the pupae by laying their eggs on the parasitoid (pre)pupae.

The common lac hyperparasitoids are *Elasmus claripennis*, *Eurytoma pallisdiscapus, Brachymeria tachardiae, Apanteles tachardiae* (Fig. 4a), *Apanteles* sp., *Bracon greeni* (Fig. 4b) and *Pristomerus sulci* (Mohanasundaram et al., 2016). *E. claripennis* is a parasitoid of the important lac predator, *E. amabilis* which emerges to be an implicit biotic agent in the natural control; it has a short life cycle 11-20 days in summer and rainy season, and 20-32 days in winter, a favorable female ratio (84.3%), relatively high fecundity (on an average 28.4, and a maximum of 118 eggs/female), an adult life (approx. 26 days for female and 8 days for males), activity which is well synchronized with that of the host, has no hyperparasites and parasitizes the host larvae in their early instars (Meena and Sharma, 2018). Since hyperparasitoids have the potential of biological lac pest control, they are positive players in lac cultivation.

Trophic level 5: Microbes

Insects and plants have partnerships with microbes to develop novel useful functionalities. Bacteria perform a variety of advantageous tasks for their hosts, such as boosting stress resistance, protecting against adversaries, and even developing resistance to insecticides, *etc*. However, the supply of dietary supplements is the most typical host advantageous characteristic. The microbial partners which are symbionts to host insects (including lac insects, lac predators, parasitoids, hyperparasitoids, and lac host pests) are called endosymbionts, and those are symbionts to host plants are endophytes.

A. Endophytes

Endophytes are diverse group of microbes that usually impact plant communities by increasing fitness which is achieved through conferring of abiotic and biotic stress tolerance, increasing biomass, decreasing water consumption. Endophytes produce a broad range of phyto-hormones, such as auxins, cytokinins, and gibberellic acids to assist proper growth of the plants. They are also capable of synthesizing bioactive compounds that are used by plants for defense against pathogens and some of these compounds have proven to be useful for novel drug discovery as well as in industries, and agriculture. Depending on how they interact with their host plant, they might be categorized as advantageous, neutral, or harmful. Endophytes are often found in the vascular tissues and intercellular space of plants. The endophytes *Agrobacterium larrymoorei*, *Rhizobium sp*., *Sphingomonas sp*., and *Priestia megaterium* have been identified from the phloem sap of lac host plants, *Flemingia* spp. (unpublished data from our lab). Bacterial strains were isolated from the root nodules of *Flemingia* spp. and are classified as *Bacillus* (55%), *Rhizobium* (10%), *Pseudomonas* (10%), *Agrobacterium* (4%), *Brevibacillu*s (4%), *Ensifer* (4%), *Lysobactor* (4%) and new (10%) based on 16S rDNA genotyping. Rhizobial culture-treated plants showed significant increase in plant height, nodule count on roots, and leaf area by 62%, 32%, and 50%, respectively (Tribhuvan et al., 2017). Endophytes with positive impact on plant growth and health would have a beneficial role in lac production.

B. Endosymbionts

Interaction of insects and microbes are from obligate mutualism to facultative parasitism. Insects shelter symbiotic bacteria on the integument, in the digestive tract, and in some unique structures within their body. The role of endosymbionts in insects includes digestion (of recalcitrant food), nutrition (supplementation of vitamins and other essential nutrients), protection (production of anti-fungal agents, detoxification of pesticides), resistance (against predators, parasites and pathogens), inter and intra-specific communication (pheromone production), increasing efficiency as disease vectors, host insect morphogenesis and temperature tolerance (Dillon and Dillon, 2004).

Lac insects are associated with both bacteria and fungi. Bacteria are mostly symbiotic and sometimes pathogenic. *Wolbachia* is the most ubiquitous endosymbiotic bacteria of insects, which is present in lac insects and may have been held responsible for its putative role in lecanoid chromosome system of sex determination and in the biased sex ratio of *K. lacca* population (Jaipuriar et al., 1985). *Wolbachia* mainly undergoes vertical transmission from mother to offspring. Other than *Walbachia*, *Pantoea* sp. was found to be another dominant bacterial genus found in lac insects (Kandasamy et al., 2022). It was also found that the bacterial diversity varies between different life stages of lac insect and lac insects grown on different host plants. *Bacillus kochii, Bacillus oceanisediminis, Bacillus amyloliquefaciens*, *Bacillus nakamurai*, and *Enterobacter cloacae* were observed on *kusmi* lac insects collected from *kusum*. *Klebsiella quasipneumoniae* subsp. *similipneumoniae, Citrobacter amalonaticus*, *Providencia vermicola* and *B. nakamurai* were found in lac insects collected from *ber. Enterobacter ludwigii, B. nakamurai* and *Enterobacter cancerogenus* were found in lac insects collected from *F. semialata* (Thamilarasi et al., 2018).

C. Fungal growth on lac insects

Lac insect association with fungi is not always beneficial. Being phytosuccivorous in habit, lac insects excrete large quantity of sugar-rich honeydew which becomes a major cause of fungal contamination. *Capnodium*, *Fumago*, *Conidiocarpus*, *Polychaeton* sp. *Aspergillus awamori* Nakazawa, *Aspergillus terricola* and *Penicillium citrinum* are some of the fungi present on lac crop (Sharma and Jaiswal, 2011). A complex of fungal species inhabits the lac insects and causes sooty mold disease of lac crop. Fungal infection affects lac yield by inhibiting respiration, mating process and larval emergence (Sharma and Kandasamy, 2023).

Others

Besides fungal growth, honeydew serves as an excellent medium for bacterial growth. *Enterobacter sp., Klebsiella variicola*, *Stenotrophomonas maltophilia, Pantoea cypripedii*, *Pseudomonas stutzeri, Pantoea dispersa, Bordetella trematum* and *Cedecea davisae* were isolated from lac insect honeydew (Shamim et al., 2019).

The honeydew that the lac insect excretes is naturally consumed by several ant species, honeybees, and other insect species, preventing losses due to fungal infestation. This illustrates the importance of honeydew in the development of tri-trophic interactions between plants, insects, and their natural enemies.

Conclusion

Lac insects are one of the most fascinating insects known to mankind and such is the ecosystem in which they exist. This article described only the biotic components of the lac ecosystem; however, abiotic components also have a remarkable role in lac production. Systemically studying lac ecosystem provides clues to the researchers in increasing lac production and also to control lac insect pests and diseases. Although the lac ecosystem is studied greatly, still more studies are needed to further explore the lac ecosystem and tweak the system in more fruitful ways.

