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Special Insect Interest Group

Editorial Board

***Cover Page: Dragonflies, AICRP Vegetable Field, Mahatma Phule Krushi Vidyapeeth**
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Insect Environment

(Quarterly journal to popularize insect study, conservation, and watching)

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IE is back by popular demand as a popular online insect quarterly journal. The first issue of Insect Environment was published in 1996. The sole objective of Insect Environment is to popularize Insect study through popular, semi technical research notes and essays on all aspects of insects. The journal is published quarterly, in March, June, September and December.

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Author guidelines

Short popular insect notes, records, and views are acceptable. There are no page charges; each article should preferably not exceed 500 words. Authors can refer to the back volumes available on the website for writing style. Good photographs are encouraged. A special insect photo gallery "Insect Lens" to encourage professional and amateur photographs on insects begins with Vol. 22.

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Message

It gives immense pleasure to know that the most popular publication ***Insect Environment*** is resuming its publication after a brief gap. I understand it started publication since 1996 and served as a forum to the entomologists throughout the country to contribute short notes on recent developments. New records/ distribution, new pests occurrence, bioagents and biological control, ecological aspects and control measures for pest species were covered in a lucid manner. It was a remarkable publication which enabled quick publication and dissemination of research findings. Its resumption of publication is a welcome feature. I find in the recent years contributions to advancement of entomology have been remarkable from Karnataka state and am sure that ***Insect Environment*** will maintain its yeomen service to the cause of entomology in the country and also as a reference to international organizations.

I am indeed very happy to note that the revival of ***Inect Environment*** is being carried out by our eminent entomologist Dr. Abraham Verghese and his colleagues. I wish all success and request all Indian entomologists to contribute scientifically and financially and ensure sustenance of the publication.

Dr. B. Vasantharaj David
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14.08.2020

Dr. A V with Dr. David

Editorial

Unlock, reboot, IE has again arrived!

Recently when I was in the Tamil Nadu Agriculture University (TNAU), Coimbatore, for the trans-boundary insect seminar, many asked me why *Insect Environment* (IE) the popular quarterly journal has stopped. "Can't you revive it again?" was one refrain echoing loud. Dr. B. Vasanthraj David, the doyen of Indian Entomology was even more passionate: "It was one journal which kept the insect lovers connected, from amateurs to students to professionals." This was in March 2020, when Covid was still to raise its ugly restrictions, and we could still travel. This set me thinking. I should revive IE, for the enthusiasm was palpable, and requests for re-launching IE was unmistakably sincere.

IE existed for 21 years and the 21st volume, released in 2017 was apparently the last. From 1996 to 2012, IE came out as a hard copy, handy, front covers pictured and readable in one go. From 2012 onwards, we set it on online as soft copy, for convenience, cost-saving and wider circulation, piggy-backing on "*Current Biotica*" web. For some reason, by 2017 *Current Biotica* lost its steam and its deceleration on the track hit IE too.

Meanwhile, requests for many short notes published in IE were being sent to me. Fortunately the library of the internationally renowned, ICAR-National Bureau of Agricultural Insect Resources, Bangalore, housed all the back volumes. All these requests for notes were immediately scanned and sent to requestors, by Mr Jayaram, Librarian at ICAR-NBAIR. I am grateful to him and will be! This was very strongly indicative of the fact that IE notes were popular, and fulfilled an important literature demand. To fulfil the future demand, I felt the supply curve should begin. If IE has a purpose to serve entomologists, it should have a revival, hence the re-launch of this volume 22 (September) 2020.

I have been IE's Editor since its inception in 1996, and I knew, if IE has to grow the generation next has to take over. My mind would obviously go in search of potential editors, and to me, who else than my loyal Ph.D. students, who encompass about me as their 'academic' father. When I broached this idea to them at a zoom meet on 18th May 2020 there was a loud "Amen! and that set the ball rolling.

In a short span, this young team of editors comprising of mostly smart young women editors (this by itself is some sort of a record) with me as a figurative "Editor-in-Chief", breathed back life into IE. In its new *avatar*, it is taking an 'e' turn, to become an online *Insect Environment.*

One policy is to have free subscription to all who request with a mail id, and it is freely downloadable, printable, and forwardable too!

For IE it is 'unlockdown' now! The rebooting has begun with this issue. When Volume (1), our first issue came out, the late Prof T.N. Ananthakrishnan who remained as IE's life-time Patron remarked, "IE is the best thing that could happen to entomology in India." At that point of time, he closely associating with us really propelled the take-off of IE.

Thanks to the digital revolution, today communication has become rapid and cheaper. The printed copy traversing land and sea became a thing of the past. The hard copy era was indeed tough. I should remember with gratitude my students in the fruit entomology laboratory of ICAR-Indian Institute of Horticultural Research who helped me with address writing, sticking stamps, and the myriads of postmen who helped IE reach even to, too remote villages of India. Dr A K Chakravarthy and Mr S Sridhar gave valuable support in editorial and printing.

My memories inevitably drift to the formative years. To cut costs before the ramification of personal e-mails as it is today, the humble postcard costing 0.50 paisa was the means of communicating referee/editorial comments, and that too handwritten. These were mostly written by me. It was after all worth it, as I discovered, many years later, while visiting the Agricultural Institute of ICAR, at Port Bair, Andamans. Dr Bharathimeena, the scientist (Entomology) there, whom I was seeing for the first time, was 'excited' meeting me. "I always wanted to meet you," she said, and from her cupboard pulled out a postcard, with my comments on her article, she sent to IE as a student in TNAU. Referee comments are sent only when changes have to be made in the article; many times it was not very palatable! Yet Bharathimeena said, "this postcard from you is very special to me that I will be keeping it always as a souvenir!" IE postcard won a pen-pal friend for me!

IE family will consist of writers (and readers) from a wide spectrum: students (school and college), amateurs, apiculturists, sericulturists, hobbyists, nature lovers, and of course professional entomologists. These will be the **Special Insect Interest Group** (**SIIG**) which will in fact publish IE. It is 'your' journal, and we all claim it together! That's the uniqueness of IE and its main focus is to promote insect news and communication among SIIG.

There are a lot of insect notes and some remarkable photos shared on media like WhatsApp, Facebook etc. While these are very typically useful, are ephemeral; the same chartered also into IE will make it enduring and quotable. I request entomologists to make a note of this and send insect information and photos to IE, as the reach is in 1000s multiplied over.

This issue has a heady insecty mix: from short student essays to research notes. Accounts of insects in space, forensic science, 'warfare', nanotechnology, biotechnology, butterfly park, insects as fish food, book review, etc. For a true insect lover IE is bound to be enjoyable reading loaded with 'insect information'.

So next time you, see something 'insecty' in the field or laboratory, or even in your house or garden; some peculiar occurrence or an invasive's threat, think of IE for your communication and documentation. For the smart phone geek, catch an insect on your mobile, while on the go; send it across to our photo-feature gallery, "Insect Lens", with a short account of the place (geo-coordinates) etc. Before I sign off a special thanks to Dr. M S Swaminathan, the doyen of green revolution in India, for his good wishes for this re-launch issue. On behalf of the Editorial Team I thank all our distinguished Editorial Advisors for agreeing to be our support. They are all accomplished writers and editors.

The next issue, Volume 23 (December) 2020 is on the anvil. We will again meet at that! Till then cheers!

Dr Abraham Verghese

Editor-in-Chief

Life of desert locusts: To follow the crowd or walk alone

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As a child, we were always advised not to follow the crowd but rather to pave our own independent path in this journey called 'life'. This 'carving your own niche' attitude suggested to us by our grandparents and parents really inspired us and directed us to strive to become our own person with our own distinct unique personality. In short, more the uniqueness in you, the more you stand out in a crowd that increases the probability of you getting selected at job interviews, irrespective of the field. Broadly speaking, your uniqueness increases your chances of survival. Currently, desert locusts or *Schistocerca gregaria*, are pretty much everywhere in the news. They are short-horned grasshoppers known for their ability to transform from a solitary phase to a gregarious swarming phase exhibiting collective migration. Recently, parts of east Africa and western parts of India faced the biggest desert locust outbreak this year with billions of desert locusts attacking fresh vegetation of the rainy season. This has led to famine and starvation.

The desert locusts are found to follow the crowd to form swarms. This 'swarming' behavior in desert locusts was initially thought of as a cooperative interaction to efficiently attack the food source together. But now, it has been proven by ethologists that this unusual behaviour is definitely not cooperation. When the population numbers of the locusts increase drastically in high moisture conditions during rains, causing food (plant hosts) scarcity, then, locusts start behaving in a cannibalistic manner with each other. To avoid the cannibalism, some of the locusts begin following the other locusts that are moving away. Other locusts soon follow suit, thereby forming the huge swarms traversing in a line. However strange it may be, this behaviour increases their chances of survival till they hit the nutrient rich vegetation regions and crop fields. Therefore, changing the survival strategies- walking alone when food is unlimited and following the crowd when food is in short supply-has become a way of life for these locusts.

Thus, swarming behaviour prove to be beneficial to these insects only because the crowd is moving in the right direction. But imagine a situation where the crowd was drifting towards the wrong direction and we blinded by faith, followed the crowd! Scary, ain't it! I guess that is exactly why we were told not to follow the crowd!

Swarming desert locusts [PC: @ picture-alliance/NurPhoto/V.Bhatnagar]

Desert locust spotted in Jaipur, Rajasthan, 2020 [PC: Hindustan Times]

Butterflies and conservation: Many people speak, but only a few deliver: A note on Sammilan Shetty's Butterfly Park, Belvai

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Butterflies are the most beautiful creatures among insects, due to their brilliant colours and wing patterns. They have fascinated man since ages. Their colourful fluttering wings invite our awe. Children love to chase them, and poets get inspired to write poems about them. Their strange life pattern baffles even the wisest scientists, while nature lovers owe their gratitude for the valuable role played by these winged beauties in perpetuating life on earth (Subbireddi and Meerabai, 1984).

Butterflies are, in fact, the gems of evolution and have served our planet for over 200 million years sharing food with early dinosaurs. They are nature's die-hard survivors who have learned to adapt and outlive most other forms of life on earth by a wide margin of millions of years. Today butterflies signify freedom and beauty in popular folklore. Their diversity helps to indicate the health of an ecosystem. They are also essential pollinators, next to bees and wasps and form an integral part of the food web (Murphy and Weiss, 1988)

There are many scientific studies in India on the understanding of butterfly biology, diversity, ecology, behaviour and many other details. However, the change in climate and other anthropogenic activities are threatening these beautiful creatures. It is evident from many research articles published across the world. Although schedules 1 and 2 of Wild Life Protection Act, 1972 of Parliament of India, listed a large number of butterfly species for absolute protection, measures to increase their population by any agencies are almost negligible. Hence there is a greater need for awareness and education among the people to conserve butterflies and make them understand the importance of butterflies in nature.

In India, there is very little conservation activity directed specifically towards butterflies. It is surprising to note that the first catalogue of the butterflies of independent India was published in 2015. Peter Smetacek, a butterfly conservationist and taxonomist, rightly said, 'No wonder then that we are an estimated 70 years behind the rest of the world in our understanding of Indian butterflies' (www. dailyo.in).

Nevertheless, there is always a ray of hope in distress; a few people have taken it in a challenging way to conserve butterflies and their habitat. In Karnataka, at least two such active conservation activities could be mentioned here. First is Bannerghatta Butterfly Park at Bengaluru, which supports education, conservation and research activities with an exclusive focus on butterflies. Established in 2003, by Zoo Authority of Karnataka, it is a unique project in the entire country and is serving as a role model in butterfly conservation and education.

Karnataka's first-ever private Butterfly Park is located in a village called Belvai in Moodabidri Taluk of Dakshina Kannada District and is home to more than 100 species of butterflies belonging to the Western Ghats, one of richest biodiversity hotspots of the world. Not many people would have thought of dedicating their private land to conserve the indigenous flora of the region, for butterflies and other native fauna, but Sammilan and his family did.

This park which is spread across 7.35 acres of semi-forest land was inaugurated by none other than 'Butterfly Man of India', Isaac Kehimkar for public viewing in 2013, from whose book Sammilan was inspired to initiate this conservation work. It also focuses on educating the general public and students about butterflies and sensitizing them the importance of conserving the natural flora. The park encourages and motivates people to create and preserve the natural habitat for butterflies and other wildlife forms.

Located in the foothills of Western Ghats, this butterfly park looks like a cluster or nothing more than a host of ordinary plants and trees, but one would be bound to get an enlightening experience at 'Sammilan Shetty's Butterfly Park' taking you to the beautiful world of butterflies. The visitors are initially briefed about the butterflies and their life cycle which is later followed by a walk in the natural habitat of butterflies in the midst of trees like *Hopea ponga*, *Leea indica*, *Zanthoxylum*, *Citrus* and various other wild flowering plants. Sammilan explains with enthusiasm on the life of butterflies, common names, their seasonality in park, behaviour, their host plant preferences etc. The awareness program concludes with the video presentation on butterflies taken exclusively from the butterfly park by him. Over the years, the species observed in the park are increasing due to the efforts of Mr. Shetty, who studied, understood and created such an environment for these winged beauties. To mention, so far in the State of Karnataka, around 320 species have been reported, more than 100 species can be sited in the park here alone.

Sammilan Shetty has a degree in MBA (Tourism) and was working as a lecturer in a hotel management college, in Mangalore, but left his line of specialization to pursue his passion on butterflies, which he had developed during his graduation days at Alva's College Moodabidri. His 100 minutes documentary film "Life of butterflies", released in 2019, reveals the exciting facts about butterflies and their life history. The footages for the documentary were shot, exclusively at the butterfly park by him, in a 4 years span. It is the country's first-ever comprehensive documentary on butterflies and is appreciated by butterfly experts and enthusiasts across the nation.

He was featured in 'Amazing Indians' Season III by Times Now as an 'Exceptional Eco Saviour' in 2013 for his work on butterfly conservation. The butterfly park was also honoured by 'World Book of Records', London, UK, in 2018 for hosting awareness programs and conservation activities. Recently, he was awarded the 'Popular Choice Award' in 2020 by Deccan Herald at the DH Changemakers 2020 event.

The best time to visit the park is between June and November. On arrival. Mr. Sammilan Shetty himself welcomes the visitors with his signature smile. Those who are planning to visit the park can ring up Mr. Shetty to take prior appointment so that he can arrange the visit in batches. In fact, many people changed their opinion about insects as a whole and the way they look at, after visiting the park. A sense of thinking starts in their mind to conserve them.

Our thanks to Mr. Sammilan Shetty on behalf of all entomological fraternity of India. (Mr. Sammilan Shetty may be contacted on his mobile :+91-9845993292 and e-mail: sammilan.shetty@gmail.com)

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Mr. Sammilan delivering lecture to visitors

Pachliopta hector, Crimson Rose

Charaxes schreiber (Godart, [1824]) – Blue Nawab

Author with graduate students at the park

Validated performance of organic Indian traditional knowledge (ITK) concoctions for the management of brinjal shoot and fruit borer *Leucinodes orbonalis* Guenee

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ABSTRACT: Studies taken up to understand the organic pest management practices in shoot and fruit borer *Leucinodes orbonalis* Guenee in brinjal indicated that organic Indian traditional knowledge (ITK) concoctions in brinjal reduced *L. orbonalis* damage. The mean shoot damage observed among the five organic ITK concoctions were tested, *Agniasthiram* with a mean percent damage of 10.16 was found as better treatment followed by ten leaf extract (14.5%) and *Neemastram* (16.10%), Neem oil (24.92%). *Agniasthiram* also recorded minimum fruit damage (8.47 %) and was the best treatment followed by Ten leaf extract (14.5%) and *Neemastram* (18.77 %), Neem oil (20.18 %) and *Meenamilam* (27.59 %).

KEY WORDS: Brinjal, *Leucinodes orbonalis*, IPM, ITK concoctions

INTRODUCTION

Brinjal, *Solanum melongena* (L.) is the economically important vegetable crop cultivated throughout India (Javed *et al.*, 2017). It is a bushy plant also called eggplant belonging to Solanaceae family. According to Tewari and Moorthy (1984) more than 150 insect pests infest the brinjal crop, of which brinjal shoot and fruit borer (BFSB), *Leucinodes orbonalis* Guenee (Crambidae: Lepidoptera) is the most serious and destructive pests on brinjal crop cultivated in South and Southeast Asia. The larvae of *L. orbonalis* cause extensive damage both in vegetative and reproductive stages of the crop (Banerjee *et al.*, 2009; Panja *et al.*, 2013). The larvae bore inside tender shoots and affect the plant. As a result the unripe fruits become unmarketable. The peak *L. orbonalis* infestation up to 90 per cent was recorded by Baral *et al.* (2006).