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Fig. 1a. *Kusum* tree

Fig. 1b. *Palas* tree

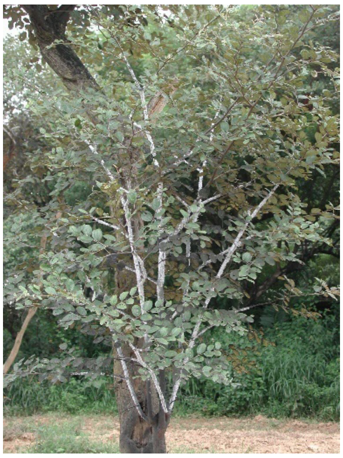

Fig. 1c. Lac insects on *ber* tree

Fig. 1d. Lac insects on *Flemingia semialata*

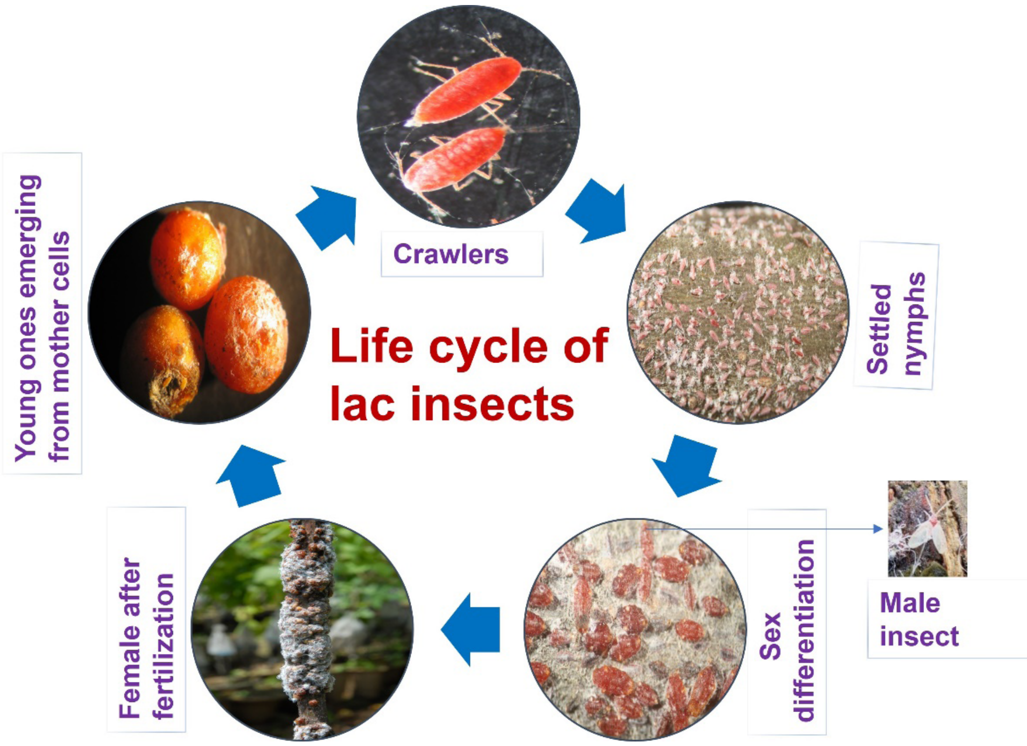

Fig. 2. Life cycle of lac insects

Fig. 3a. *Eublemma amabilis*

Fig. 3b. *Syncola* sp.

Fig. 3c. *Chrysopa* sp.

Fig.3d. *Aprostocetus purpureus*

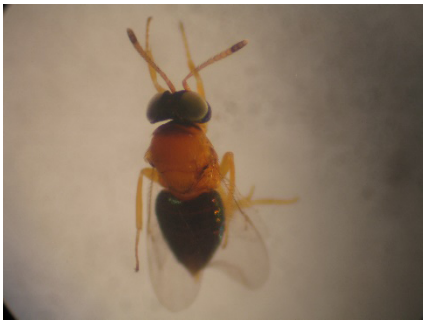

Fig. 3e. *Tachardiaephagus tachardiae*

Fig. 4a. *Apanteles tachardiae*

Fig. 4b. *Bracon greeni*

All figures courtesy: Dr. A. Mohanasundaram

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FIELD NOTE

First report on red palm weevil (*Rhyncophorus ferrugineus*) as entomophagy from chhattisgarh, India

Rajesh Kumar Patel, Beena Singh and Vandana Chadar

Abstract

In India red palm weevil is one of the serious pest of coconut but the indigenous tribes of Abujmarh, Orcha of Naranpur, Bastar, Dantewada and Sukma districts of Bastar Division of Chhattisgarh consumes grub stage of red palm weevil for their own diet still it is not commercialized. Gond, Muria, Abuj Maria and Halba people popularly called it as Ind pudg in Gondi and Chhind keeda in Halbi dialect. They collect it from dead wild date palms from month of April to June. The grubs are tasty with high nutritional value.

The word 'Entomophagy' is composed of two Greek words i.e. "Entomon" meaning insects and "Phagein" meaning food. Thus, entomophagy refers to the practice of eating insects. Insects are eaten by humans as food for over a thousand years since the time of hunters and gatherers and this practice continues for several years with subsequent civilization. Insects, a traditional food in many parts of the world, are highly nutritious and especially rich in proteins and these represent a potential food and protein source. There is huge entomophagy diversity in India. Over 2100 species of insects are available as food (Fontaneto et al., 2011). The United Nations Food and Agricultural Organization (FAO) report mentioned that the maggots of different edible insects are rich in calcium, potassium, magnesium, zinc, iron, and also in B-vitamins (Fromme, 2002). The insects are also a source of protein, amino acids, vitamins, fats, and trace elements (Alamu et al., 2013). As a side dish, people like to eat de-oiled silkworm pupae meal and red ant chutney (Malakar, 2022). The red palm weevil, *Rhynchophorus ferrugineus* (Olivier) (Coleoptera: Curculionidae) is one of the promising insects with potential in foodstuff application. It is believed that with the advancement of new knowledge and technology, edible insects, specifically RPW larvae, would gain more acceptance globally, expand their market, and serve as a more sustainable alternative to meat (Fernado et al., 2022).

The word Abujmarh means "the unknown hills" in the Gondi language native to the region. Abujmarh is a hilly forest area, spread over 4,000 square kilometres (1,500 sq m) in Chhattisgarh, covering Narayanpur district, Bijapur district and Dantewada district. It is home to indigenous tribes of India, including Gond, Muria, Abuj Maria and Halbas. It was only in 2009 that the Government of Chhattisgarh lifted the restriction on the entry of common people in the area imposed in the early 1980s. Geographically isolated and largely inaccessible, the area continues to show no physical presence of the civil administration (Annonymous, 2010 and Mittal, 2012).

Seasonal availability of edible weevil:

The indigenous tribes of Abujmarh, Orcha of Naranpur, Bastar, Dantewada and Sukma districts of Bastar Division of Chhattisgarh (Fig. 1 and Fig. 2) consumes grub stage of the red palm weevil for their own diet still it is not commercialized. The grub collection is practised during April to June month from wild date palms in the forest.