Over dependence on chemical pesticides is not only non-sustainable it also affects the quality of brinjal fruit and ultimately human health (Patil, 2016). According to Walunj *et al.* (1996) opinion insecticides of plant origin which are cheaper, easily available and safer to mankind need to be promoted in the management of *L.orbonalis* in brinjal crop. There is an increase in awareness on utilization of organic products in pest management not only as an ecologically viable option and such products help in reducing the environmental and other ill effects caused by insecticides (Rajendran, 1993). Some of the Indigenous Technical Knowledge (ITK) practices by the organic farmers are playing a pivotal role in reducing the pest problem in crop protection leading to minimal use of toxic chemicals.

MATERIALS AND METHODS

Preparation of ITK Organic Concoctions

Preparation of *Meenamilam*

Meenamilam is an indigenous concoction used by 26.41 per cent of the farmers interviewed. Fish waste and nattu vellam (jaggery) each @ one kg were taken and mixed well in a plastic bucket. The content was mixed once in five days up to one month period and kept undisturbed for fermentation up to 40 days. After a period of one and half months the content was filtered and kept in an airtight container for further use. *Meenamilam* is used at 10ml/litre of water after filtering through muslin cloth.

Preparation of '*Agniasthiram*'

'*Agniasthiram'* is an ITK concoction used by 17.42 per cent of the farmers interviewed. The main constituent of '*Agniasthiram*' is green chili, ginger, garlic and dry leafs of tobacco. '*Agniasthiram'* is prepared by taking 500 gm of each crushed chilli, ginger and garlic and 250 gm of dry tobacco leaf. All this ingredients are taken in 10 litres of country's cow urine and boiled in a mud pot till the total volume of the extract reaches one third of the initial volume. The extract was kept for 24 hrs and then filtered and stored in an airtight pet jar in room condition for further use in the experiments. *Agniasthiram* is used at 30 ml/ litre of water after filtering through muslin cloth.

Preparation of ten-leaf extract

Ten-leaf extract is an ITK organic concoction based on ten selected green leaves and is being used by 16.4 per cent of the farmers interviewed. This concoction is locally called as '*Pathilaikasayam*'. The ten leaf extract includes notchi (*Vitex negundo* L.), Aristolochia leaves (*Aristolochia indica* L.), Papaya (*Carica papaya* L.), Heartleaf moonseed (*Tinospora cordifolia* Miers.) and custard apple (*Annona squamosa* L.) as basic five ingredients in addition to leaf from other five plants namely Neem (*Azadirachta indica* A. juss), Erukam (*Calotrophis gigantean* L.), Kolingi (*Tephrosia purpurea* L.), Katamanaku (*Jatropha curcas* L.), pungam (*Pongamia pinnata* L.). The concoction used in the present study was prepared by taking neem leaf 5 kg, leaves from Notchi (*V. negundo*), Aristolochia leaves (*A. indica*), Papaya (*C. papaya*), Heartleaf moonseed (*Tinospora cordifolia* Miers) and custard apple (*A. squamosa* L.) Neem (*A. indica*), Erukam (*C. gigantean*), Kolingi (*T. purpurea*), Katamanaku (*J. curcas*), pungam (*P. pinnata*) each 2 kg in 200 liter of water having 5 liters of country cow urine and 3kg cow dung. The 200 liters water having all the ingredients was stored in an airtight plastic container for three months for fermentation.The plastic container was kept in a cool shaded place and stirred three times in a day for efficient mixing and uniform fermentation. Ten-leaf extract was used @ 40 ml per liter of spray fluid.

Preparation of '*Neemastram'*

'Neemastram' is the indigenous organic concoction used by 27.1 percent of the organic farmers interviewed. '*Neemastram'* is prepared by mixing 5 kg of neem leaf paste in 100 liters of water added with 5 liter of country cow urine and 5 kg of cow dung collected from the country cow. The concoction is kept open in plastic containers with the neck portion covered with cadda cloth. The concoction is kept for one week with periodic stirring and use. The concoction '*Neemastram*' is used @25 ml per liter of water.

Testing under field condition

The performance of organic concoctions for the management of *L. orbonalis* was validated in an organic farmer field at Subramaniyapuram village in Tenkasi Taluk, Tirunelveli District during 2017 *rabi* season. The popular brinjal variety KKM 1was used. The crop was planted on 07.10.2017 with a spacing of 60 x 60 cm. The crop was grown following the organic farming practices of the farmer. Experiment was conducted with four replications adopting Randomized Block Design (RBD) involving six treatments (Plate 1)

A total of three sprayings were given starting from 30 days after transplanting, at an interval of 15 days. Observation on shoot damage caused by *L.orbonalis* was recorded before spraying and on the 7th day and 14th day after every spray. Number of damaged shoots among the total plants from each plot was recorded throughout the vegetative stage of the crop season and the damage was expressed in terms of per cent shoot damage. A total of three sprayings were given starting from 100 days after transplanting at an interval of 15 days.

Observation on fruit damage caused by *L.orbonalis* was recorded before spraying and on the 7th day and 14^{th} day after every spray. Fruit damage was recorded during each picking and extent of fruit damage was worked out on number basis and the percent fruit damage was calculated.

Studies on phytotoxicity effect of ITK concoctions

The phytotoxicity effect of the ITK organic concoctions such as *Meenamilam* (10ml / litre), Neem oil (2ml/ litre), *Agniasthiram* (30ml/ litre), Ten leaf extract (40ml / litre), *Neemastram* (25ml / litre) was studied at recommended dose and double the recommended dose. Potential plants of brinjal variety KKM1 in vegetative stage (50 Days after planting) were used. The treatments were replicated four times and each potted plant constituted a replication. Phytotoxicity score was done from 1 to 5 scale as per the standard procedure (Visnupriya and Muthu Krishnan, 2017) and graded as detailed below.

Scale	Phytotoxic symptom	Description
1.	Burn	The tip, the edge, as spots on the leaf or the whole leaf surface may appear like burned. The developing tip or bud is also affected.
2.	Necrosis (Death of the plant tissue)	Similar to burn and influencing plants in a similar damage
3.	Chlorosis (yellowing or blanching)	Appears as spots, tip yellowing or as a general chlorosis of the whole leaf.
4.	Leaf distortion	Twisting, Crinkling, or Cupping of the leaf.
5.	Hindering development	Unusual development in sprayed plant

COMMENTS and DISCUSSION

Effect of ITK concoctions on shoot damage against *L. orbonalis*

The percent shoot infestation data indicated reduction in shoot damage the following application of organic ITK concoctions. In the vegetative phase of the crop prior to 1^{st} spray the shoot damage observed the organic crop ranged between 20.04 to 22.69 per cent. Following seven day after first application, compared to 25.37 per cent shoot damage recorded in untreated plot a minimum level of damage of 14.41 per cent was noticed in *'Agniasthiram'* treated plot. Extend of shoot damage observed in ten leaf extract sprayed plots was 16.07 per cent. In Neem oil and *Meenamilam* applied plot the shoot damage observed 19.74 and 22.12 per cent respectively. At 14 day after, the shoot damage infestation percentage in the organic ITK concoctions treated plot ranged from 16.16 per cent in *Agniasthiram* sprayed plot 23.13 per cent in *Meenamilam* sprayed plot. Shoot damage observed during this period in the untreated plot was 28.79 per cent. In terms of overall mean, following single application of organic ITK concoctions a significant reduction in shoot damage by *L. orbonalis* was noticed .Among the five organic ITK concoctions tested *Agniasthiram* with a mean percent damage of 15.28 was found as best treatment followed by Ten leaf extract (17.37%) and *Neemastram*(19.39%).

When the organic ITK concoctions were applied for the second time at 15 days after 1st spray further reduction in extent of shoot damage was noticed. On seven days after the second application, the extent of shoot damage was found minimal (12.38%) in *Agniasthiram* applied compared to 29.44 percent noticed in untreated control. The extent of shoot damage observed (% shoot damage) during this period in plot treated with ten leaf extract, *Neemastram* and Neem oil was 16.53, 17.11, 18.38 respectively. At 14 days after the second spray, the shoot damage observed in the control plot has reached a maximum of 31.36 per cent. The impact of the organic ITK concoctions showed in terms of reduction in shoot damage by *L. orbonalis* in the organic ITK concoctions treated plots was found statistically minimal. The product *Agniasthiram* which was showing a minimal level of damage (14.87%) was found superior among all the treatment tested followed by Ten leaf extract (17.01%), *Neemastram* (17.46%), Neem oil (23.94%) and *Meenamilam* (25.63%). In terms of overall mean comparison, two rounds of application of the organic ITK concoctions found to result in reduction in shoot damage by *L. orbonalis* to a significant level. Compared to 30.40 per cent shoot damage observed in untreated control, the mean per cent fruit damage among treatments ranged between 13.63 in *Agniasthiram* and 24.17 per cent in *Meenamilam* applied plot. The data collected on per cent shoot damage in brinjal crop following the third application made at 15 days after second spray indicated further effectiveness of the concoctions. After 15 days interval after 2nd application, compared to the shoot damage recorded in the untreated plot was 32.31 per cent and a minimum level of damage of (9.91%) was noticed in *Agniasthiram* treated plot. The extent of shoot damage observed during this period in ten leaf extract sprayed plots was 12.55 per cent and in neem oil and *Meenamilam* applied plot it was 23.28 and 24.77 per cent respectively. Following 14 day after spraying, the shoot damage infestation percentage in the organic ITK concoctions treated plot ranged from 10.41 per cent in *Agniasthiram* to 30.29 per cent in *Meenamilam* sprayed plot. Shoot damage observed during this period has reached a maximum level of 33.33 percent in untreated plot. Following third application in terms of overall mean, it is found that among the five organic ITK concoctions tested *Agniasthiram* with a mean per cent damage of 10.16 was found as the, second best treatment followed by ten leaf extract (14.5%) and *Neemastram* (16.10%), Neem oil (24.92%).

Fruit damage

The results of the observations made on fruit damage caused by *L. orbonalis* following three rounds of spray application of ITK concoctions made in the reproductive phase of crop. In the experiment plot, in the reproductive phase of the crop the initial fruit damage by *L.orbonalis* ranged was between 18.69 to 19.12 per cent. On seven day after first application, compare to 21.47 per cent fruit damage recorded in untreated plot a minimum of 11.39 per cent fruit damage was noticed in '*Agniasthiram'* treated plot. The extend of fruit damage observed in ten leaf extract sprayed plot was 13.75 per cent and in Neem oil and *Meenamilam* applied plot the fruit damage observed 16.61 and 18.86 per cent respectively. On 14 day after spraying the fruit infestation percentage in the organic ITK concoctions treated plot ranged from 12.13 per cent in '*Agniasthiram'*to23.64 per cent in *Meenamilam* sprayed plot. Fruit damage observed during this period in untreated plot was 28.74 per cent. In terms of overall mean, following single application of ITK organic concoctions, a significant reduction in fruit damage by *L. orbonalis* was noticed. Among the five organic ITK concoctions tested '*Agniasthiram'* with a mean per cent damage of 11.76 per cent was found as best treatment followed by Ten leaf extract (14.70%) and *Neemastram* (18.34%).

The data on the fruit damage following second application, showed further reduction in extend of fruit damage compare to the in ITK concoctions sprayed plots untreated control. On seven days after second application, the extent of fruit damage observed in *Agniasthiram* applied plot was 8.37 per cent was compared to a higher level of 34.13 per cent in fruit damage noticed in untreated control. Extend of fruit damage (% fruit damage) observed in plot treated with Ten leaf extract, *Neemastram* and Neem oil was 13.19, 19.49, 20.52 respectively. Following 14 days after second spray, the fruit damage observed in the control plot increases to39.84 per cent. The impact of the Organic ITK Concoctions in terms of reduction in fruit damage by *L. orbonalis* was found statistically superior following second application. The organic ITK concoction '*Agniasthiram'* having 10.21 per cent fruit damage was found superior among all the treatment followed by Ten leaf extract (16.32 %), *Neemastram* (21.37 %), Neem oil (22.19 %) and *Meenamilam* (25.95 %). In terms of overall mean comparison, two rounds of application of the Organic ITK Concoctions found to result in reduction in fruit damage by *L. orbonalis* to a greater extent. Compared to a mean damage level of 39.84 per cent fruit damage observed in untreated control, fruit damage among the treatment range from 9.29 in *Agniasthiram* to 24.41 per cent in *Meenamilam* applied plot. After two rounds of application, compare to maximum 42.16 per cent fruit damage recorded in untreated plot a minimum damage of 7.83 per cent fruit damage was noticed in *Agniasthiram* treated plot. The extend of fruit damage observed during this period in Ten leaf extract sprayed plot was 13.54 per cent and in neem oil and *Meenamilam* applied plot the per cent fruit damage observed was 19.68 and 25.47 per cent respectively. On 14 day after spraying, the fruit damage infestation percentage recorded in the organic ITK concoctions treated plot ranged from 9.11 per cent in *Agniasthiram* to 29.70 per cent in *Meenamilam* sprayed plot and the extend of fruit damage observed during this period in untreated plot was 50.74 per cent. In terms of overall mean, following third application among the five organic ITK concoctions tested *Agniasthiram* with a minimum mean per cent damage of 8.47 was found the best treatment followed by Ten leaf extract (14.5 %) and *Neemastram* (18.77 %), Neem oil (20.18 %) and *Meenamilam* (27.59 %).(Table 1)

Impact of ITK concoctions on brinjal crop yield and Economics

The data on the yield realized in the organic brinjal production due to application of ITK concoctions is furnished in Table 1. The yield data recorded from the organic farming field trial revealed an increased yield realization in the organic ITK concoctions applied plot. The higher quantity of brinjal fruit harvested in *Agniasthiram* 12.63 ton/ha followed by Ten leaf extract 12.21 ton / ha, *Neemastram* 12.05 ton / ha, Neem oil 10.47 ton /ha, *Meenamilam* 9.67 ton/ha as compared to control 9.43ton/ ha. The maximum net return was obtained from *Agniasthiram* Rs 91,471 /ha followed by Ten leaf extract Rs 88, 101 /ha, *Neemastram* Rs 73,031 /ha, Neem oil Rs 55, 912 /ha, *Meenamilam* Rs 46,097 /ha as compared to control 62,910 Rs /ha. Among the treatments studied the best and most economic treatment Benefit cost ratio was in *Agniasthiram* 2.26 followed by Ten leaf extract 2.25, *Neemastram* 1.87, Neem oil 1.70, *Meenamilam* 1.58 as compared to control 2.05.

Phytotoxicity of ITK Concoctions

The organic ITK Concoctions were tested for their possible phytotoxicity effect at the practicing dose and at double the practicing dose. Observation made on phytotoxicity effect is furnished in Table 2. The phytotoxicity study revealed that at recommended dose the ITK Concoctions *viz*., *Meenamilam* (10 ml/ lit), Neem oil (2 ml/ lit), *Agniasthiram* (30 ml/ lit), ten leaf extract (40 ml/ lit) and *Neemastram* (25 ml/ lit) were found to cause no phytotoxicity symptom is brinjal plant. However, at double the practicing dose *Meenamilam* (20 ml / lit), Neem oil (4 ml/ lit) were found to cause phytotoxic effect. *Meenamilam* when applied twice at 15 days interval on vegetative stage of the crop at 20ml per lit has resulted in chlorosis in leaves (Grade3) and Neem oil at 4ml per lit caused discoloration of the leaves (Grade 2).

Information available on bioefficacy of different ITK concoctions used in the present study is limited Sinha *et al.*(2008) while testing various ITK concoctions on different vegetable under in north eastern India condition indicated a cow based decoction consist of cow urine, chilly and garlic @, 2:1 and 5:25 ratio was effective ITK concoctions for the management of defoliators in vegetable crops. For management of *Helicoverpa armigera* in vegetable and flower crops. Patil (2016) indicated a fermented ITK concoction consisting of twenty liters of cow urine + 2 kg neem leaves + 500 gm tobacco + 500gm crushed green chilly + 250 gm of crushed garlic. In the work of Mathur *et al.* (2012), illupai and Pungam oil based indigenous botanical preparations being suggested to bring down damage caused by *L. orbonalis* and for increasing the fruit yield. They also claimed illupai and pungam oil as potential alternatives for insecticide application. In his report Deka *et al.*(2017) indicated ITK based plant protection as less expensive, non-hazardous and long term sustainable. Sundamari and Ranganathan (2003) suggested use of ITK product for the management of *L. orbonalis* as there is no chemical hazard involved in ITK produce use. The use of ITK produce knowhow helps in addition to reduction in cost of cultivation and the benefits of biodiversity.

Foliar application of ITK concoctions was found to reduce *L.orbonalis* damage in brinjal crop both in organic and inorganic cultivation. Under organic farming condition reduction in shoot damage observed following three rounds of application was 69.04 per cent in *Agniasthiram*, 55.67 per cent in ten leaf extract, 50.94 per cent in *Neemastram*, 24.04 per cent in Neem oil. *Meenamilam* application resulted in 16.12 per cent reduction in shoot damage. In terms of cost benefit yield, the ITK concoction were in the order of *Agniasthiram* (2.26) > Ten leaf extract (2.25) > *Neemastram* (1.87) > Neem oil (1.70) > *Meenamilam* (1.58).

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Plate 1. Field view of on-farm organic trial (Subramaniyapuram village)

Table 1. Efficacy of organic ITK Concoctions on Fruit damage by *L. orbonalis* on brinjal crop in field conditions

Treatment Details	After 1st Spray Percent of Fruit infestation				After 2st Spray Percent of Fruit infestation			After 3st Spray Percent of Fruit Infestation			**Yield t/ha**	Benefit cost ratio
	Pre count	**7 DAS**	**14 DAS**	**Mean**	**7 DAS**	**14 DAS**	**Mean**	**7 DAS**	**14 DAS**	**Mean**		
T1 *Meenamilam* @ 10 ml / lit	19.80 (26.42)	18.86 (25.74)	23.64 (29.09)	21.25	22.86 (28.56)	25.95 (30.63)	24.41	25.47 (30.31)	29.70 (33.03)	27.59	9.67	1.58
T2 Neem oil @ 2ml / lit	18.28 (25.31)	16.61 (24.05)	21.71 (27.77)	19.16	20.52 (26.93)	22.19 (28.11)	21.36	19.68 (26.33)	20.68 (27.05)	20.18	10.47	1.70
T3 *Agniasthiram* @ 30 ml/ lit	18.69 (25.62)	11.39 (19.73)	12.13 (20.38)	11.76	08.37 (16.81)	10.21 (18.63)	09.29	07.83 (16.24)	09.11 (17.57)	08.47	12.63	2.26
T4Ten leaf extract @ 40 ml / lit	19.43 (26.15)	13.75 (21.77)	15.65 (23.30)	14.70	13.19 (21.29)	16.32 (23.83)	14.75	13.54 (21.59)	15.85 (23.46)	14.50	11.65	2.25
T5 *Neemastram* @ 25 ml / lit	18.26 (25.30)	17.73 (24.90)	18.96 (25.81)	18.34	19.49 (26.20)	21.37 (27.53)	20.43	17.34 (24.61)	20.20 (26.71)	18.77	10.68	1.87
T6 Control	19.12 (25.93)	21.47 (27.60)	28.74 (32.42)	25.10	34.13 (35.75)	39.84 (39.14)	36.98	42.16 (40.49)	50.74 (45.43)	46.45	7.43	2.05
SEm	0.36	0.17	0.18	-	0.17	0.19	-	0.11	0.13	-	-	-
CD (0.05)	NS	0.53	0.56	-	0.51	0.57	-	0.32	0.4	-	-	-

*Figures in the parentheses are arc sine transformation, DAS-day after spray

Field incidence of hawk moth in mungbean

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Greengram (*Vigna radiata* L. Wilczek) is the most important short duration pulse crop of India and occupies an area of about 4.25 m.ha with a production of 2.40 m.t and 567 kg ha^{-1} productivity and Andhra Pradesh is one of the major state in India with highest productivity of 613 kg ha^{-1} (AICRP on MULLaRP, 2019). It is a highly remunerative crop grown in *kharif* as well as in r*abi* both in uplands and rice fallows in Andhra Pradesh and a large number of insects have been recorded on this crop from sowing to harvesting.

Severe and unusual incidence of Death's head hawk moth, *Acherontia styx* Westwood larvae was recorded in mungbean for the first time in experimental plots at Regional Agricultural Research Station, Lam, Guntur, Andhra Pradesh during kharif, 2019. Small death's head hawk moth, A. styx is found primarily in India and Southeast Asia which is easily noticeable for skull-like marking on the thorax dorsum of adult moths. The adult is a large moth with dark dull brown forewing and yellow hind wing (Hill, 2008). It is polyphagous pest which feed more than 100 species of plants in various families such as Labiatae, Bignoniaceae, Verbenaceae, Cucurbitaceae, Solanaceae, Myrtaceae, Convolvulaceae, Oleaceae, Leguminosae, Pedaliaceae and others (Robinson *et al*., 2010).

Large number of hawk moth larvae (Plate.1) was observed for a short period of two weeks from the end of August, 2019 after continuous heavy rainfall when the crop was at vegetative phase. Larvae were bright green in colour with a horn like structure which is straight and yellowish in colour on the dorsal side of the final abdominal segment. There are seven sharply defined yellow oblique lateral stripes on 5 to 11 abdominal segments, each stripe extending upwards and slanty to near the dorsal line of the each segment and the yellow stripe on 11 abdominal segment extended backwards to the base of the horn. The true legs are black in colour, while prolegs and claspers are green in colour (Bell & Scott, 1937). Nine pairs of spiracles were found which are oval, brownish with the central white slit, the whole bordered with whitish green circle. Mostly fourth and fifth instar larvae were found on leaves and caused severe leaf damage by eating the lamina by causing irregular patches on leaves (Plate.2). However, foliar application of a contact insecticide could control the hawk moth larvae effectively.

Plate 1: Hawk moth larvae on mungbean

Plate 2: Large irregular patches on leaves due to hawk moth larvae

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Fruit flies in Southern Kerala –the changing scenario

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Fruit flies (Diptera: Tephritidae) are serious pests of fruits and vegetables, worldwide. In Kerala, *Bactrocera dorsalis* (Hendel) in mango and *Bactrocera cucurbitae* (Coq.) in cucurbitaceous vegetables are major pests. The cryptic nature of the larval stage of the pests makes their management difficult. The different habitats of the various life stages of the pests makes the management more complex.

The project on 'Integrated management of fruit flies' (IMFFI) during 2002-2005 could develop suitable IPM, integrating Male Annihilation Technique (MAT), Bait Application Technique (BAT)and cultural control. This IPM practice has later been modified to suit the homestead conditions of Kerala after incorporating biological control also. Post harvest hot water treatment of mango was modified for mango suited to small farmers in Kerala. The technology was popularized in Kerala through a RKVY project during 2008-2011. The IPM technology could substantially reduce crop loss in cucurbits and mango. The management strategies are further being disseminated among the farmers, by various means.

In Kerala the incidence of the *B. dorsalis* was seen mainly in three fruit crops *viz.*, mango, guava and banana and *B. correcta* and *B. zonata* were also reported from guava and other fruits. *B. cucurbitae* was observed in cucurbitaceous crops, *viz*. snake gourd, bitter gourd, pumpkin cucumber and coccinia. Infestation by other species of fruit fly was also recorded from rose apple and solanaceous vegetables *viz.*, brinjal and tomato. The species was identified as *B. latifrons* (Hendel).

Trap collection studies using MAT, in Thiruvananthapuram during 2007 under an APEDA project revealed a species composition, having the dominance of *B. dorsalis* (78.56%), over *B. caryeae* (17.53%). However, during 2014, a similar study showed the prevalence of four *Bactrocera spp. viz., B. dorsalis*, *B. caryeae*, with a species composition of 28.74, 69.85, per cent, respectively. The fortnightly population of *B. caryeae* (278.91) and *B. dorsalis* (124.82) reached the peak level in June 2014, coinciding with the peak fruiting season of mango. However, more number of *B. dorsalis* hatched out from fruit, than *B.*

caryeae. Correlation with weather parameters revealed that the maximum temperature, average relative humidity and sunshine hours had a significant positive correlation with the population of *B. dorsalis* and *B. caryeae.* Another interesting observation was that fruit flies were damaging black pepper (*Piper nigrum*) plants in a mixed cropping system, in Southern Kerala. The affected plants were in the early flowering stage. Male fruit flies were hovering and settling on the spikes for feeding. The females of fruit flies are notorious for causing damage to fruit crops by oviposition. Contrary to this, here the males were found causing serious infestation by feeding. The fruit flies observed, belonged to *Bactrocera dorsalis* and *B. caryeae,* present in equal ratios. In a random count, 47.5% of the spikes were found to be damaged. The fruit flies were lapping the sap from the soft tissues of spikes. The feeding spots turned black and coalesced, turning the entire spike black. Subsequently, the spikes dried up. This is a new concern to black pepper growers, which needs attention.

The OP compound Malathion has been widely used in BAT and MAT. Identification of newer molecules, botanicals and bio-agents that are safe and effective will reduce pesticide residues in the environment. In a study conducted at Vellayni, it was found that spinosad could be an effective alternative. Alcohol, lure and spinosad (6: 4: 0.2 v: v: v) was found as the best treatment in MAT. Ten per cent jaggery along with spinosad 0.02% was effective in BAT. However, emphasis should be given to identify more green labelled newer molecules for use in MAT and BAT.

Biological control using predator's parasites and microbial pesticides is another area of concern. At the Kerala Agricultural University, studies were undertaken to identify promising biocontrol agent for managing fruit flies. In a study under an ICAR project, soil application of the biocontrol agents *Beauveria bassiana* (ITCC6063) and *Paecilomyces lilacinus* (ITCC6064) was found effective for managing the pest in the pupal stage.

Effective fruit fly management is possible only by adopting area wide management. However, in Kerala, due to the characteristic homestead situation, the implementation of area wide management programme has difficulties. So, research on botanicals, biocontrol agents and habitat manipulation should be taken up, for the effective management of fruit flies.

Is the use of nanoparticles in pest and disease management safe?

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The increase in demand for pesticide is predicted significantly in the years to come. The main aim of application of nanopesticides and nanofertilizers in agriculture is to reduce pesticide and fertilizer applications thereby enhance the suppression of pest and optimize nutrient management. The development of nanoformulations against insect pests is aimed at reducing the quantity of AIs, controlled release and protection from degradation. A variety of formulations have been proposed for insecticidal compounds. Nanoemulsions are promising candidates for the delivery of water-insoluble AIs and typically contain 5–10 % of surfactant, as compared to 20 % in microemulsions (Kah and Hofmann 2014). Current research is focused on the controlled release of insecticides and herbicides using polymer-based nanoformulation. These studies demonstrated the wide range of polymer-based nanosystems for the controlled release and protecting of photo-labile compounds in pest management programmes. In this context, controlled release of azadirachtin-A was achieved by encapsulation in nano-micelles of polyethylene glycol (PEG) based amphiphilic copolymers and various dimethyl esters (Kumar *et al*. 2010). In recent years nanoparticles like ZnO, TiO2 and Ag are used in many applications in plant disease management. Nano Herbicides and nanofertilizers have a great future in the coming years in the field of agriculture, horticulture and agroforestry systems, but a vast knowledge regarding their potential risk is required before products are brought to market. Some nanoparticles have been found toxic to different environments including humans proven through several research studies. Strict regulation is required for the manufacturers to correctly represent the composition and the characteristics of nanopesticide formulations developed.

The present knowledge in estimating the benefits and risk of nanopesticides and lack of satisfactory information and low adequacy of experimental protocols impede inclusive risk assessment. In view of this, quantitative structure–toxicity relationship (QSTR) models for prediction of cytotoxicity of metal oxide nanoparticles are developed by periodic table-based descriptors that can powerfully encode cytotoxicity of metal oxides leading to models with high statistical quality as well as interpretability. The information required for descriptor calculation is independent of nanoparticles size, thus nullifying a noteworthy dilemma that various physical properties of nanoparticles change for different size ranges. Recently, nano quantitative toxicity–toxicity relationship (nano-QTTR) models for interspecies cytotoxicity correlation have been developed that can be employed for the extrapolation of the data of cytotoxicity of one species to another (Kar *et al.* 2016).

Understanding the behavior of nanomaterials in different environments is rapidly evolving, but still it is very limited by the lack of robust and integrative research. Studies on the effect of a particular nanoparticle type on different biological systems can make a significant impact for developing safer nanopesticides. Each biological system provides a unique setting to examine the fate of nanoparticles, therefore combining the knowledge in understanding the behavior of nanoparticles across diverse ecosystems which is a critical step in determining the safety of mankind.

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The Red Palm weevil *Rhynchophorus ferrugineus* Olivier situation in the Gulf Cooperation Council Countries of the Middle East

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The Red Palm Weevil (RPW), *Rhynchophorus ferrugineus* Olivier (Coleoptera: Curculionidae) has emerged as a key pest on date palm in the Gulf Cooperation Council (GCC) Countries of the Middle-East. The six GCC countries comprising of Saudi Arabia, UAE, Sultanate of Oman, Kuwait, Qatar and Bahrain account for nearly 30% of the global date production. During the mid 1980s RPW was first recorded in UAE where it arrived through ornamental palm shipments and has since gained a strong foothold on date palm in the region and beyond. FAO has designated RPW as a category-1 pest on date palm in the Middle-East and through its 'Rome Declaration' of 2017 called for coordinated efforts of all stakeholders at the national, regional and international levels to combat this pest. Globally RPW is being reported from 50 countries with a host range of 40 palm species (FAO, 2017; EPPO, 2020).

RPW has been managed with varying degrees of success and failure in the region by deploying a pheromone based IPM strategy proposed by Abraham *et al*. 1998 comprising mainly of trapping the adult population using pheromone traps, visual inspection of palms to detect infestation, preventive and curative chemical treatments and eradication severely infested palms. Lack of phytosanitary protocols coupled with weak enforcement of quarantine regimes have facilitated the spread of RPW in the GCC region and elsewhere. Absence of effective biological control agents in the field together with the lack of an efficient, cost effective and easy to use detection device has made RPW management difficult. Although date palm cultivars of the region exhibit varying levels of resistance to the pest, host plant resistance against RPW is yet to be exploited for its control. Area-wide RPW-IPM programs in the region are highly input driven and difficult to sustain in the long run. Besides trained man power such field operations require a wide range of material and equipment including pheromone lures, insecticides, motor sprayers, trunk injectors, vehicles, chain saws, power drills, palm shredders etc.

Efficient data collection for periodic validation of area-wide RPW-IPM programs is vital for the judicious use of resources. To systematically collect standard geo-referenced data, FAO is developing a global RPW monitoring and early warning system consisting of a mobile App (*Susahamra*) for data collection in the field and GIS- based online system for data analysis and mapping, combined with remote sensing imagery. Furthermore, efficient semiochemical mediated technologies involving dry traps and 'attract & kill' are also available to better manage RPW in the field.

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Attract & Kill Technology against RPW in Saudi Arabia

Wild insect pollinators deserve more attention to combat climate change crisis

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The annual economic value of pollination services by different species of insects is estimated to be €153 billion worldwide (Gallai *et al.,* 2008). This cannot be an exaggeration as 35% of global crop production including 87 of the major food crops are dependent on cross pollination affected by various pollinators (Klein *et al.,* 2007). Of late, reports on 'pollinator decline' have been a matter of concern and this phenomenon is attributed to several factors like habitat loss, pesticide poisoning, invasive species and pests and diseases. Recent addition to this list is the climate change which is a potential major threat to pollinators and their ecosystem services as it adversely affects the synchrony of plant-pollinator interactions (Christmann and Aw-Hassan 2012; Reddy et al., 2012). Extreme weather conditions associated with climate change would put both pollinators and the plants they forage at risk leading to a probable cascade of species extinctions (Biesmeijer *et al*., 2006).

An option to overcome these eventualities and minimize the losses caused by the adverse effect of global warming on pollinators is expanding our attention to beyond the conventional species of pollinators, especially managed or domesticated pollinators like hive bees and commercialized bumble bees. Many are not aware that the wild pollinators contribute to about 85% of the global pollination services and honey bees alone cannot compensate for the loss of wild species diversity (Nabhan and Buchmann, 1997). There is a tendency that insect pollinators are often synonymized with honey bees. Though there is no denying that honey bees (*Apis* spp.) are one of the most efficient pollinators of a wide range of plants including wild and crop species, they too have limitations and are not an answer to all situations. The over reliance on one or two species might affect the preparedness to future potential threats. Wild native pollinators, overlooked for reasons unknown, could be a sustainable option. Honey bees being social insects are more vulnerable to temperature fluctuations as they have to spend their energy in maintaining colony temperature. Beyond a certain point of temperature inside the hive, bee colonies tend to leave brood and food behind them and abscond. Their communication through dancing too is adversely affected if the hive temperature is not adequate. Another limitation attributed to the hive bees is their limited flight range during cold, windy, wet and dark days thus making them unavailable to crop plants, especially those with short blossom periods (Imperatriz Fonseca *et al.,* 2009).