Cultural practices associated with collection of edible weevil:

The Maria and Muria tribes of Abujmarh, Narayanpur utilises wild date palm mainly for the purpose of sap tapping. They cut the crown region of palm tree for tapping tadi. The wild date tree is fail to producing sap after 4-6 years of tapping practice. The unproductive

Fig.1 Chhattisgarh

Fig. 2 Bastar Division

trees are cut and collect the grubs. Due to cutting for sap tapping attracts the female of red palm weevil for egg laying. In fact this grub is a serious pest of the wild date palm as well as coconut causing damage by feeding internal tissue of the palms.

Mode of insect consumption:

Gond, Muria, Abuj Maria and Halba people popularly called it as ind pudg in Gondi and Chhind keeda in Halbi dialect. Only the grub stage is used to eat by the tribes. The collect grubs, cleaned properly then boil, oil fried, cocked like vegetables and remaining grubs will sundry and stored for future. They also sale the fresh or sun dried grubs in local market in Tongpal area of Sukma district. Both the larval and the pupal stages of *R. ferrugineus* were analyzed for their nutrient composition, protein solubility, mineral, functional and anti-nutritional factors. The pupal stage had higher protein content (32.27%) than the larval stage which had 30.46%. The fat content of the larva was 22.24% while that of the pupa was 19.48%. The ash content was higher in the larva (7.64%) than that in the pupal stage (6.34%) as reported by Abdel et al., 2017. The crude fat, protein and chitin contents were 52.4–60.1%, 18.0–28.5% and 3.8–4.5% (dry weight), respectively. The sago palm weevil larvae were rich in macro- (potassium, phosphorus, magnesium, sodium, and calcium) and micro- (zinc, manganese, iron, and copper) elements (Chinarak et al., 2020).

Conclusion

Edible insects are a sustainable natural food supply with health, economic, and ecological advantages for people all over the world. Insects are the ideal food because of their high protein content, digestibility and combination of minerals, vitamins, lipids, and carbohydrates. Entomophagy is currently, however, a less widespread practice. As food scarcity in India worsens on a daily basis, entomophagy needs to be revalidated and pushed in the near future. The fundamental issue in this scenario is that although locals have a wealth of ethno-entomological knowledge that has been passed down orally from generation to generation, those outside the communities in issue are hardly ever aware of this reservoir of information.

Nutritional fact:

Quantity	100g
Calories	485.44 kcl
Fat	22.82g
Protein	37.57g
Carbohydrate	32.38g
Fiber	0.13g
Water	2.23g

Source: (Abdel *et. al*, 2017)

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(a)Collection of grubs of *R. ferrugineus* from dead wild date palm in forest, (b) Collected grubs, (c) Washed and clean grubs, (d) Fried grubs, (f) Serve with rice and (g-h) Eating grubs by tribe.

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Male frons dimorphism: *Chrysomyia bezziana* Villeneuve (Diptera, Calliphoridae) and *Myospila argentata* Walker (Diptera, Muscidae)

Nandan Jana, Pravas Hazari and Shuvra and Kanti Sinha

Abstract

Dimorphism, the condition of a trait having two distinct morphs. Differences may include colouration, ornamentation, secondary sexual characters, body shape, and size. Generally, such disparity is very commonly seen in various organisms between the sexes. But within the same sex, it is very rare and only a few numbers of species show such a peculiar phenomenon. Frons dimorphism among male individuals of a particular species of families Muscidae and Calliphoridae has not been reported before. The study aims to document frons dimorphism in male individuals of two distinct calyptrate flies, namely *Chrysomyia bezziana* Villeneuve (Diptera: Calliphoridae) and *Myospila argentata* Walker (Diptera: Muscidae), highlighting an unusual phenomenon in their head capsules.

Frons, in calyptrate flies, constitutes the structural part of the head capsule between two compound eyes, from the upper edge of the occiput to the margin of the frontal suture and have a significant role in species and sex recognition (Senior-White et al., 1940). In many Diptera species, both male and female flies exhibit a significant dimorphism in their frons with features including shape, size, number of bristles, colouration, width, length etc. and provide a way to distinguish them without examining their genitalia (Deeming, 1981). Insect orders other than Diptera, such as Coleoptera and Lepidoptera, have also been found to exhibit this type of morphological polymorphism (Deeming, 1981; Anderbrant and Schlyter, 1987). Most of the males of families Muscidae and Calliphoridae typically have thin or reduced frons along with holoptic or sub-holoptic compound eyes. In contrast, females have an open or broad frons and dichoptic compound eyes (Senior-White et al., 1940; Emden, 1965). Despite such variations, previous studies have focused on male eye dimorphism in certain calyptrate flies, and described patterns of incongruities (Fan, 1965; Kurahashi, 1982; Wells et al., 1994). But still, there is no study on male frons dimorphism within the Muscidae and Calliphoridae families. The present study addresses the occurrence of frons dimorphism among male individuals in two calyptrate flies *viz*., *Chrysomyia bezziana* Villeneuve and *Myospila argentata* Walker.

Materials and Methods

The examined flies, *M. argentata* were obtained through field collection at forest sites as part of the Muscidae project in West Bengal, India (23° 43' 49.9152" N 88° 31' 51.8124" E; altitude 21.00m). Males *C. bezziana* were obtained from laboratory culture colony. Both species (*C. bezziana and M. argentata*) were identified in the laboratory under a stereoscopic microscope (SYS-45ETR) by studying their morphology and chaetotaxy with corresponding taxonomical keys and descriptions following Senior-White et al. (1940) and Emden (1965). The photographs of head capsule were captured using a camera (38MP FHD) attached to microscope (SYS-45ETR).

Results

In laboratory examinations, a remarkable frons dimorphism was found among male individuals of two distinct calyptrate flies *viz., C. bezziana* and *M. argentata*. Based on their morphological anomaly, we categorized them into normal frons and open frons (Figs 1A-D). In the normal frons, parafrontal plates are closely positioned and the median frontal vitta is not visible (Figs 1A and 1C). On the other hand, open frons exhibit somewhat separated parafrontal plates and a distinct frontal vitta (Figs 1B and 1D).

Discussion

In taxonomy studies, a single character sometimes leads to a new species from their closely related members. Since in this context, it is very difficult for us to consider flies having variations in their frons as the same species or two different species. Although thorough examinations of morphological features, including chaetotaxy and terminalia among male individuals of normal and open frons in both *C. bezziana* and *M. argentata*, revealed no significant differences between them. Kukuk (1996) studied male polymorphism in *Lasioglossum* (*Chilalictus*) *hemichalceum* and suggests that their alternative morph between males is primarily environmentally influenced. However, herein exact cause of such variations remains unclear to us and there is no supporting published reports on such type of phenotypical discrepancy worldwide. Our documentation is preliminary, further observation and more evolutionary and genetic research work are needed to understand such variations.