There are several wild species like carpenter bees, bumble bees, stingless bees, syrphids and calliphorids whose contributions to pollination are not quantified or systematically studied in different agro-ecosystems. For instance, in mango, the calliphorid species, *Chrysomya megacephala* has been found to be the most efficient pollinator with wide thermal adaptability compared to honey bee species (Reddy *et al*., 2016). Similarly carpenter bees play a significant role in pollination of solanaceous and leguminous vegetables and they need to be conserved.

In the direction of the effective utilization of wild pollinator species to agriculture in the ensuing climate change scenario, an approach called 'Farming with alternative pollinators' (FAP) has been proposed (Christmann and Aw-Hassan, 2012) and being popularized by the FAO and other international organisations. Adoption of FAP is especially desirable in areas that rely heavily on insect pollination like fruit, vegetable and plantation cropping systems. This approach is considered to not only enhance climate change resilience of agro-ecosystems but also the income of farmers as high biodiversity of pollinators results in increased quantity and quality of crop yields (Christmann *et al*., 2012). The FAP primarily involves enhancing fields and orchards with pollinator forage corridors between fragmented natural habitats and agricultural fields thus enriching the species richness (Memmott *et al.,* 2010). These corridors would also help in preventing soil erosion and also providing nesting and breeding sites for various natural enemies of pests like ladybirds, green lacewings, hover flies, birds etc.

Such initiatives involving habitat management go a long way in conserving the biodiversity of pollinator species as well as sustaining crop production in the face of climate driven shifts. In addition, spreading awareness and impressing upon the contributions of native non domesticated species to the cropping ecosystems are essential to reverse the 'pollinator decline' crisis.

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Invasion diary of the conifer forests

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Imagine you are walking past a vast expanse of green conifer trees in a forest. After a few months, you visit the forest again—only to see a stretch of red conifer trees! How did the green patch of forest change to red? Who cast the colour changing charm on the trees? Agreed—that it is a beautiful display of color gradient to watch on the go while casually strolling in the woods. However, a closer look at the tree barks, and you realize the problem with the colour! The pine trees with red needles are heavily infested with 'bark beetles'that live in self-made tunnels under the tree bark. These insects dig into the inner bark of the tree trunk and have the ability to ravage entire forests.

Bark beetles have always been an important part of the conifer forest ecosystem across different countries in the world. They attack the dying trees and, in the process, accelerates the decomposition rate of the trees and helps in the quicker regeneration of forests. However, bark beetles can chemically 'talk' to one another and aggregate in large numbers, when they find a patch of conifer trees to mass attack. Together they interfere in the process of transmission of nutrients from the leaves to the inner bark of the trees, causing nutrient starvation in the trees—that eventually kill these infested plants. Over the years, these insects have turned into pests owing to their ability to mass attack, spread and destroy tree barks in a short span of time. The timber industry has suffered heavy losses financially due to these infestations at the global level.

For a long time, the conifers were able to defend themselves by producing a sticky sap enriched with toxic chemicals to kill the beetles. With the advent of global warming, the change in our climate has been evident. Higher temperatures and longer periods of drought have resulted in increased loss of water from the plants. This has negatively affected the sap synthesis in conifers exposing them to multiple mass attacks. Further, the bark beetles seem to have adapted to the drier hot environment earlier than the conifers, leading to disruption of acres of conifer forests. There is, therefore, an urgent need to devise methods to ward off the bark beetles from the forests; else we shall not be able to save the lungs of our home planet. It is indeed terrifying to know that such a small pest can have so big an effect!

A Canadian pine forest infested with mountain pine beetle

Picture Credit: Time Gage

Symbiosis in urban jungle: An association between Lycaenidae caterpillars and ants

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In nature organisms protect themselves from predators using adaptations such as aposematism, mimicry, crypsis and masquerade. The Lycaenidae family of butterflies commonly known as blues represents nearly 40% of all known butterfly species. Lycaenid caterpillars maintain myrmecophilous associations with ants by secreting limited amounts of sugars, amino acids or by chemically mimicking the ant odour. In turn, ants harvest these secretions and do not attack the caterpillars. Therefore, these phytophagous insects defend themselves from natural enemies by associating with ants and provide nutritional rewards in return (Oliver & Stein, 2011).

Lycaenid caterpillars associate with different species, genera or sub-families of ants. The larvae feed on plant tissue and tender leaves (Pierce et al., 2002). These caterpillars have specialized adaptations such as appeasement pheromones and nectar glands (Atsatt, 1981). Tactile organs help in sensing tail pheromones of ants which directs the ant aggregation towards the caterpillars. Pore cupola organ is an epidermal gland that secretes appeasement pheromones which helps to reduce aggressive behaviour in ants. Dorsal nectar organ (DNO) is a larval organ that has a nectar gland which secretes carbohydrate rich substances for the ants to feed on as the reward. These secretions alter neurotransmitters in the brain of the ants resulting in low locomotor activity and increase in ant aggression towards predators and parasitoids (Basu & Kunte, 2020).

Protection of Lycaenid caterpillar by ants: Ant aggregation around the caterpillar provides them with the necessary protection from predators and parasitoids and therefore the caterpillars can easily feed on the terminal foliage of the plants which are young and nutrient rich. Consumption of more nutritious food throughout the day can permit shorter development time. This type of protection can encourage behavioural crypsis (the ability of an animal to avoid detection by other animals) among Lycaenidae (Baylis & Pierce, 1993).

A rare Lycaenid caterpillar *Tarucus nara* (Common name: Striped Pierrot) was observed foraging on *Ziziphus mauritiana* associated with *Camponotus compressus*

(Carpenter ant) (Fig 1a) in a scrub habitat at Mysore, Karnataka. *Tarucus nara* larvae feed on the top epidermal and dermal layer of the leaves (Fig 1a). Another example of caterpillar associated with two different species of ants was observed in *Chilades lajus* (Lime Blue) feeding on citrus sp., it was found to be associated with *Tapinoma melanocephalum* (Ghost ant) and *Camponotus* sp. (Fig 2a and Fig 2b) in an urban habitat at Bangalore, Karnataka.

These observations show that a mutualistic relationship exists between ants and Lycaenidae caterpillars, and some species of Lycaenids exhibit mutualism with multiple species of ants. Different species of ants were observed on the respective host plants of the caterpillars. It is speculated that there might be species specific preference for the host plant by the ants. Further studies with different species of Lycaenid caterpillars, their association with different species of ants and the ant - host plant relationship can provide more insights on this mutualistic behavior.

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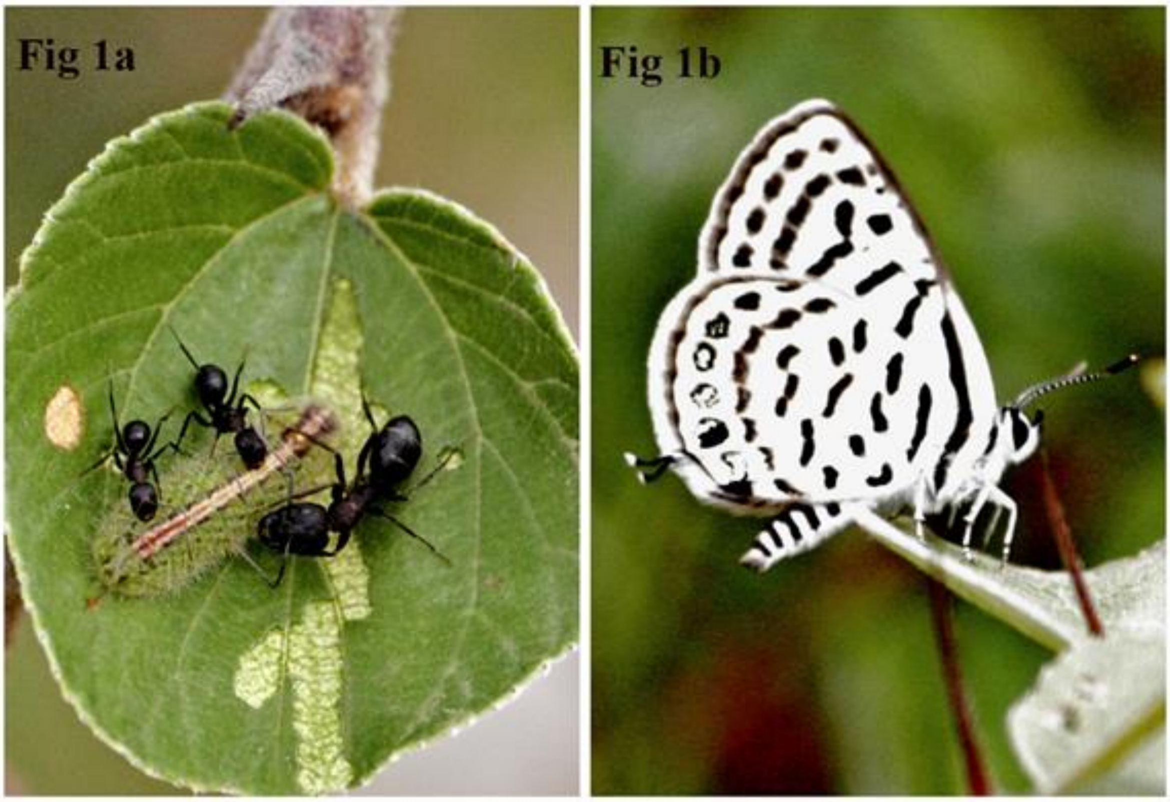

Fig 1a: *Tarucus nara* caterpillar association with *Camponotus compressus.*

Fig 1b: *Tarucus nara* adult.

Fig 2a: *Chilades lajus* caterpillar association with *Tapinoma melanocephalum*.

Fig 2b: *Chilades lajus* association with *Camponotus* sp.

Fig 2c: *Chilades lajus* adult.

Evaluation of odour-based attractants for *Drosophila melanogaster*: A preliminary report

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Drosophila melanogaster is a species of fly (the taxonomic order Diptera) in the Drosophilidae family. The species is known generally as the common fruit fly or vinegar fly. It is easy to grow fruit flies due to its simple food requirements, short reproductive cycle, less space requisite and production of a large number of offspring.

Although the vinegar fly, *Drosophila melanogaster*, has never been considered as a serious pest, it is a nuisance in households and in commercial food marketing and handling areas. These flies can be raised easily wherever fermentation is in progress. Volatile chemicals associated with fermentation, such as ethanol, acetic acid, ethyl acetate, and acetaldehyde, either as single components or in mixtures, previously have been reported to attract several Drosophila species (Barrows, 1907; Hunter et al, 1937; West 1961).

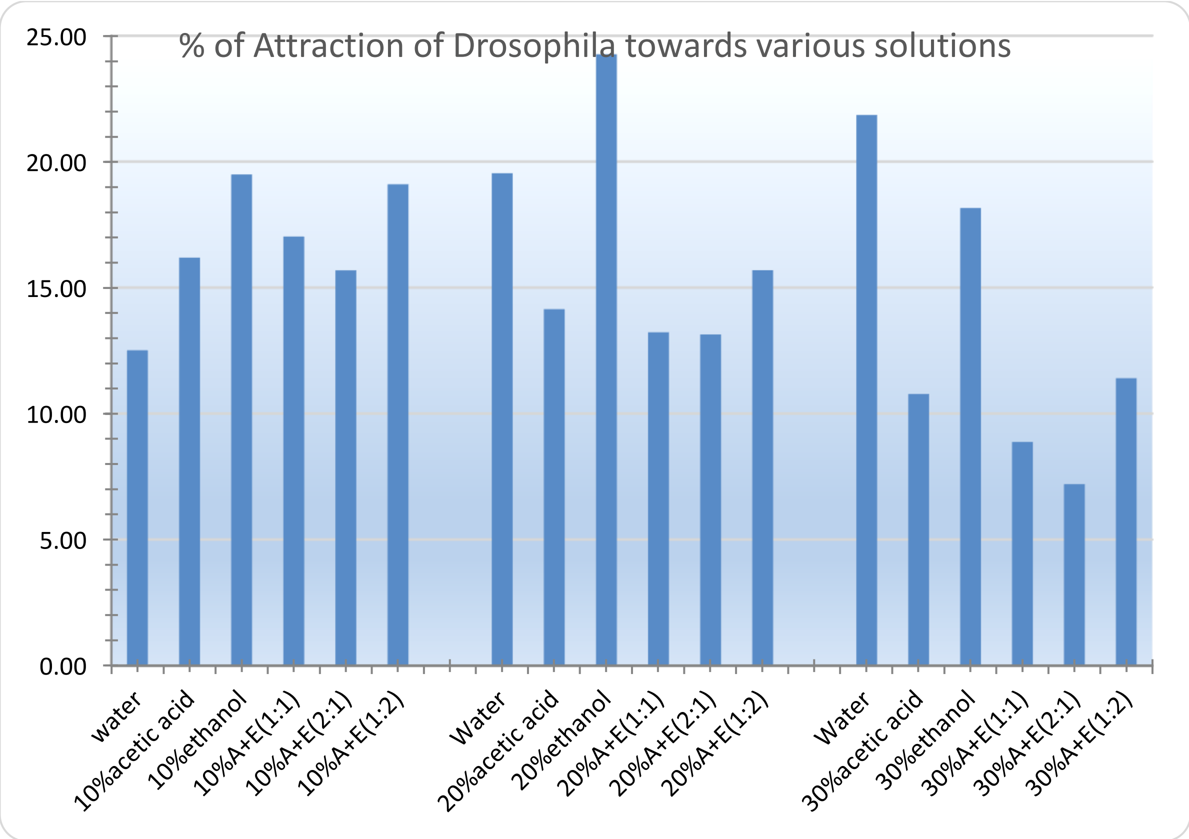
Reed (1938) demonstrated D. melanogaster fly attraction to ethanol and to acetic acid in a laboratory olfactometer. West (1961) used olfactometer assays, baited traps tested indoors and traps placed in the field to evaluate materials and chemicals attractive to *D. melanogaster* and *Drosophila virilis* Sturtevant. *Drosophila melanogaster* was attracted in laboratory cage tests to a blend of ethanol, acetic acid and 2-phenylethanol isolated from odours of over ripe mango fruits (Zhu et al. 2003).

Based on the above reports, a preliminary study was conducted using the volatile compounds at different concentrations. The compounds taken were ethanol and acetic acid at different concentrations either singly or in combination at different ratios.

The study was conducted for almost three months, where the flies were maintained in a culturing container under the laboratory conditions at 25 ± 5^0C. Rotten banana was consistently used as feed for the 200 plus flies during the study.

Three sets of studies were done with various concentrations as mentioned below and the results are summarized in the graph.

Set 1	Set 2	Set 3
water	Water	Water
10%acetic acid	20%acetic acid	30%acetic acid
10%ethanol	20%ethanol	30%ethanol
10%A+E(1:1)	20%A+E(1:1)	30%A+E(1:1)
10%A+E(2:1)	20%A+E(2:1)	30%A+E(2:1)
10%A+E(1:2)	20%A+E(1:2)	30%A+E(1:2)



Based on the above study, different concentrations of ethanol came out as the best attractant among all the other solutions especially 20%. A more comprehensive study around ethanol at different concentrations may help in identifying a concentration which will be useful in developing traps for use wherever the fly is a nuisance .

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Pollinator diversity in Jnana Bharathi Campus, Bangalore University

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Pollinators are the keystone species for a functional ecosystem providing essential services to humans. They are both ecologically and agriculturally important. Insects pollinate most flowering plant species without this service, many interconnected organisms and processes working within an ecosystem will collapse (FAO. 2019).

Jnana Bharathi campus (12^{o}56’19.59” N 77^{o}30’11.45” E) is located in Mysore road with a total geographical area of about 1100 acres. The campus has a luxurious vegetation cover and is also known as the “green lungs” of Bangalore city (Kumar et al. 2015). The campus provides a diversity of native wild plants habitat for pollinators. In view of the importance of pollinators for any functional ecosystem, a faunal biodiversity survey of different pollinators was carried out in Jnana Bharathi Campus, Bangalore University, Bengaluru. The study was conducted in December 2019; the study sites were selected randomly in wild areas within the campus. The insects were swept using insect net at an interval of 4 days for a month skipping rainy days from 7 am to 10 am, the pollinators were killed at spot by using ethyl acetate in a killing jar and brought to laboratory for further processing (FAO. 2016). The sampled specimens were identified with the help of Scientists from the Department of Entomology, Agricultural University, GKVK.