Acknowledgements

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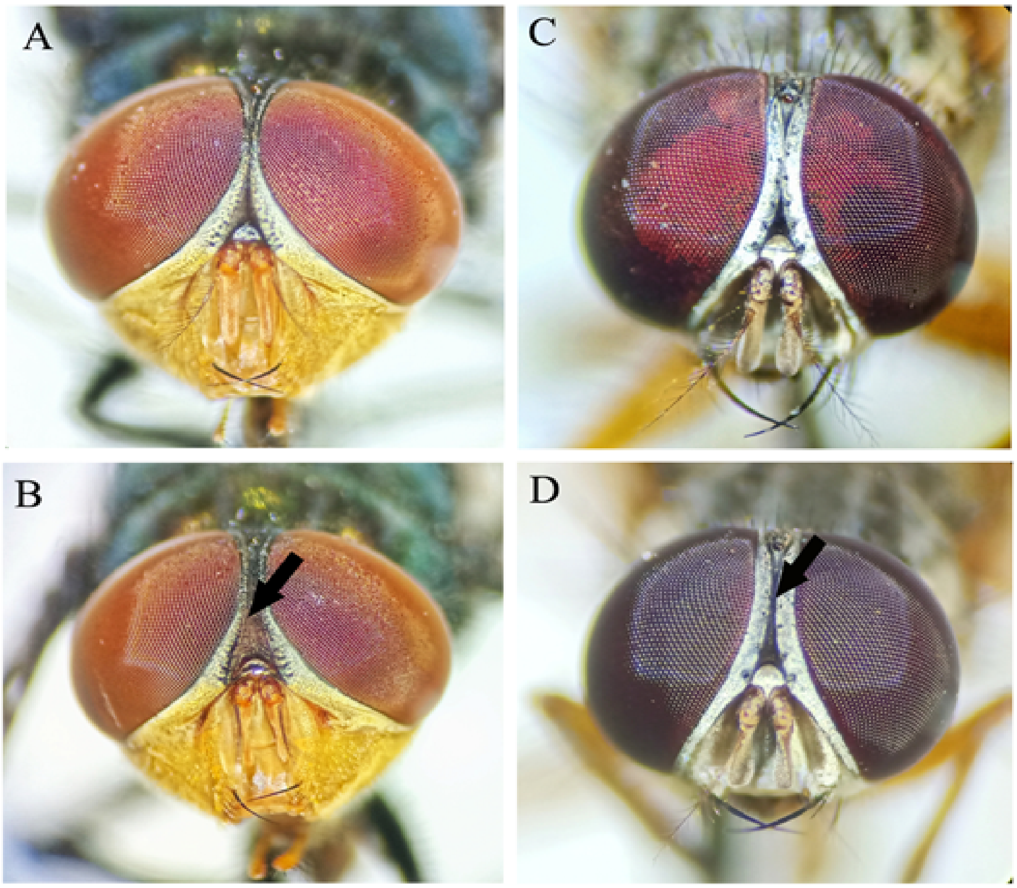

Fig. 1. Head capsules of male Chrysomya bezziana and Myospila argentata. A. Male C. bezziana head capsule with normal frons; B. Male C. bezziana head capsule with open frons; C. Male M.argentata head capsule with normal frons; D. Male M. argentata head capsule with open frons.

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Asian weaver ants, *Oecophylla smaragdina* (Fabricius, 1775) (Hymenoptera: Formicidae): A natural solution for orchard pest management

Ipsita Samal and Vinod Kumar

Abstract

Certain species emerge as inconspicuous heroes in the complex symphony of the natural world. An intriguing instance of sustainable pest control in fruit orchards is demonstrated by the Asian weaver ants *Oecophylla smaragdina* (Fabricius). These industrious insects have garnered attention for their capacity to mitigate pest infestations in orchard situations. They are renowned for their intricate nest construction and collaborative foraging methods. This article examines the role of Asian weaver ants in orchards as a natural and non-chemical method of pest management. The "Asian weaver ant" or "red ant" is a species of ant that is commonly found on trees in various parts of world. Weaver ants are intriguing organisms due to their unique nest-building behaviour and possess distinctive ecological characteristics serving as valuable partners in promoting sustainable agriculture. Weaver ants provide a practical alternative to traditional pesticides for safeguarding against agricultural pests. Their role in biocontrol provides proof of the potential of organic pest control strategies. Integrating weaver ants into pest management programs can be beneficial for both the economy and nature as agriculture transitions towards more sustainable practices. Weaver ants play a crucial role in maintaining the delicate equilibrium between agricultural productivity and environmental conservation. To promote the widespread utilization of weaver ants in pest control, it is imperative to educate and motivate farmers to take advantage of the numerous benefits offered by this insect.

In the intricate dance of nature, certain species emerge as unsung heroes, silently orchestrating ecological balance. Among them are the Asian weaver ants *Oecophylla smaragdina (*Fabricius), whose presence in fruit orchards offers a fascinating case study in sustainable pest management (Sangma and Prasad, 2021). These industrious insects, renowned for their intricate nest-building and cooperative hunting strategies, have garnered attention for their potential to mitigate pest infestations in orchard ecosystems (*Hawkeswood et al., 2020*). This article delves into the role of Asian weaver ants as a natural solution for orchard pest management.

Fig 1. Red ants found in Litchi orchard, ICAR-NRCL

The 'Asian weaver ant' or 'red ant' is an arboreal species of ant that is found ubiquitously in Asian countries including Australia, Indonesia, Philippines, China, Taiwan and India. Weaver ants are fascinating creatures known for their unique nest-building behaviour (Fig 1). They build nests by weaving leaves together, hence their name. These ants play an important role in maintaining ecological balance and act as effective biological control agents against various agricultural pests. The Asian weaver ant is scientifically known as *O. smaragdina* (order

Hymenoptera, family Formicidae). These ants form colonies with multiple nests in trees, each nest being made of leaves stitched together using the silk produced by the ant larvae, hence the name '*oecophylla*'[Greek for 'leaf-house'].

Behaviour

Weaver ants are highly territorial and aggressively defend their territories against intruders. They are found in abundance in African-tropical regions and the Indo-Pacific terrestrial region (Offenberg, 2021). There are two main species– *O. longinoda*, which is found in equatorial Africa, and *O. smaragdina,* which is found in the Indian subcontinent and Southeast Asia (*Rwegasira et al., 2020*). Workers and major workers are mostly orange in colour. Workers are 5–7 millimetres (0.20–0.28 in) long. They collect honeydew to care for the larvae. Major workers are 8–10 millimetres (0.3–0.4 in) long, with long strong legs and large mandibles. They forage, assemble and expand the nest. Queens are typically 20–25 millimetres (0.8–1.0 in) long, and normally greenish-brown, giving the species its name smaragdina (Latin: emerald) (antARK, 2024).