The collected pollinators during this study period are listed in Table 1. A total of forty-two species of pollinators were recorded belonging to 14 families and 6 orders. The most diverse group of pollinators, by a large margin were the Lepidopterans with 26 species, followed by Hymenopterans (10sp.). The least pollinator members recorded were from the orders viz, Orthoptera (2sp.), Coleoptera (2sp.), Hemiptera (1sp.) and Odonata (1sp.) correspondingly. The most commonly observed pollinators are shown in Figure 1.

Table 1: List of pollinators observed in Jnana Bharathi campus, Bangalore university

S. No.	Order	Family	Scientific name	Common name
1.	Coleoptera	Cerambycidae	*Obereopsis* sp.	
2.	Coleoptera	Coccinellidae	*Coccinella* sp.	Lady Bird Beetle
3.	Hemiptera	Scutelleridae	*Chrysocoris* sp.	Metallic Shield Bugs
4.	Hymenoptera	Apidae	*Apis dorsata*	Giant Honey Bee
5.	Hymenoptera	Apidae	*Apis cerana*	Indian Honey Bee
6.	Hymenoptera	Apidae	*Apis florea*	Dwarf Honey Bee
7.	Hymenoptera	Apidae	*Amegilla* sp.	
8.	Hymenoptera	Apidae	*Ceratina* sp.	
9.	Hymenoptera	Apidae	*Xylocopa confusa*	
10.	Hymenoptera	Formicidae	*Camponotus* sp.	Carpenter Ant
11.	Hymenoptera	Megachilidae	*Megachile* sp.	Leafcutter Bees
12.	Hymenoptera	Sphecidae	*Sphex* sp.	Digger Wasps
13.	Hymenoptera	Vespidae	*Allorhynchium sp.*	
14.	Lepidoptera	Lycaenidae	*Castalius* sp.	Common Pierrot
15.	Lepidoptera	Lycaenidae	*Talicada nyseus*	Red Pierrot
16.	Lepidoptera	Lycaenidae	*Leptotes plinius (fabricus)*	Zebra Blue
17.	Lepidoptera	Lycaenidae	*Acytolepis puspa*	Common Hedge Blue
18.	Lepidoptera	Nymphalidae	*Danaus genutia*	Striped Tiger
19.	Lepidoptera	Nymphalidae	*Junonia hierta*	Yellow Pansy
20.	Lepidoptera	Nymphalidae	*Mycalesis* sp.	Bushbrown
21.	Lepidoptera	Nymphalidae	*Junonia lemonias*	Lemon Pansy
22.	Lepidoptera	Nymphalidae	*Neptis hylas*	Common Sailor
23.	Lepidoptera	Nymphalidae	*Tirumala linniace*	Blue Tiger
24.	Lepidoptera	Nymphalidae	*Euploea core*	Common Crow
25.	Lepidoptera	Nymphalidae	*Hypolimnas sp.*	Danaid Egg Fly
26.	Lepidoptera	Nymphalidae	*Acraea terpsicore*	Tawny Coster
27.	Lepidoptera	Papilionidae	*Pachliopta sp.*	Crimson Rose
28.	Lepidoptera	Papilionidae	*Graphium agamemnon*	Tailed Jay
29.	Lepidoptera	Papilionidae	*Papilio polytes*	Common Mormon
30.	Lepidoptera	Papilionidae	*Delias* sp.	India Jezebel (Drury)
31.	Lepidoptera	Pieridae	*Catapsilla pomana*	Common Emigrant
32.	Lepidoptera	Pieridae	*Pareronia valeria*	Common Wonderer
33.	Lepidoptera	Pieridae	*Eurema brigitta*	Small Grass Yellow
34.	Lepidoptera	Pieridae	*Cepora sp* (Fabricius)	Common Gull
35.	Lepidoptera	Pieridae	*Catopsilia pyranthe*	Mottled Emigrant
36.	Lepidoptera	Pieridae	*Catopsilia sp. 1.*	Lemon Emigrant
37.	Lepidoptera	Pieridae	*Ixias pyrene*	Yellow Orange Tip
38.	Lepidoptera	Pieridae	*Eurema* sp. *1.*	Grass Yellow
39.	Lepidoptera	Pieridae	*Leptosia nina*	Psyche
40.	Odonata	Lestidae	*Lestes elatus*	Daselfly
41.	Orthoptera	Acrididae	*Acrotylus* sp.	Grasshopper
42.	Orthoptera	Acrididae	*Acrida exalata*	Grasshopper

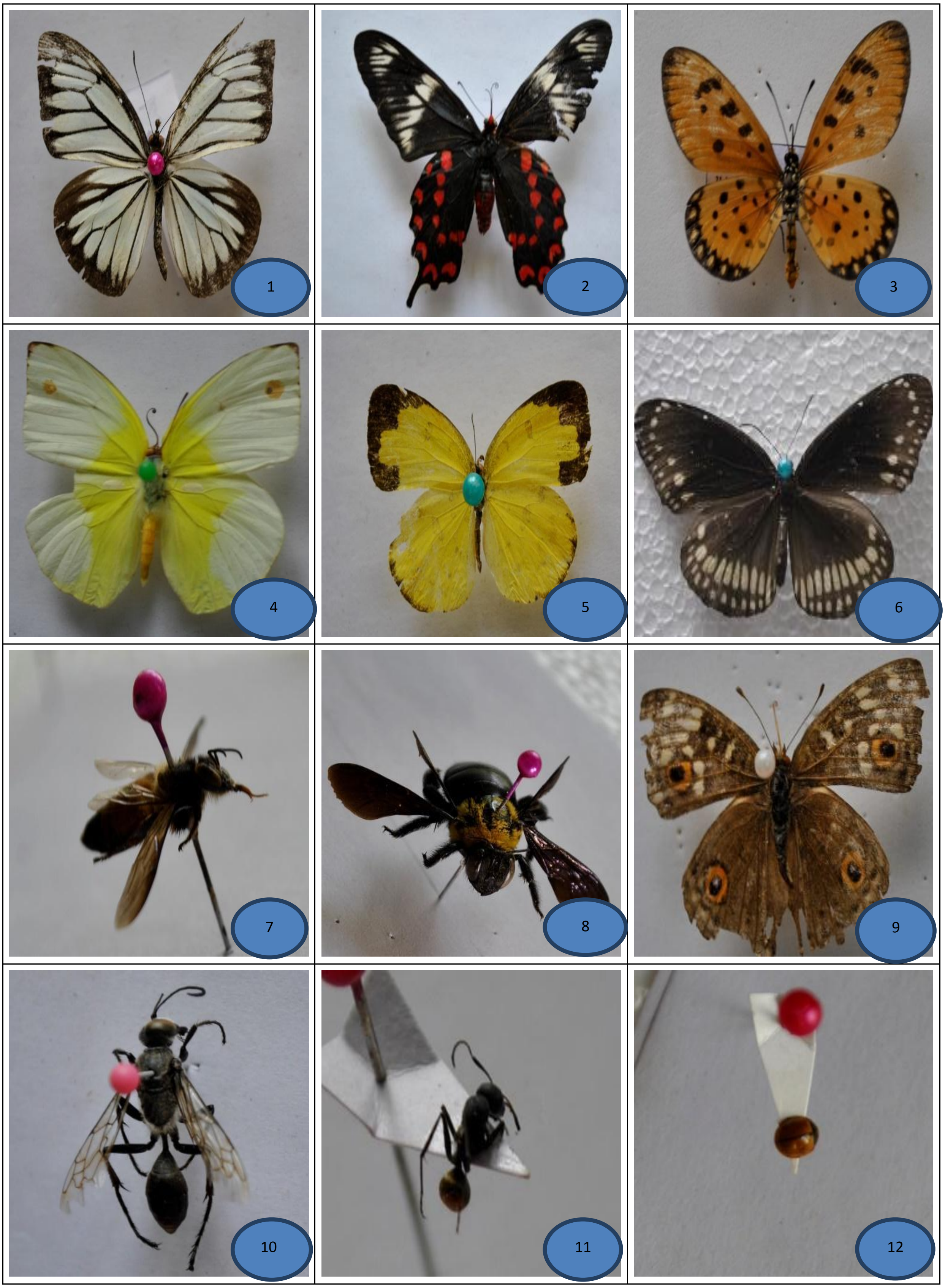

Figure 1: 1- *Pareronia valeria*. 2- *Pachliopta* sp. 3- *Acraea terpsicore*. 4- *Catopsilia sp. 1*. 5- *Eurema brigitta*. 6-*Euploea core*. 7-*Apis dorsata*. 8-*Xylocopa confuse*. 9- *Junonia lemonias*. 10- *Sphex* sp. 11- *Camponotus* sp.12- *Coccinella* sp.

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Foraging behaviour of honey bees: an insight

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Foraging behaviour is one of the distinctive behaviours of honey bees, which connects the bee colony with the ambient environment. It is greatly impacted by various, in-colony and out-colony factors. The behaviour has immense importance not only for the colony sustenance, but also for the food security and ecosystem sustainability through the means of pollination. Out of the estimated total pollination activities, over 80% is performed by insects and among them bees are considered as the best pollinators (Robinson and Morse, 1989), where more than one third of the world's crops require pollination to set seeds and fruits.

Factors imparted:

The foragers are workers over 21 days of age when they begin to perform out-colony tasks *viz*., nectar, pollen, water, or resin collection. The in-colony factors include the genotype of bee strain; colony strength and brood rearing activity; queen presence and case (virgin or mated); types of bee hive; and the hygienic status of foraging bees. The out-colony factors include availability of plant resources and other environmental factors mainly temperature, humidity and light intensity; and time/season of the year. Additionally, natural enemies, insecticides, presence of other species etc. also influence. However, the shifting of nurse bees to foragers are impacted by elevated levels of the *foraging* gene (Amfor) or the variations in the abundance of mRNA in the worker's brain (Whitfield et al. 2003).

Foraging activity:

Foragers of two categories; scout bees, who first search for the best food resource and reticent bees conducting the task based on information from the scout bees, disseminated by dancing. In general, reticent bees range from 40–90% of the total foragers (Nest and Moore 2012). According to the collection of resources, they can be classified into nectar, pollen, water or resin foragers and rarely, they can also collect wax from scale insects, *Ceroplastes* sp. The recruitment and change in the proportion of different forager types is related to the colony conditions, such as under pollen shortage or pollen dearth conditions, colonies increase the proportion of pollen foragers without increasing foraging rate (Pernal and Currie 2010).

Foraging preference:

Foragers prefer the collection of nectar, pollen, water or resin from some resources over others and they exploit the single sources until exhausted (*i.e.,* floral constancy) which make them superior pollinators. They prefer to forage during day hours that tend to fluctuate with time intervals. Their foraging distance varies simultaneously and can be explained by both energy and optical flow hypotheses (Esch and Burns 1996).

Disadvantages of foraging:

Distinctive disadvantages include transmission of bacteria *Erwinia amylovora*, that cause fire blight of apple and pears (Keitt 1941) and pollen-borne blueberry leaf mottle virus (BBLMV) (Boylan-Pett et al. 1991) that can remain infectious within colonies for at least 10 days. Moreover, bee to bee contact can also be responsible for the transmission and spread of bee diseases and parasites. Even the collected poisonous pollen when stored also may harm the colony's health.

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Outbreak of mango semilooper *Perixera illepidaria* in mango in Telangana

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Mango is a major fruit crop cultivated in Telangana state, India. Hoppers, thrips, fruit fly and mealy bugs are the major sucking pests in Telangana.There are several lepidopteran pests that attack mango inflorescence such as *Penicillaria, Hyposidra talaca,Thalassodes quadraria, Parasa lepida*. But during the flowering season *ie*., January and Febraury 2020, an outbreak of semilooper *Perixera illepidaria* (Lepidoptera : Geometridae) was recorded. The incidence of *Perixera* was noticed on mango leaves and inflorescence in mango orchards of Veepangandla mandal villages of Wanaparthy district of Telanagana state. Outbreak of *Perixera illepidaria* was noticed on litchi trees during 2011 and 2012 in Muzabbarpur (Vinod Kumar *et al* 2014). The common name of *P.illepidaria* is mango semilopper which is listed as an invasive alien species (Shine *et al* 2003). Nafus (1997) has reported *P. illepidaria* as pest of mango in the Federal status of Micronesia and in Palau. *P.illepdidaria* generally oviposits near webs of juvenile spiders as a significant defence against predator (Nafus and Schrecner 1991). In addition to mango it attacks litchi, longan, rambutan and castor. (Dharma p.abrol 2015).

The mean number of insect larvae per inflorescence in farmers' fields during the first week of February was 6.5 larvae per inflorescence. The damage on inflorescence was severe and it was to an extent of 20-25 percent. The larvae severely damaged the inflorescence of mango var Banganpalli. Larvae fed tender shoots also. The newly formed pupae were green in colour and they turned brown before the adult emergence. The pupae were scattered on the leaves. The adults were pinkish in color and the wings of adults had two rows of dark brown spots on the dorsal surface. The period of occurrence of looper in mango was severe from the second fortnight of January to the second fortnight of February. Damage of *Perixera* to the mango inflorescence has a direct impact on mango production. However losses in terms of fruit yield needs to be studied. Outbreaks may be due to change in climatic conditions.Hence there is a need to see for the further spread and studies are to be conducted with regard to climatic conditions, ecobiology, in order to predict the further incidence so that effective management strategies can be developed to minimize the production losses in mango.

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Larvae of *Perixera*

Pupae

Pupal cases on leaves

Conserve the Giant Honey Bee *Apis dorsata* Fabricius (Insecta: Hymenoptera: Apidae)

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The Giant Honey bee/ Rock bee *(Apis dorsata*, Fabricius, 1798) are eusocial insects belonging to the superfamily *Apoidea*. It is widely distributed throughout South East Asia, ranging from the Indian subcontinent, up to southern China and down throughout Indonesia and Malaysia. It is seen all over India in the plains and hilly tracts up to a height of 1220 m above sea level.

Compared to other *Apis* spp. giant honey bee is very large (17- 20 mm) building large single combs measuring about 1.5 m in width and 1 m in depth. It lives in the open, on a single honeycomb hung from the thick branch of a tree, a rocky cliff or the caves of tall buildings.

This single comb can contain a population ranging from 25000 to 80000 bees as a single colony (Reddy, 1986). It is highly clustered in a specific location in some trees termed ‘bee trees’ containing multiple nests in a single tree. The authors counted more than 100 colonies in a banyan tree in Dharwad in 2005. The colonies shift from place to place in search of nectar and pollen and to avoid extreme cold.

Giant honey bees are mainly tropical and in most places they migrate seasonally, up to 200 km following wet and dry seasons. Some evidence suggests that the bees are capable of returning to the same nest sites as previous years. This mechanism of memory retention with the honey bee colony remains a mystery. The scent left on the limb of a particular tree, by the previous swarm may attract the new swarm. Waggle dance is to communicate the location of food source to other bees in the colony. The foragers can travel a maximum of 500 meters.

Harvesting of honey is done from April to July, October & November by professional honey gatherers. They forage from Mathi (*Terminalia elliptica, Willdenow*), Nandi (*Spathodea campanulata)* and other forest flowers. Therefore honey of this region is most sought for its medicinal importance. The Siddi tribes of Uttara Kannada district in Karnataka harvest about 100 combs from 7 pm to 2 am during dusk.

Collection of honey has been a traditional occupation of the tribals and forest dwellers. There are many tribal families who engage in honey hunting for a livelihood The high honey yielding (up to 30kg/single comb) qualities of this wild species lured many beekeepers to keep them in movable frame hives(domestication), resulted in the sudden absconding without any apparent cause, thus success has so far eluded them.

It is an important wild pollinator and honey producer in tropical rain forests and agricultural areas across Asia. More than 10 lakh ha occupies forest in Kerala. Several anthropogenic activities that posed significant threats to their conservation are burning the colonies and destroying the entire comb for honey harvesting, deforestation, indiscriminate use of pesticides and herbicides and climate change.

Conservation of these species is very important since it plays a vital role for conservation of forest ecosystems by facilitating cross pollination that in turn promotes genetic diversity and contributes to ecosystem stability. It is the "Nature's Apiary in the air".