Habitat

It is an arboreal species, which makes its nest among the leaves of trees. Nests are constructed during the night, with major workers weaving the exterior and workers completing the interior structure. An ant colony may consist of several nests on one tree, or nests may be spread over several adjacent trees. The number in colonies can reach five lakhs. In one example, a colony occupied 151 nests distributed among twelve trees. In each colony, there is a queen in one of these nests, and her offspring are carried to other nests in the colony. The average life of a mature colony may be eight years.

Biocontrol capability

Recent studies have highlighted the usefulness of weaver ants in controlling agricultural pests. Extensive data is available on their habits, foraging behaviour, social organization and nesting behaviour. People in southern China in 1st millennium BC used weaver ants to protect their citrus orchards in the early 20th century (Sangama and Prasad, 2021), and they also used bamboo to accommodate movement in the branches of nearby trees (Offenberg et al., 2013) to promote ant nests and colony expansion. Weaver ants are thought to be the only arthropod predator that preys on the pest Luprops tristis, a nuisance in rubber plantations. They have been used successfully to control pests in cashew, citrus and mango orchards.

Fig. 2. Colonization of red ants in mango

Some specific examples

Citrus

These ants hunt various insects that damage orange, tangerine, lemon, pomelo trees and other fruit trees. The aggressive behavior of weaver ants helps keep various insects away from flushing shoots, as they can capture nymphs directly for their food supply. Studies conducted by Peng and Christian (2005a) showed that weaver ants were effective in controlling the fruit-spotting insect on cashew and mango crops. Nalini and Ambika (2019) found that weaver ant pheromone was effective in deterring herbivorous insects and fruit flies.

Mango

Weaver ants play a beneficial role in mango orchards by providing natural pest control and contributing to the health of the ecosystem. Integrating red ants into integrated pest management strategies can help reduce dependence on chemical pesticides and promote sustainable agricultural practices in mango cultivation. Weaver ants (*O. smaragdina*) were evaluated as biocontrol agents against mango hopper (*Idioscopus clypealis*) in mango orchards by Peng and Christian (2005b) (Fig. 2). The results showed that it is an effective biocontrol agent. The presence of these ants resulted in healthier inflorescence/plant (77.00%) and also increased fruit set/inflorescence (11.25%). Hopper numbers were effectively reduced during the 2nd to 28th day after exposure to ants. The results showed that they are effective in causing mortality or enabling antixenosis behaviour (Ferdous and Jahan, 2021). Colonies inhabiting mango trees (Mangifera indica) in Darwin, Australia were found to deposit significant amounts of nitrogen on their host trees through their waste. This deposition increased when ants were provided access to additional sucrose resources (Pinkalski et al., 2016).

Litchi

Weaver ants provide versatile benefits to litchi orchards, acting as guardians of both crop health and ecological harmony. As voracious predators, they tirelessly hunt down insects that threaten litchi trees, effectively curbing the need for chemical pesticides. Furthermore, their simple nest-weaving habits deter not only herbivorous insects, but also birds, and thus prevent potential damage to litchi fruits and leaves (Fig. 3).

Beyond pest control, weaver ant colonies can indirectly enhance soil health by accumulating organic matter, promoting fertility and microbial activity. Although they are not primary pollinators, their activities within orchards may inadvertently facilitate pollination to some extent, contributing

Fig. 3. Nest of Asian weaver ant on litchi trees

Fig. 4. Foraging activities of Asian weaver ant on litchi trees

Fig. 5. Weaver ants predating on a litchi pest ash weevil (*Myllocerus undecimpustulatus* Marshall)

to overall ecosystem dynamics (Fig. 4 and 5). By maintaining ecological balance and reducing reliance on harmful pesticides, the integration of weaver ants into orchard management embodies a sustainable approach to pest control, promoting agricultural resilience and biodiversity conservation. Overall, weaver ants play a valuable role in litchi orchards by providing natural pest control, protecting trees from herbivores, contributing to soil health, and promoting ecosystem balance. Integrating these ants into orchard management practices for sustainable agriculture can increase sustainability and productivity while reducing the environmental impact of chemical pest control methods.

Coconut

Weaver ants are used selectively to control the pest, coconut bug (*Pseudotheraptus wayi*). *O. longinoida* is a natural enemy of the coconut bug, an insect that has caused the loss of 67% of the coconut crop in Tanzania. The weaver ant competes with other species of ants living among coconut trees, and is sometimes displaced by the ground-dwelling *Pheidole megacephala*. However, the weaver ant is much more effective as a biological pest control agent, and baits are used to selectively control *P. megacephala*, allowing the weaver ants to thrive and effectively control the coconut bug (Ashwathi and Thomas, 2014).

West African orchards

Oecophylla longinoda plays an important role as a biological control agent against fruit flies in West African orchards and, by extension, also in forest and savanna ecosystems within sub-Saharan Africa (Van Mele et al., 2007). These weaver ants are one of the most effective and efficient predators of arthropods in perennial tropical tree crops; their presence also acts as a deterrent to insect herbivores, particularly tephritid female fruit flies, due to the semiochemicals they produce. Emerging African markets for organic and sustainably-managed fruits and nuts have encouraged an interest in the use of weaver ants. Protection of tropical forests and savannas is ecologically and environmentally crucial and also essential for the protection of *O. longinoda.*

Other utility- Increased activity of parasites (parasitoids)

Fanani et al. (2020) examined the influence of these species on the introduced parasitoid *Anagyrus lopezi*, a species used to control the invasive cassava mealybug *Phenacoccus manihoti* (Hemiptera:

Pseudococcidae). They found that when ants were absent the average time spent foraging by individual parasitoids was significantly longer (27.39 minutes) compared to when ants were present (2.47- 4.68 minutes). As a result, parasitoids spent less time in finding hosts and a longer time in handling hosts. This resulted in more oviposition activities and a 2-3-fold increase in parasitism and the number of wasps that emerged from their hosts.

Are these ants truly blessings for orchards, or do they pose a menace to agricultural practices?

Ecological blessings

1. Natural Pest Control: Weaver ants are voracious predators, preying on a variety of insects such as caterpillars, aphids, and fruit flies, which are common pests in orchards. Their presence helps in naturally controlling pest populations, reducing the need for chemical pesticides.
2. Orchard Health: By targeting pests, weaver ants indirectly contribute to the overall health of fruit trees. This pest control service can lead to improved fruit quality and yield, benefiting orchard productivity.
3. Ecosystem Services: Beyond pest control, weaver ants play essential roles in ecosystem functioning, such as nutrient cycling and seed dispersal. Their presence contributes to the biodiversity and ecological balance of orchard ecosystems.

Agricultural menace

1. Tending behaviour: Weaver ants exhibit tending behaviour, where they 'milk' honeydew-producing insects for their sugary secretions. While this behaviour benefits the ants, it can also promote the growth of honeydew-producing pests, such as scale insects and aphids, which may damage fruit trees if left unchecked.

2. Damage to fruit: In some cases, weaver ants have been observed causing damage to ripe fruits by creating galleries in the flesh, leading to spoilage and economic losses for farmers. This behaviour is particularly problematic in orchards with high ant densities.

3. Human interaction: Weaver ants can be aggressive defenders of their territories and may pose a nuisance or even a danger to orchard workers during fruit harvesting and other agricultural activities. Their stings can cause discomfort and allergic reactions in some individuals.

Advantages of using weaver ants for biocontrol

- Reduction in chemical use: Because weaver ants are natural predators, the need for chemical pesticides is greatly reduced, resulting in an eco-friendlier approach to farming.
- Sustainable pest management: Unlike insecticides, to which insects can develop resistance, weaver ants provide a long-term solution without the risk of building resistance.
- Improved pollination: These ants can also contribute to the pollination process, indirectly helping the reproductive success of plants.
- Economic benefits: Farmers can save on pesticide costs and potentially earn more due to higher crop quality.

Challenges and future prospects

Although the benefits are obvious, there are challenges in integrating weaver ants into agricultural practices:

- Ant Management: It is important to maintain the right balance of ant population. Too little can be ineffective, while too much can cause them to become a nuisance.
- Crop specificity: Not all crops may benefit from weaver ants; Research is needed to identify which crops are most suitable.
- Farmer education: Farmers need to be educated about how to manage weaver ants effectively and safely. This ant keeps harmful insects away from the area around its nest, thereby providing protection to the plants from harmful insects.

Apart from this, this ant also helps in making the soil aerated and fertile, thereby providing the plant roots with the necessary oxygen for better growth. On the other hand, weaver ants also have some negative effects. This ant makes its nests by damaging and stitching leaves, which can affect plant growth and photosynthesis processes. Additionally, if ant numbers become excessive, it can become an additional burden to plants.

Conclusions

Weaver ants are not only remarkable in their ecosystem but also serve as valuable allies in sustainable agriculture. Weaver ants provide a promising alternative to chemical pesticides in the protection of agricultural pests. Their role in biocontrol is a testament to the potential of natural pest management solutions. As agriculture moves toward sustainable practices, the use of weaver ants may become a standard component of integrated pest management programs, benefiting both the environment and the economy. The balance between ecological conservation and agricultural productivity is delicate, and weaver ants play a vital role in maintaining this balance. Educating farmers and promoting the benefits of using weaver ants for pest control is essential for their widespread adoption.

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10TH INDIAN ENTOMOLOGIST PHOTO CONTEST

The Indian Entomologist Photo Contest aims to promote insect photography among photographers, professionals, amateur entomologists, and laymen. The theme for the tenth edition of the photo contest was "Insects and aspects related to insect life." The contest was open from the 4th of April until May 3rd, 2024. Each participant was asked to submit one good photograph that meet a few specified formats, as well as a filled-in application form in which he or she must include his or her details, caption, description, photograph specifications, and a declaration of the ingenuity of the photograph. We received an overhelming response from 72 participants, who submitted a total of 93 images. The photos were initially screened by Bug Studio associate editors for the prescribed standards and overall image quality and further sent to two independent and anonymous external reviewers to judge the best three photos. Based on the reviewer results, the final evaluation was done by a committee of independent members under the oversight of the three editorial board members. During the complete review process, the entries were assessed based on the following criteria: quality (clarity, lighting, depth of field, composition), relevance of the subject matter (theme, rareness of subjects), creativity and originality. To ensure a blind review, the details of the photographer were hidden, and the evaluators were only presented with the photograph, caption, description and technical specifications.

The following are the winner for 10th Indian Entomologist photo contest

- The first place was won by Dharmendra R. Padiyar (C-83, Laxmi row house, At. Delad, Po. Sanyan, Ta.Olpad, Dist. Surat-394130), who captured incredible photo of kissing bug preying on fly.
- The second place was won by Amrutha V. M. (Alampallil house, Mamnkara, Kamblakallu P.O., malapurram, kerala-679333) for her incredible close up photo of robber fly.
- The third place was won by S C Kedar (S/o C.N. Kedar, 104 mashal Nagar, Bijapur road, Solapur-413004) for capturing a photh of predatory stink bug preying on hariy caterpillar.

Congratulations to the winners, and we acknowledge all the participants who took an interest in 10th Indian Entomologist photo contest and sent their entries!!

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First place: Kissing bug preying on a fly submitted by Dharmendra R. Padiyar from Surat.

Second place: A close up shot of robber fly by Amrutha V. M. from Mallapuram, Kerala.

Third place: A predatory stink bug preying on hairy caterpillar by S C Kedar from Solapur, Maharasthra.

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N V MANIKANTA REDDY
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Manikanta Reddy is influenced by his professors from insect science Dr K. Vijaya Lakshmi and Dr G. Anitha from Dept. of Entomology, PJTASU and the passionate Entomologist Dr. Kamala Jayanthi from ICAR-IIHR. He had started praising and understanding these miniature wonders, the Shatpadas. He did his master's degree from IGKV, Raipur and took the dissertation work on evaluating various Bio-intensive pest management modules in Rice for pest management at ICAR-IIRR under the guidance of Dr. Chitra Shanker, Principal scientist, Dept. of Entomology. At present he is pursuing his Ph.D. in Agricultural Entomology from IGKV, Raipur and carrying out my research at ICAR-NBAIR under the guidance of Dr. T. Venkatesan, Principal Scientist and Head, Division of Genomic Resources. His area of work is investigating the transcriptomic changes from the life stages of Leucinodes orbonalis and gene function studies to devise novel targets for the management of this devasting pest through exogenous dsRNA-based gene silencing. Though passionate about molecular studies, he would prefer to design projects and work for conservational Entomology.

Mr. SURIYA S
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Suriya S is currently pursuing a Ph.D. in Entomology at the Division of Entomology, Faculty of Horticulture, SKUAST - Kashmir. His research focuses on tackling the challenges posed by sucking insect pests like aphids, thrips, whiteflies, and mites on chrysanthemum and carnation plants. Under the guidance of Dr. Akhtar Ali Khan, his work investigates the morpho-molecular characterization, population dynamics, and management of these pests in protected environments to accurately identify and effectively manage these pests. His approach involves monitoring pest populations using predictive models based on climatic data to optimize control measures. Additionally, he advocates for sustainable pest management practices, utilizing a combination of chemical treatments, organic pesticides, entomopathogens, and sticky traps to minimize environmental impact. He holds a B.Sc. in Agriculture and an M.Sc. in Agricultural Entomology from TNAU, Coimbatore, where he specialized in the bio-ecology and management of invasive whiteflies in coconut plants under the guidance of Dr. G. Preetha. Throughout his academic journey, Suriya has demonstrated his expertise by clearing the ASRB NET twice (2021 & 2023) and contributing significantly to scientific literature through 2 research papers, 1 review paper, 13 book chapters, 1 book, 9 popular articles and attended numerous national conferences and workshops. Looking ahead, he aspires to further develop integrated pest management strategies against sucking pests aimed at reducing the reliance on pesticides and mitigating their environmental consequences.