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Population density of minor lepidopteran pests of mango

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Insect species richness and understanding of its distribution is one of the major goals of insect ecology. Insects that belong to the order Lepidoptera offer good opportunities for studies on population dynamics and are biological indicators of the ecosystem (Geldmann *et al*., 2013 and Rabieh, 2018). Lepidopterans being a key component of the herbivore group, larval stages of them feed primarily on plants, and serve as food source for predators and the adults help in pollination (Thakur and Kumar, 2014). The dynamics of minor lepidopteran populations across seasons in three commercial varieties of mango *viz.,* Totapuri, Alphonso and Banganapalli was studied. Mango is the most important fruit crop of India, with pests, including lepidopterans limiting its yield (Tandon and Verghese, 1985). With quantitative data gathered on biodiversity of minor lepidopterans, this study is perhaps the first of its kind in the mango ecosystem.

The study found nine species of minor lepidopterans during vegetative and reproductive stages of mango *viz., Acrocercops syngramma* (Meyrick)*, Porthesia scintillans* Walker, *Thalassodes falsaria* Prout, *Euproctis fraterna* (Moore)*, Hypotima* sp., *Nanaguna* sp., *Anarsia* sp., *Perixera illepidaria* (Guenee), and *Orgyia australis postica* Walker from three commercial varieties of mango.

The minor lepidopteran infestation was similar in all three varieties of mango studied, but varied from vegetative phase to reproductive phase. Some lepidopterans probably affect even subsequent flowering (Nafus,1991). During vegetative phase, lepidopterans *viz., A. syngramma,* P. scintillans*, T. falsaria, E. fraterna* and *Hypotima* sp. infested leaf bud, tender green leaf and pink leaf stages of mango. The population densities of these lepidopterans highest during November and December but started infestation from October to January in both the years irrespective of the varieties. Lepidopteran insects attacking flowers are very crucial as they directly affect fruit set and hence yield (Kannan and Rao, 2006). During reproductive phase *Hypotima* sp., *Nanaguna* sp., *Anarsia* sp., *P. scintillans, P. illepidaria,* and *O.australia postica* were minor lepidopteran insects recorded on inflorescence bud, bloom and full bloom stages. The population of lepidopterans infested reproductive phase mostly occurred during January and February when flowering was at its peak. Slight changes in the temperature rise (by one or two degree), shift in insect movement and spread can be expected (Ahmad *et. al.,* 2011).

Conclusions

Most of the minor lepidopterans, while contributing to diversity, are not limiting to mango yield or growth hence can be regarded as only potential pests. However, with change in climatic condition, a minor pest can switch their status to major pest and become serious, so monitoring these are equally important. Generally, if chemical sprays are avoided or judiciously given during both vegetative and reproductive phases or minimized, natural enemies will keep these minor insects under control. So, it is necessary to monitor the biodiversity of the entire lepidopterans and their natural enemies to prevent flare-ups or outbreaks of any minor pests.

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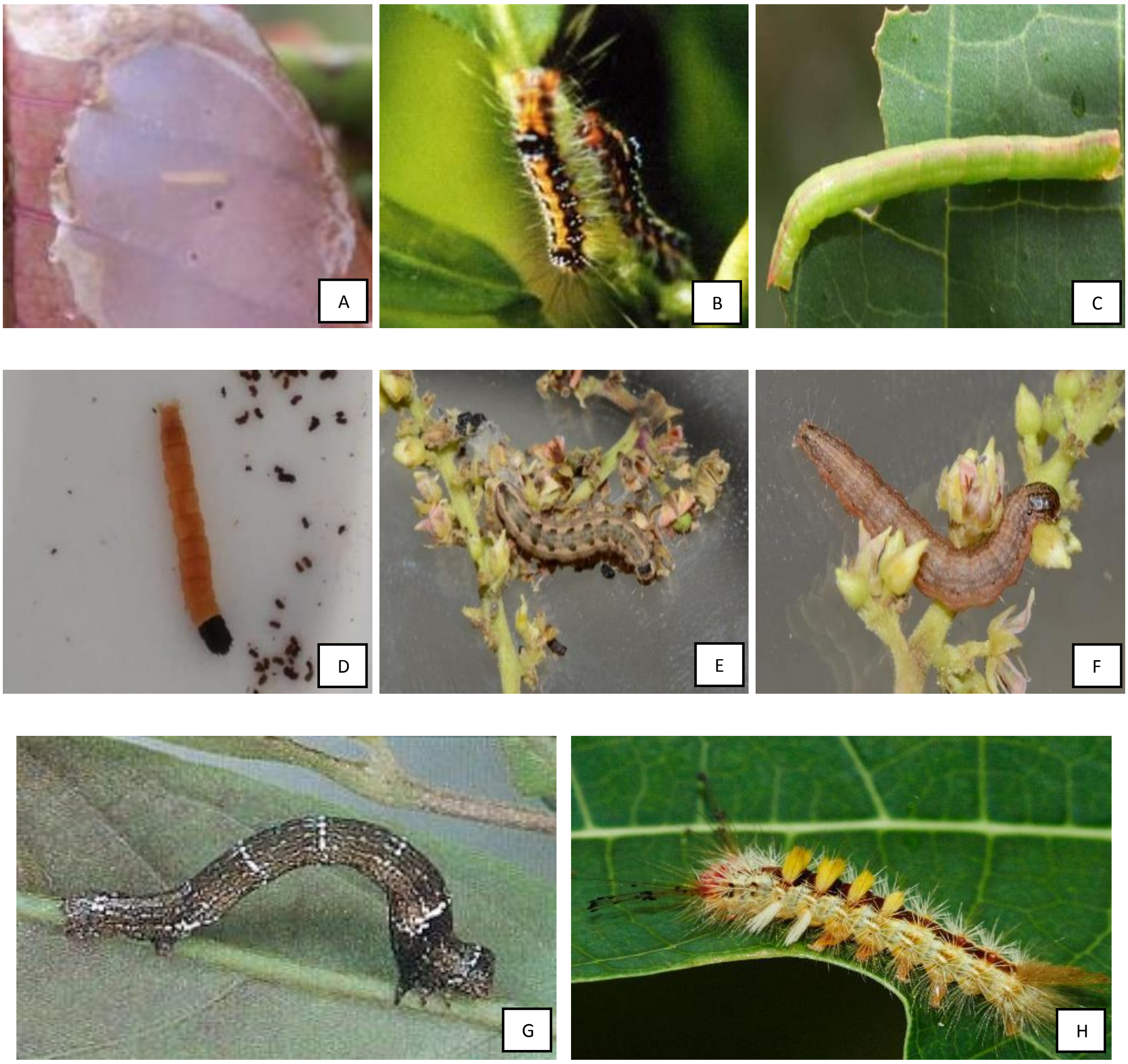

Minor lepidopterans of mango ecosystem, A: *Acrocercops syngramma*, B: *Porthesia scintillans* C: *Thalassodes falsaria* D: *Hypotima* sp. E: *Nanaguna* sp. F: *Anarsia* sp. G: *Perixera illepidaria* H: *Orgyia australis postica*

Alternate host plants for pink bollworm *Pectinophora gossypiella* Saunders (Gelechiidae: Lepidoptera) during off seasons in Andhra Pradesh.

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Surveys were made in 2019 (February-June) alternate host plants to evaluate their role in spread of pink bollworm *Pectinophora gossypiella* (Saunders) in cotton growing districts of Andhra Pradesh, south India as the feeding ethology of pink bollworm is traditionally from times immemorial said to be monophagous feeding only on cotton. Three malvaceous plants, *Hibiscus cannabinus*, *Abelmoschus esculentus* and *Abutilon indicum* were found to be important host plants of the pink bollworm in that they provide a continuous food supply for breeding during the off season around cotton. Several other plant species were also attacked in other cotton growing areas namely *Hibiscus sabdariffa*, *Hibiscus trilobus*, *Hibiscus bifurcates*, *Abutilon hirtum*, and *Althaea rosea* (Fife,1936).

Knowledge of the importance that alternate host plants play in the perpetuation of the pink bollworm from one cotton crop to the next is valuable in formulating methods for its management. Here this has been studied in Andhra Pradesh. Cotton growing districts in Andhra Pradesh are comparatively rich in Malvaceae, the only family of plants that has been found to include species attacked by this pest. The importance of each of these food plants in maintaining the pink bollworm in the absence of cultivated cotton as alternate hosts is briefly discussed here with recent findings observed and recorded during survey.

Okra, *Abelmoschus esculentus*

Okra is cultivated quite extensively in some parts in cotton growing districts of Andhra Pradesh. Since pod infestations of okra is as high as 50 to 90 percent have been recorded in other countries when this crop was being grown adjacent to heavily infested cotton; used as a laboratory host and it is considered a rather favorable host plant of the pink bollworm . Consequently, as a means of controlling the pink bollworm, it would seem logical to avoid the growing of okra during the closed season (summer) of cotton production (plate 1 and 2). Khidr *et al*., (1990) reported that in Egypt, pink bollworm preferred okra to cotton and towards the end of the season. Likewise Siddiqui *et al*., (1987) assessed the infestation of pink bollworm on Abutilon sp. as 12 per cent and on okra as 22.4 per cent.

Hibiscus spp.:

The majority of the known host plants of the pink bollworm belong to the genus *Hibisicus*, of which at least 18 different species have been reported from various countries of the world. Only two species, however, were found to be attacked by Pectinophora gossypiella in Andhra Pradesh namely *Hibiscus cannabinus* and *H. sabdariffa* which were extensively cultivated for commercial purpose in this region (Plates 3 and 4). There was a 6.25 per cent incidence of pink bollworm on *Hibiscus cannabinus* commonly called Mesta.(Swami,1999).

Abutilon

Seed capsules of *Abutilón hirtum* were collected repeatedly near infested cotton and placed in rearing cages for emergence. From 200 Abutilon pods collected during survey 2019 (February to June) as a part of distribution studies of pink bollworm from each district viz., Guntur, Prakasam, Kurnool regions, a meagre emergence of 18 moths was recorded in Guntur region as well as incidence of adult emergence from other regions was 12 and 15 respectively. Hence abutilon though considered as an alternate source of food for existence of pink bollworm is a meagre source of infestation (Plates 5 and 6). It is interesting to note that Holdaway (1926) reported *Abutilón octocarpus* and *A. amplum* as host plants of *Pectinophora gossypiella* in "West Australia and *A. indicum* in South India.

Miscellaneous records:

Three wild species of malvaceous plants are very common in Andhra pradesh. These are *Sida cordifolia*, *Malachra capitata,* and *Malvastrum* sp. Large numbers of these plants were collected repeatedly near infested cotton and placed in rearing cages but no stages of the pink bollworm were ever found on them. However, species of both Sida and Malvastrum have been reported as host plants of the pink bollworm in other parts of the world. Other than cotton, both weeds and vegetable crops of the Malvaceae family act as food plants for the pink bollworm in the off season.

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Plate 1. Exit hole on okra	**Plate 2. Exit hole on hibiscus**
	
Plate 3.PBW damage on okra	**Plate 4. Damaged seed pod of Hibiscus**
	
Plate 5. PBW damage on Abutilon pods	**Plate 6. Flower damage of Abution**

Six legged soldiers as biological weapons in warfare

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Entomological warfare (EW) is a specific type of biological warfare that uses insects in a direct attack or as vectors to deliver a biological agent causing plague or cholera. Essentially, entomological warfare involves dispersal of the insects infected with a pathogen over target areas, and then they act as a vector to spread diseases. The second other way is by agro terrorism that affects the food and agriculture industry. The final method of entomological warfare is to use uninfected insects, such as bees. (Chaudhary *et al*., 2017)

For thousands of years, military strategists have used insects as weapons of war not only to inflict debilitating pain on enemies, but also to deliver deadly pathogens and destroy agriculture, with the intention of causing widespread misery, sickness and hunger. Insects are being used as biological weapons from times immemorial. The14th century witnessed a minor plague (Black Death) spread through fleas was the earliest event in Asia to have used insects as a biological weapon. In World War 2 Germans used Colorado potato beetles against enemy crops, wherein Japanese also used plague infected fleas and cholera infected flies against Chinese. (Montana State University) Beehive catapults (Fig.1.), scorpion bombs, bug pits (Fig.2.) and wasp nests being used as warheads.

Examples of insects being used as warfare weapons

Colorado potato beetle: *Leptinotarsa decemlineata* (Say) (Coleoptera: Chrysomelidae)

It is an orange yellow coloured major potato pest with a fecundity of approximately 800 eggs. Germans produced Colorado potato beetles in large numbers during World War 2 to destroy enemy food sources.

Ironclad beetle: *Zopherus nodulosus haldemani* Horn, (Coleoptera: Zopheridae)

These beetles are being developed for use in military vehicles. The Department of Zoology, University of Oxford developed a defense surveillance drone called the Skeeter that mimics natural flight of dragonflies. Skeeter will have four independently flapping wings, a camera, a microphone, to explore disaster areas and locating survivors in earthquake zones. It can fly up to 45 kmph. (http://www.oxfordtoday.ox.ac.uk/interviews/drone-inspired-dragonfly)

Oriental Rat Flea: *Xenopsylla cheopis* (Siphonaptera: Pulicidae)

It is the vector of bubonic plague. Japan used this flea on large scale as a biological weapon against China in World War 2. These plague fleas were dropped by low flying planes on the city of Changde which resulted in 500,000 deaths. (Chaudhary *et al*., 2017)

Assassin bugs: *Triatoma spp* (Hemiptera: Reduviidae)

These bugs are also known as "kissing bugs," But are not literally so! They bite the lips and eyes of humans while they sleep (Chaudhary *et al*., 2017). These bugs not only bite, but their "kiss" can spread a parasite that causes Chagas disease, damages major organs, leading to heart failure, and hence fatal. Assassin bugs can be devious hunters, using the bodies of dead prey to attract new victims.

House Fly: *Musca domestica* (Diptera: Muscidae)

House flies act as a lethal biological weapon. It is a vector for 100 different kinds of pathogens that are responsible for significant ocular pathology and vision loss. Mosquito transmitted pathogens can cause diseases like malaria, cholera, typhoid, salmonellosis, anthrax, tuberculosis. chikungunya, dengue, and encephalitis.

Ticks: *Argas persicus* (Arachnida: Argasidae)

Ticks can also be used as biological weapons as they act as vectors for *Aegyptianellosis* in poultry caused by *Argas persicus*. It spreads from one bird to another. Similarly cattle tick is a vector of *Babesia bigemina* which caused $3 billion annual losses to the U.S. cattle industry in the early 20th century.

Mosquitoes: (Diptera: Culicidae)

Mosquitoes can also be used as lethal biological weapons to cause diseases in humans and animals. They are the vectors of malaria (*Anopheles spp*), dengue, chikungunya and yellow fever (*Aedes aegypti*). During the cold war, the USA made a laboratory with a production capacity of 100 million yellow fever infected mosquitoes to attack the Soviet

Union. In 1955, the United States dropped 300,000 yellow fever infected mosquitoes during the operation big buzz to check their survivability.

Black Flies: *Simulium spp*. (Diptera: Simuliidae)

These are 3 to 6mm small robust flies that feed on the blood of poultry and cattle. Large numbers of fly attacks can cause death of animals due to acute toxaemia. Black flies also act as protozoan vectors which causes Leucocytozoonosis in poultry. In humans they transmit onchocerciasis by acting as vectors of parasitic nematode *Onchocerca volvulus*.

Horse Flies and Deer flies (Diptera: Tabanidae)

They are used as biological weapons as they are major livestock pests especially by transmitting different diseases like bovine leukemia, infectious anemia, hog cholera, and *Trypanosoma spp.*

Warble Fly: *Hypoderma bovis* (Diptera: Oestridae)

These are bee-like in appearance with hairy orange-yellow bodies. In 1976, the United States alone faced $360 million loss due to this cattle grub. When tissue invading cattle grub larvae reaches the oesophagus and spinal cord they cause paralysis. In humans, *H. bovis* species larvae cause intracerebral myiasis in which invasion of intracerebral tissues takes place. So warble flies if produced in large scale in a laboratory can be used as an anti livestock biological weapon.

Screw Worm Fly: *Cochliomyia hominivorax* (Diptera: Calliphoridae)

It is a common parasitic meat fly whose larvae infest open wounds of cattle and other livestock. Screw worms can cause tissue loss, vital organ destruction and even death in extreme cases. Screw worm females lay up to 3000 eggs in its lifespan and could travel up to 200km in search of a suitable host.