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DEPARTMENT OF ENTOMOLOGY

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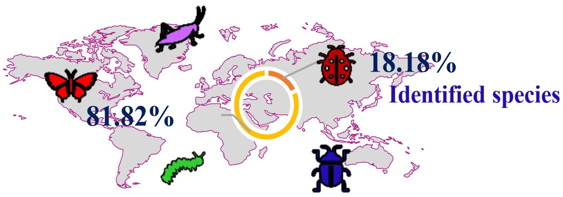
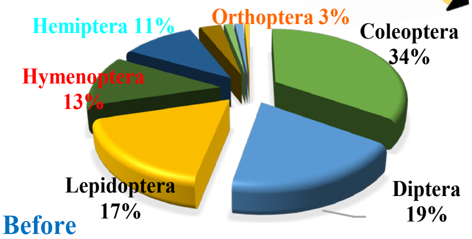
Abhishek V is currently pursuing a PhD in Entomology at Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga. He is the recipient of the ICAR-SRF fellowship award for his doctoral program. Presently he is working under the supervision of Dr. David, K. J. Senior Scientist, ICAR-NBAIR, on "Taxonomic studies on species complexes of fruit flies of tribe Dacini (Diptera: Tephritidae: Dacinae) in India. He has been conducting extensive surveys since 2022 to ascertain the diversity of members of such species complexes in Dacini across India, which can lead to a description of new taxa, and nomenclatural changes like synonymisation/ separation from synonymy as there exists a lot of ambiguity in delimiting various species in these complexes primarily to heavy reliance on external morphological characters which are highly homoplasious. As these complexes do have economically important invasive species, precise identification is extremely important. Till now he had described four new species of fruit flies viz., Dacus nagarathnae Abhishek, David & Hancock and Zeugodacus nasivittatus David & Abhishek from Meghalaya, Dacus venkateshi Abhishek & David from Karnataka, and Zeugodacus sinuvittattus David & Abhishek from Himachal Pradesh. He also recorded two species of fruit flies viz., Bactrocera abbreviata and Dacus vijaysegarani for the first time from India. He also explored the Andaman and Nicobar Islands for his fruit fly collection. Abhishek completed his postgraduate studies at Kerala Agricultural University, Thrissur, under the mentorship of Dr. Mani Chellappan, Professor, Head and Dean of KAU. He studied the microbial diversity in hive-stored pollen of the Indian honey bee, Apis cerana indica, where he carried out experiments regarding palynological identification, physicochemical properties and microbial composition of pollen where he isolated seven microbial isolates, characterised them morphologically and molecularly, for which he bagged the "Best poster presentation award" in the field of beneficial insects at Entomological students' conclave, 2024 held at GKVK, Bangalore. Besides, he is very much interested in insect photography.

A Guide to Discovering New Insect Species

Vidya Madhuri E, Sudipa Das & Shashank P R, IARI, New Delhi- 110012





Majority of insects species will extinct Before they are known to science

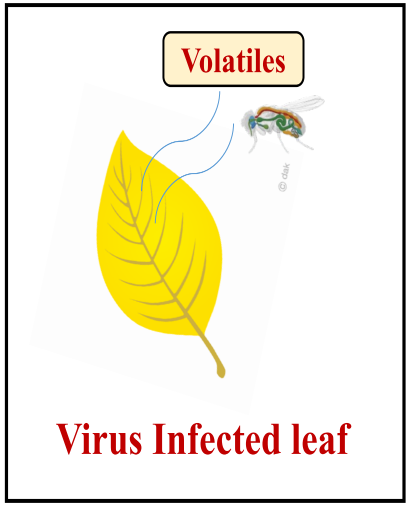
STEPS IN RECOGNIZING SPECIES & ESTABLISHING IDENTITY

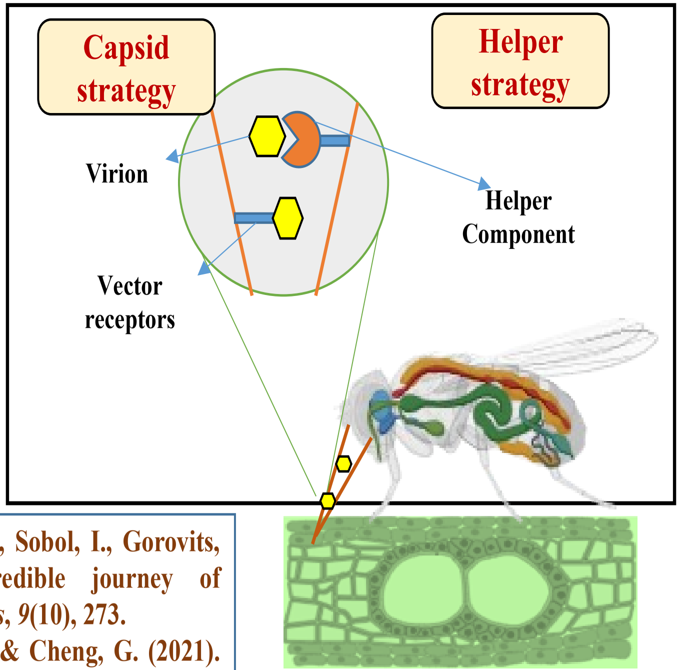
- Habitat choice, survey & observation
- Specimens collection & labelling
- Literature search & taxonomic study
- Establishing identity
  - Similar with certain available specimens
    - Writing specimen description along with designated scientific name
  - Distinct from available specimens
    - Naming of the new specimens (Following the rules of the International Code of Zoological Nomenclature (ICZN))
    - Writing specimen description
    - Deposition of type & voucher specimens (Deposit in recognized scientific institutions such as museums or universities)
    - Publication (Published in a peer-reviewed scientific journal specializing in taxonomy, entomology, or biodiversity)

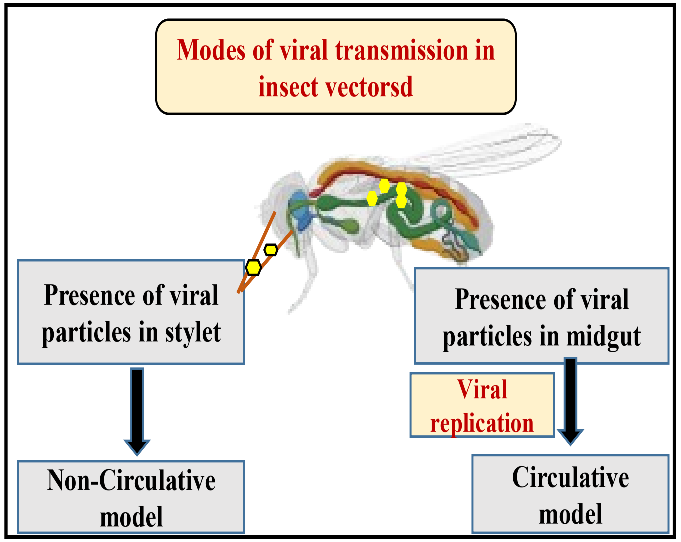
FURTHER READINGS:

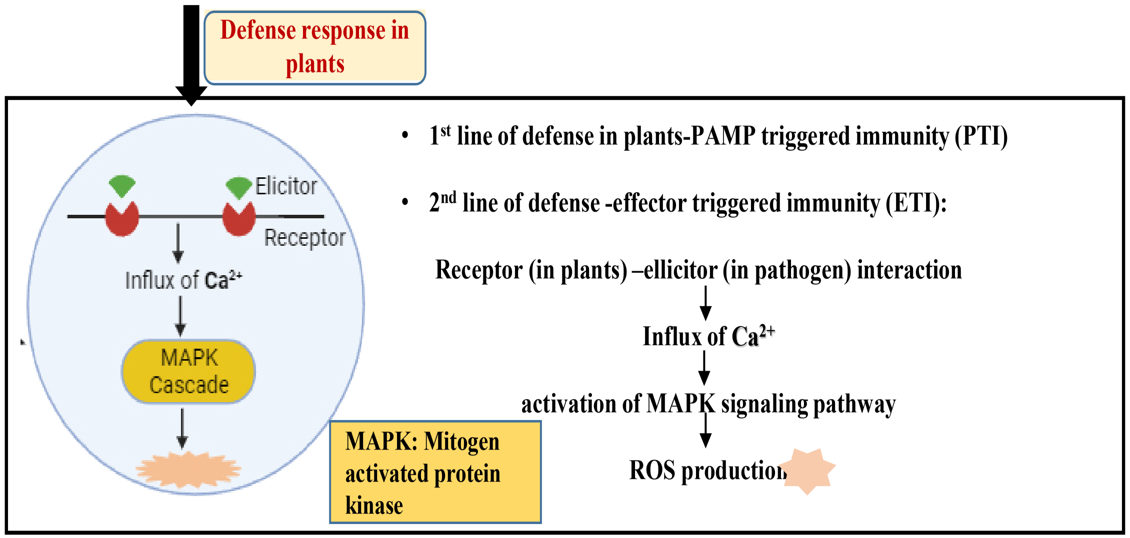
- Winston, J. E., & Disney, H. (2000). Describing species: practical taxonomic procedure for biologists. *Nature*, *405*(6787), 619.
- Catalogue of Life, version 2023-08-1, https://www.catalogueoflife.org.

Molecular interactions of insect vectors and viruses









References: Czosnek, H., Hariton-Shalev, A., Sobol, I., Gorovits, R., & Ghanim, M. (2017). The incredible journey of begomoviruses in their whitefly vector. *Viruses*, *9*(10), 273.
Ma, E., Zhu, Y., Liu, Z., Wei, T., Wang, P., & Cheng, G. (2021). Interaction of viruses with the insect intestine. *Annual review of virology*, *8*, 115-131.
Marwal, A., Verma, R. K., Khurana, S. P., & Gaur, R. K. (2018). 12 Molecular Interactions between Plant Viruses and Their Biological Vectors. *Plant viruses: diversity, interaction and management*.

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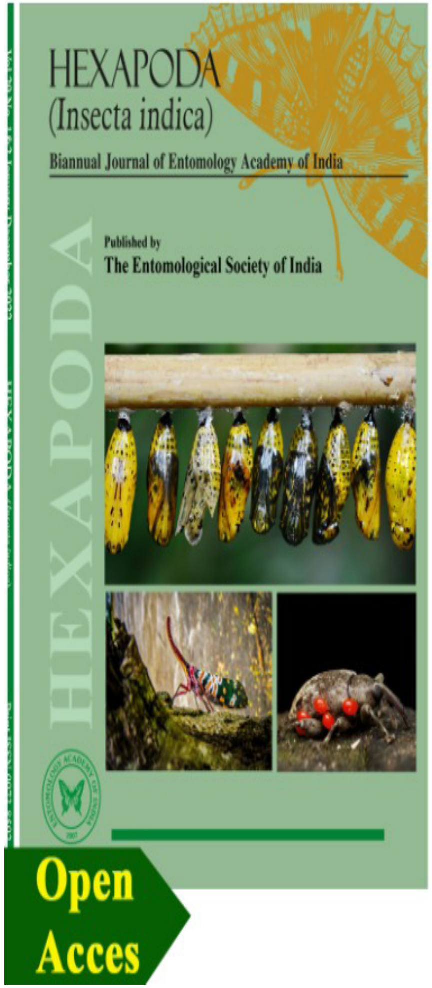

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Notes for Contributors

Articles submitted should not have been published elsewhere and should not be currently under consideration by another journal/ magazine. Interested authors are advised to follow the author guidelines of Indian Journal of Entomology for reference citations and to follow as closely as possible the layout and style, capitalization and labelling of figures. All papers are subject to peer review and may be returned to the author for modification as a result of reviewers reports. Manuscripts are acknowledged on receipt and if acceptable proofs are sent without further communication. Minor editorial alterations may be made without consulting the author. Make sure to submit the photographs of high quality in .jpg format. For those who want to contribute commentary and feature articles please contact editors before submission.

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IE is intended to publish following categories of articles

Commentary – We encourage opinions or critical analysis of current entomological happenings. Submissions should be no more than 5,000 words in length.

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Feature articles – these must be of broad interest to biologists, amateur and professional entomologists. These articles should be no longer than approximately 5,000 words. Articles should contain high quality photographs.

Natural histories & short research articles with focus on insect life cycle, occurrence etc. and have the same requirements as feature articles. Submissions should be up to 5,000 words in length.

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Bug studio – "Indian Entomologist Photo Contest" will be conducted for every volume of the magazine and best three winners will be announced in the magazine. Images should be submitted as high quality (300 dpi TIFF, jpeg files) files with a detailed photo caption. The announcement for photo contest will be made on our website www.indianentomologist.org

Student corner – students working on interesting topics of entomology to share their views and opinions about their research work. Can submit with personal photograph; it should not be more than 1,000 words in length. We encourage entomologists to contact us if you have any interesting story to share about insects. Contributions to be sent to the Managing Editor, in digital format (MS Word) as an e-mail attachment to indianentomologist@gmail.com

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