Conclusions: Use of insects as biological weapons is very inexpensive and effective warfare. They can easily be used to spread diseases among humans and plants or to destroy enemy crops and livestock. But unlike conventional weapons they act slowly and their use in war is illegal and considered as war crime so there should be laws and regulations to prohibit their proliferation or to be used in war. If not legally prohibited, these weapons could be misused by terrorists. One way to curtail it is through the monitoring of imports and exports at airports by entomology security teams. In order to keep a check over smuggling of biological weapons from one country to another it is recommended to appoint an entomologist in in anti-terrorism investigation teams, borders.

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Status of Ericulture in Northeast India

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Ericulture forms a unique component of agriculture in northeastern India, where agroforestry based farming is predominant. Eri silk is next only to the mulberry silk in the silk production in India with a total production of 6910 MT in 2018-19. Apart from providing spun silk, it provides food to farmers in the form of pre-pupa and pupa. Eri spun silk has good thermal properties and is used in various fabrics. Pre pupae and pupae are edible here and are rich in proteins and lipids. The domesticated variety of eri silkworm, *Samia ricini* is multivoltine in nature. Eri is the only silkworm reared completely indoors among the Vanya silks. Eri silkworm forms an open ended cocoon which enables extraction of live pupa from the cocoon making it Ahimsa silk, wherein the pupa is allowed to complete metamorphosis to its moth stage. Eri is most suitable for an integrated farming ecosystem in Northeast India as it is polyphagous with host plants both annual and perennial. In general Eri silkworm tolerant to various biotic and abiotic stresses which makes it amenable for rearing in diverse agro-climatic conditions throughout the year

The dual purpose Eri host plants castor and tapioca apart from providing leaves for feeding eri silkworms also provide additional income to farmers through castor seeds and tapioca tubers respectively. Eri silkworm has vast biodiversity that includes many reported ecoraces and genetic strains. A total of twenty six eco-races of *Samia ricini* have been identified and characterized from Northeastern region and are being maintained at Central Muga Eri Research and Training Institute (CMERTI), Jorhat. Most of these ecoraces produce white color cocoons whereas Kokrajhar, Barpeta and Rongpipi ecoraces produce brick red colored cocoons. Based on larval colour and markings, six pure line strains have been characterized namely Yellow Plain, Yellow Spotted, Yellow Zebra, Greenish Blue Plain, Greenish Blue Spotted and Greenish Blue Zebra. C2 is a newly registered high yielding hybrid of eri silkworm developed by hybridization of Genung and Borduar ecoraces. These phenotypic variants can be useful genetic resources for the study of insect genetics and breeding.

Recently many new technologies are being developed and adopted in Ericulture to transform it from a cottage industry to a large scale industrial production. The Ministry of textiles, Government of India is funding to develop Eri clusters to give Ericulture an industrial status. With government supports and technological interventions Eri silk production is poised to increase exponentially in coming years. Hence, Ericulture is an apt farming practice which integrates well into any other farming systems to provide additional income to farmers.

Raw Eri Pupae Used for Consumption

Yellow Plain Strain

Yellow Zebra Strain

Green Blue Plain Strain

Green Blue Zebra Strain

RNA interference and insect pest management

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Introduction

Some insects compete with us for food and transmit human, livestock diseases, but other insects are beneficial. Therefore, there has been a continuous demand for developing target-specific insect management methods. Among the various approaches, the RNA interference technique gained popularity and has been used as an efficient means for blocking the selected gene expression. Identification of the Nobel prize-winning gene silencing mechanism in the nematode by Andrew Fire and Craig Mello, opened up the technology's immense potential (Fire et al., 1998). RNAi has excellent potential as a research tool to study the biological function of genes. Transgenic corn plants (*Zea mays*, Smartstax PRO) expressing *Bacillus thuringiensis* (Bt) crystal proteins and dsRNA of *Diabrotica virgifera*, sucrose non-fermenting 7 *(Snf7*) gene received approval for commercial release. Various dsRNA sprayable products have been tested and available soon for field application against Colorado potato beetle, *Leptinotarsa decemlineata*. This article highlights the RNAi mechanism, delivery methods, target gene selection for insect control, and RNAi efficiency focusing on insects.

RNAi mechanism and delivery methods

Binding, cleavage, and mRNA degradation are the critical steps in the RNAi pathways. Dicer initiates RNAi is an enzyme belonging to the RNase III nuclease family and is responsible for processing dsRNA into siRNA. SiRNA is a short nucleotide dsRNA produced by cleavage of dsRNA and is incorporated into the RISC, guiding it to mRNA. This nuclease is complex composed of proteins and siRNA targets and destroys endogenous mRNAs complementary to the siRNA (Figure 1 (Meister & Tuschl, 2004; Zhu & Palli, 2020)). The insect cells have to uptake the dsRNA for triggering the core RNAi machinery. The popular dsRNA delivery methods are microinjection, feeding, and plant-mediated intake, as described in Figure 2. Novel strategies for dsRNA delivery include symbionts, plant viruses, trunk injections, root soaking, and transgenic plants (Joga, Zotti, Smagghe, & Christiaens, 2016; Zhu & Palli, 2020).

Selection of target genes

The identification of efficient target genes plays a crucial role in successful RNAi for commercial applications. Transgenic corn expressing dsRNA targeted to the midgut enzyme vacuolar ATPase (v-ATPase) demonstrated excellent silencing against western corn rootworm larvae, *D. virgifera* (Baum et al., 2007). Hexamerin, Ecdysone receptor (EcR), Hunchback, Cytochrome p450 monooxygenase, Chitinase, Serine proteases, Inhibitor of Apoptosis (IAP), etc. are some of the successful targets which demonstrated potential for pest management applications (Mamta & Rajam, 2017; Yoon, Koo, George, & Palli, 2020). RNAi worked efficiently in the stored grain pest-red flour beetle, *Tribolium castaneum,* and emerged as an excellent coleopteran model for exploring target genes and mechanisms.

RNAi efficiency among insect orders and challenges

Comparative analysis of dsRNA degradation and processing in various insects belonging to five different orders demonstrated varying RNAi efficiency. The five insect order tested showed difference in dsRNA into siRNA processing efficiency (Coleoptera> Orthoptera, Diptera, Hemiptera> Lepidoptera) and dsRNA degradation (Lepidoptera> Hemiptera> Diptera, Orthoptera> Coleoptera) (Singh, Singh, Mogilicherla, Shukla, & Palli, 2017). Enzymatic degradation, the dsRNA stability, variability in core RNAi machinery among insect orders, differences in cellular uptake and processing, resistance development, etc. are the main challenges for successful RNAi application in insects (Figure 3 (Zhu & Palli, 2020)). Despite these challenges, RNAi is an exceptional tool.

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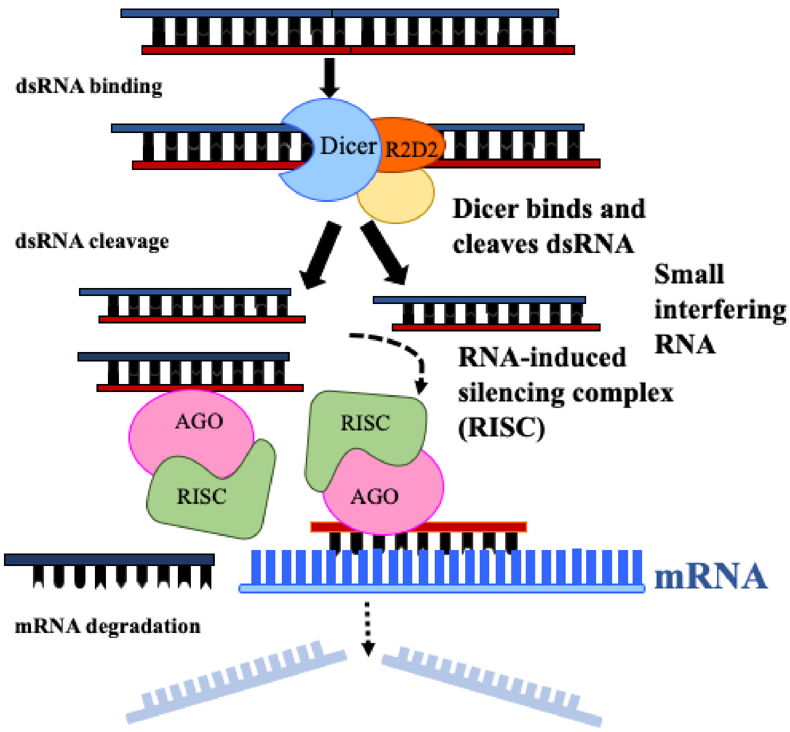

Figure 1. The molecular mechanism of the RNAi pathway in insects- endonuclease Dicer-R2D2 (dsRNA binding protein) complex binds to dsRNA and cleaves them into small interfering RNAs (siRNA). RNA induced silencing complex (RISC) and Argonaute (AGO) unwind the two strands and bind the antisense strand. Later this complex targets mRNA and triggers degradation.

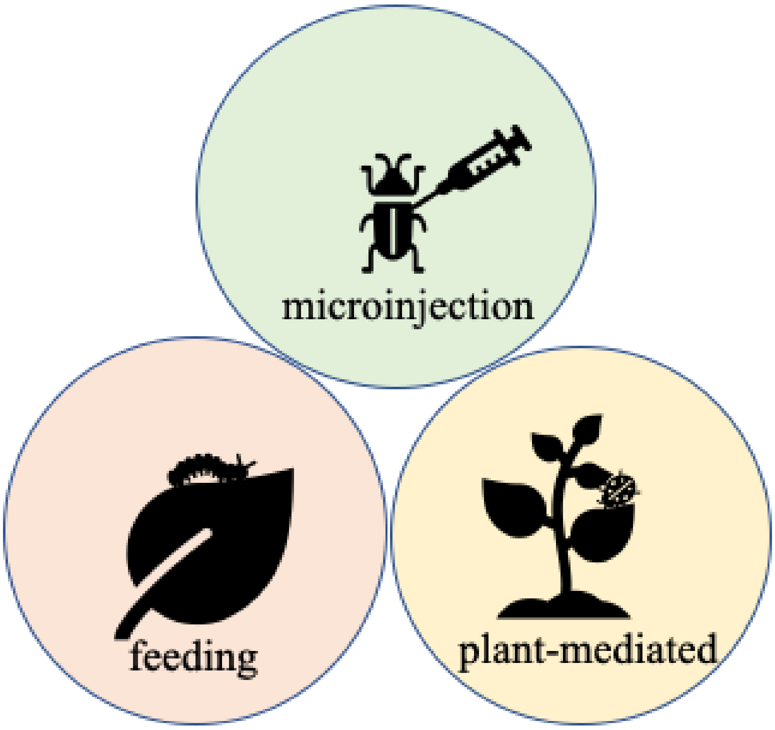

Figure 2. Popular dsRNA delivery methods are a) microinjection, b) feeding, and c) host plant-mediated.

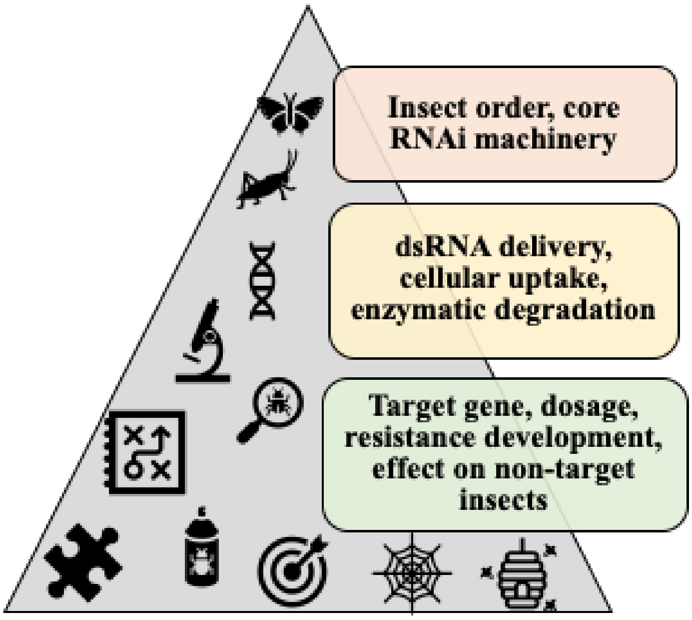

Figure 3. Major challenges to successful RNAi for insect pest management

Pollinators other than honey bees and their contribution

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INTRODUCTION:

Pollinators are animals that transfer pollen from the anthers to the stigma of a flower, enabling the flower to set seed and fruit (fertilization) and, through cross-fertilization, they play an important role in maintaining plant diversity. The important ecosystem service of pollination is provided by a variety of animals, chiefly insects. World top pollinator's contribution 73% honey bee, 19 % flies, 6.5%, bats 5% beetles, 5 % wasps, 4% birds and 4% butterflies and moths. Vertebrate pollinators include bats, non-flying mammals (several species of monkey, lemur, rodents, tree squirrel, coati, olingo and kinkajou) and birds (hummingbirds, sunbirds, honeycreepers and some parrot species). There are an estimated 352,000 species of flowering plants in the world (Paton, 2008). Of these, 87.5% (3,06,000) species entirely or partially depend on flower visitors for successful seed set (Ollerton et al., 2011) 87 of the 115 global food crops depend upon insects for pollination, 35 percent of global food production. (Klein, 2007) Among the insects, hymenopterans (largest and diversified assemblages of beneficial insects with nearly 2, 50,000 described species) are highly evolved and constitute the most important group of pollinating insects. Pollinators are crucial in the functioning of almost all terrestrial ecosystems including those dominated by agriculture because they are in the front line of sustainable productivity through plant reproduction (Kevan, 1999). Environmentally, 66 percent of angiosperms require animal pollination for sexual reproduction (Greenleaf and Kremen, 2006). Worldwide an estimated 35 percent of crop production is dependent on insect pollination (Klein *et al*.,2007). Moreover, their populations and diversity also serve as bioindicators of the state of many environments (Keven, 1999; Tylianakis et al.,2004; Roubik et al., 2005).

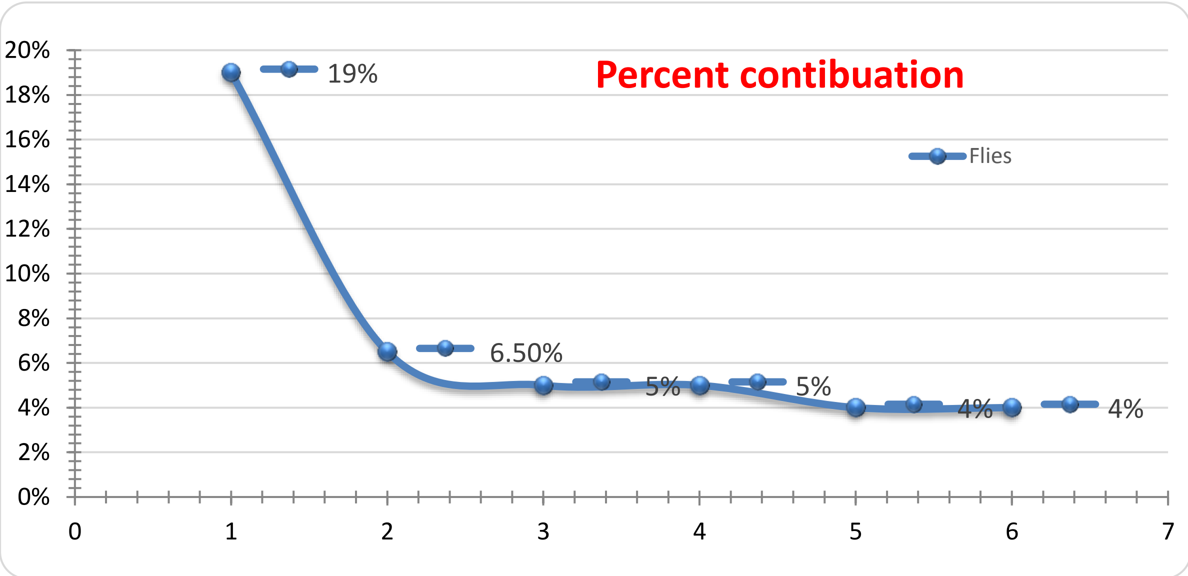
Why are pollinators important?

Somewhere between 75% and 95% of all flowering plants on the earth need help with pollination – they need pollinators. Pollinators provide pollination services to over 180,000 different plant species and more than 1200 crops. That means that 1 out of every three bites of food you eat is because of pollinators. If we want to talk dollars and cents, pollinators add 217 billion dollars to the global economy, and honey bees alone are responsible for between

1.2 and 5.4 billion dollars in agricultural productivity in the United States. In addition to the food that we eat, pollinators support healthy ecosystems that clean the air, stabilize soils, protect from severe weather, and support other wildlife.

What do we know about their status?

Pollinator populations are changing. Many pollinator populations are in decline and this decline is attributed most severely to a loss in feeding and nesting habitats. Pollution, the misuse of chemicals, disease, and changes in climatic patterns are all contributing to shrinking and shifting pollinator populations. In some cases there isn't enough data to gauge a response, and this is even more worrisome



Fact about Pollinators other than Honey bee.

Bats:

- ✔ Do you like eating bananas and mangos? Bats help pollinate these fruits and more.
- ✔ In fact, it is believed that bats play a role in pollinating more than 500 different types of tropical plants.
- ✔ Because bats migrate and fly quite a distance before they drop seeds, they play an important role spreading plants and in helping diversify growth in areas.
- ✔ Bats tend to like flowers that give off strong scents or are white/pale colors.
- ✔ Bats have long tongues that help them reach nectar in flowers.

Ants:

- ✔ Ants are pollinators too and they love nectar
- ✔ Flowers that ants visit are low growing, usually have small inconspicuous flowers and have flowers that are close to the stem.
- ✔ Many tropical plants have nectar outside of their flowers to attract ants. These plants rely on defensive capabilities of the ants to protect them from other insects.
- ✔ Ants can lift 20 times their own body weight!
- ✔ It is believed that there are more than 35,000 ant species in the world.

Butterflies:

- ✔ Butterflies have good vision and can see the color red (bees cannot).
- ✔ Butterflies have a weak sense of smell and taste with their feet.
- ✔ Butterflies help pollinate many flowers, but are less efficient than bees because their long thin legs pick up less pollen.
- ✔ Butterflies are attracted to flowers that provide landing platforms and are brightly colored (red, yellow and orange).
- ✔ Butterflies probe for nectar with their long proboscis (the technical term for butterfly mouthparts).

Flies:

- ✔ Flies have many beneficial functions such as decomposers, soil conditioners, water quality indicators and pollinators!
- ✔ Flies visit flowers to eat nectar and lay their eggs.
- ✔ Flies most often visit flowers that emit a strong or offensive odor.
- ✔ Do you love chocolate? Chocolate (Cocoa) depends on tiny flies (called midges) to pollinate its small flowers along its trunk.

Wasps:

- ✔ Wasps are pollinators! But, they are less efficient than bees because they are not generally covered with hairs that help carry pollen from flower to flower.
- ✔ Fig Wasps are responsible for pollinating fig crops. Fig are unusual fruits, as the flowers are actually inside the immature fruit. Fig wasps are typically very small, about 0.06 inches in length.
- ✔ Without one another, neither the fig nor fig wasp can complete their life-cycle.
- ✔ Almost 100 species of orchids rely on wasps for pollination.

Beetles:

- ✔ Beetles were some of the first insects to visit flowers!
- ✔ Beetles eat their way through petals and other floral parts, when they do this they get pollen on them which then aids in pollination of flowers.
- ✔ Beetles rely on their sense of smell for feeding and finding places to lay their eggs.
- ✔ Beetles like bowl-shaped flowers that have strong, sweet or fruity smells.
- ✔ Beetles are the largest order of insects with approximately 400,000 species, making up more than 30 percent of all animals.

Moths:

- ✔ Although not all moths are nocturnal, moths are one of the few nocturnal (night time) pollinators.
- ✔ They prefer flowers that are in clusters so they have good landing platforms,that are white or dull in color and have ample nectar such as morning glory and gardenias.
- ✔ Some moths (like the Hawkmoth) have proboscis (the technical term for tongue) longer than their entire body to help them reach the nectar!
- ✔ Different moths can range in size that is smaller than a pencil eraser to larger than a small bird.

Humming birds:

- ✔ Hummingbirds are important pollinators that help feed on nectar from a variety of flowers using their tongues as a straw.
- ✔ Hummingbirds can lick 10-15 times per second!
- ✔ Humming bird's heart beats 1,260 beats per minute and they flap their wings 20-80 times per second.
- ✔ Brightly colored flowers that are tubular and hold a lot of nectar are most attractive to hummingbirds.

Sunbirds:

- ✔ There are 132 species of sunbirds and they belong to the family of spider hunters.
- ✔ Sunbirds can be found in Africa, Asia and Australia.
- ✔ Sunbirds have a thin, downward curved bill and a tubular tongue that is covered with bristles.
- ✔ Sunbirds' beaks and tongues help them pollinate tubular flowers that bees and butterflies can't reach.
- ✔ Sunbirds consume nectar mostly, but also will eat fruit and some insects and spiders.

SUMMARY AND FUTURE RESEARCH:

Pollinators vary in efficiency and identity depending on location and farm management. We need to find out more about who is pollinating what differences among cultivars in pollination requirements and insect preferences. We need to know a bit about their life-styles and what they need to feed, nest, and shelter to better manage those relationships between pollinators and yield. Need to do more on pollen tube growth and fruit set

CONCLUSIONS:

One of the main reasons for not being able to break the yield plateau of some cross pollinated crops despite having the best variety and adoption of all technologies, is the depletion in population of pollinators, which results in inadequate pollination and thereby reduced productivity. Depletion in the population of native insect pollinators in natural habitats due to habitat destruction, mechanization and other agricultural practices, changing cropping pattern, pesticidal application and pollution are of serious concern. How much loss the nation has accrued over the decades because of decline in population of pollinators leading to inadequate pollination and thereby reduced productivity is difficult to assess. In the present situation, it is of pivotal significance to generate techniques for conservation, augmentation and utilization of pollinators including honey bees for maximizing pollination and to increase the production of various crops. Small as they are, pollinators will also play a key role in helping to achieve a number of the UN's Sustainable Development Goals from tackling hunger and poverty to job creation and economic growth. Pollinators are the unsung heroes of the global ecosystem.

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Insects: a luscious alternative fish feed

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During the last decade, there has been a continuous growth and consumer demand in the aquaculture sector worldwide (FAO, 2014). The aquaculture industry in India provides nutritional security, besides livelihood support and required employment to more than 14 million people. It has been noted that the total fish production during 2017-18 was around 13.77 lakh tonnes in terms of quantity and Rs. 45,106.89 crore in value; which accounts for nearly 20% of the agricultural exports, and contributes to about 0.91% of the GDP and 5.23% to the Ag-GVA of the country (NFDB 2017 India). To meet the ever-increasing demand for fish and fish products globally, farmers and industrialists adopt different approaches and follow new practices to maintain a healthy aquaculture system and increase fish food value.

Fish feeds which constitute 40-70% of the cost of the fish produced, are primarily made up of two major components, i.e. fish meal (FM) and fish oil (FO). FM is a rich source of protein with an excellent composition of essential amino acids, whereas FO is composed more of long-chain omega-3 fatty acids. However, FM and FO often contain harmful contaminants like polychlorinated biphenyls and dioxins, for which people are looking for alternative fish feeds (Arru *et al*., 2019). As a consequence, soya, cereal gluten, proteins, and other terrestrial plant products are now used in great numbers in fish feeds, but plant sources have their own limitations like decreased palatability, presence of anti-nutritional factors, and high proportions of fiber and non-starch polysaccharides (Henry *et al*., 2015).

In recent years, insects have received great attention as an alternative for sustainable fish feed, to replace FM & FO in feeds. Insects present a rich source of crude proteins, amino acids, carbohydrates, minerals and lipids/fatty acids. However, their exact composition varies in each insect depending upon their particular life stage, rearing conditions, diets, and before using them in fish meal specific requirements of the fish species of interest has to be monitored (Trans *et al*., 2015).

Advantages of the use of insects as feed source could be attributed to its rapid growth rate, easy conversion of organic waste to fertilizer, biomass production, and high feed conversion efficiency (Veldkamp and Bosch, 2015). With regard to their nutritional value, the best insect candidates tested as fish feed ingredients in partial or complete substitution for FM are listed in the table below.

Table 1: Commonly used insects as fish feed ingedients

Insects common name	Latin Name	Order	Used in Fish species
Black soldier fly (Larvae or pupae)	*Hermetia illucens*	Diptera	Channel catfish (*Ictalurus punctatus*), Rainbow trout (*Oncorhynchus mykiss*), Atlantic salmon (*Salmo salar*)
Common house fly	*Musca domestica*	Diptera	African catfish (*Clarias gariepinus, Heterobranchus longifilis),* Nile tilapia *(Oreochromis niloticus)*
Mealworm (Larvae)	*Tenebrio molitor*	Coleoptera	African catfish (*Clarias gariepinus*), European sea bass (*Dicentrarchus labrax*), Rainbow trout (*Oncorhynchus mykiss*)
Domestic silkworm (Pupae)	*Bombyx mori*	Lepidoptera	Common carp (*Cyprinus carpio*), Silver barb (*Barbonymus gonionotus*), Asian stinging catfish (*Heteropneustes fossilis*), Japanese sea bass (*Lateolabrax japonicus*)
Locusts and Grasshoppers (Adult)	*Locusta migratoria, Zonocerus variegatus*	Orthoptera	African catfish (*Clarias gariepinus*), Walking catfish (*Clarias batrachus*), Nile tilapia (*Oreochromis niloticus*).

Most of these trials with insects as an alternative to FM or FO in herbivorous, carnivorous farmed fish populations suggested that it can be replaced by 25-30% and are economically feasible. Nonetheless, before industrial production of fish diets incorporating insect species or large scale use of insects as fish feeding activities, studies should be conducted on their nutritional values, dietary manipulation, life cycle assessment, and most importantly on the safety, quality, and social acceptance. In conclusion, insects can be a luscious alternative in fish feed management in the current scenario to further develop the aquaculture industry.

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The cockroaches and its diversity

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The name 'cockroach' has been derived from the Spanish term *Cucaracha.* As per the geological aspect, they constitute a very old order. Many genera and species have existed as early as the Carboniferous and Permian periods. Cockroaches are placed within the Order Blattodea. This order contains both cockroaches and termites. Global component of Blattodea comprises about 4837 species under 510 genera in 9 families (Beccaloni 2014). In India, 72 genera and 181 species accommodated under 6 families have been reported. When compared to the species diversity of the world, Indian cockroach fauna constitutes to 3.9% of the global taxa. The dominant families are Blaberidae (83 spp.), Ectobiidae (53 spp.), Blattidae (24 spp.), Corydiidae (17 spp.), Nocticolidae (3 spp.) and Tryonicidae (1 spp.). The states with high number of records are Tamil Nadu (55 spp.), West Bengal (37 spp.), Arunachal Pradesh (25 spp.), Meghalaya & Sikkim (24 spp.) (Gupta and Chandra 2019). The members of this group have economic and medical importance. This topic could be further discussed under three headings: (1) Consumption of human food stuffs or crops, (2) Vectors of disease or parasitic organisms of man or domestic animals, (3) Spoliation of food and nuisance value in houses and buildings as a troublesome pest. There are a number of records of cockroaches causing damage to plants by eating roots and flowers. Cockroaches feed upon the bark of trees and fruits too. *Pycnoscelus surinamensis* (Linn.) is most often cited to have caused massive destruction of tobacco plants, (Roeser,1940). The importance of cockroaches as vectors of vertebrate pathogens is well known.

Cockroaches are a well-known and apparently a well-defined group of insects; most species are morphologically similar. However, recent phylogenetic studies (Klass and Meier 2006; Inward *et al.* 2007) have proved that termites are highly evolved from cockroaches and the sister group of the wood-feeding cockroach family: Cryptocercidae (Djernæs 2018). Taxonomy of many families of Blattodea is still in a confused state. In India there are 6 families so far reported. In that Family Blaberidae is the most dominant family with 83 species reported in India, Among this all the species are inhabitat in the hill area only namely *Panesthia* Serville, 1831, *Salganea* Stål, 1877 are live in the dead woods and feed the same. The Subfamily Perisphaerinae Brunner von Wattenwyl, 1865 species all are mostly inhabitat in the barks and feed on the resins and other plant parts like flowers, honey and tender leaves. Family Blattidae has some pest species *Periplaneta americana, Homalosilpha ustulata, Heberdina concina,* and *Neostylophyga rhombifolia*. These are exclusively household pests, and cosmopolitan occurs in both plains and hilly regions. Family Ectobiidae is the second most dominant species in India having 53 species, most of the species are leaf litters dwellers. Families Corydiidae and Nocticolidae are distributed in very limited ways. Corydiidae are known as sand cockroaches or desert cockroaches because the species are adapted to dry habitats. Both nymph and adult stages live in the sand only. In India only 2 species are reported in Family Nocticolidae, this cockroach is very curious because it looks “un-cockroach-like” in appearance and the total length is about less than 5 mm. Most species are cave dwellers. Males have complete wings with simple venation and females are always wingless (Djernaes 2018).

Among the 181 species, 82 species are endemic to India. At present, 74 species are recorded from the Western Ghats, among which 27 species are endemic, there are 44 species recorded from the Himalayas among which 8 species are endemic. In particular the genus *Therea* (Indian Domino Cockroach) contains only 8 species distributed in India and this genus is endemic to India too.

In some parts of the world, *Blatta orientalis* and *Neostylopyga rhombifolia* are eaten and their ootheca are collected to be fried., *Periplaneta americana* and *Periplaneta australasiae* are eaten in some part of Japan and China (Roth and Willis, 1957). Recent investigations have shown that some of the cockroaches are potential sources of biomedical compounds. For example, *B. orientalis* is used in preparation of Homeopathic medicines for asthma. Till date, some cockroaches are used as a medicine for a wide variety of diseases around the world in traditional and folk medicine (Roth and Willis 1957), *P. americana* is used in Brazilian folk medicine, to treat Asthma (Costa-Neto and Oliveira, 2000). *Eupolyphaga sinensis* and *Opisthoplatia orientalis* are used in traditional Chinese medicine, mainly for the treatments of wounds (Zhang *et.al*. 2008). Most cockroaches, namely *Gromphadorhina portentosa*, *Blaberus craniifer* and *Therea petiveriana,* are reared as pets, (Djernaes 2018).

To protect these beautiful beneficial creatures, the tropical rainforest should be protected and also a check on the application of high doses insecticide should be kept. Most of the cockroach species from the Tropical and subtropical forest Are under threat, as this habitat is under intense threats. (Beier, 1974) logging and clearing of land area for Agriculture, Deforestation, Urbanization, Natural disaster like forest fire and landslide needs to be checked. Large numbers of cockroach species are likely to be under threat or may go extinct otherwise.

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Neostylopyga ornate

Neostylopyga ornata

Indoapterolampra rugosiuscula

Thorax porcellana

Pycnoscelus indicus

Hemithryrsocera vittata

Hemithyrsora histrio

Hemithyrsocera palliate

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CRISPR as an innovative molecular tool in pest management of honey bees

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The honey bee is a social insect belonging to the genus *Apis,* well known for its social behavior, and is distributed worldwide. They are the most important pollinators for most of the plant crops (Delaplane and Mayer 2000). Like all living organisms, honey bees are infested with pests which include *Varroa destructor*, wax moths, ants, wasps, hornets etc., and can result in big loss to the apiculture industry. Increased pest pressure levels justify the need for molecular techniques like CRISPR (clustered regularly interspaced short palindromic repeats) gene editing tool which provides novel ways to IPM (integrated pest management) of honeybees by improving gene drives. The application of CRISPR has been reported in the honey bee (Hu et al. 2019). CRISPR works by cutting the double-stranded DNA at precise locations in the genome and has the ability to nick out and modify genes with scissor-like meticulousness and is commonly used as a contemporary gene-editing. It employs an enzyme called Cas9 (CRISPR associated protein) that uses an RNA molecule to direct to its target DNA by editing or modifying the DNA, which can switch off genes or insert the desired sequence.

Kandul et al. (2019) used the CRISPR gene editing tool, for altering key genes that control insect sex determination and fertility in drosophila flies. CRISPR technology has remarkable potential for genetic population control, which has been developed and utilized to control a plethora of insect pests like mosquitoes, drosophila, moth, beetle, wasps, grasshoppers etc. CRISPR can be used to simultaneously disrupt key genes that control female viability and male fertility in pest species. A new CRISPR-based technology named precision guided sterile insect technology (pgSIT) which relies on a dominant genetic technology that enables simultaneous sexing and sterilization, facilitating the release of eggs into the environment ensuring only sterile adult males emerges. pgSIT offers to lead far superior pest population suppression over existing approaches, thereby revolutionizing SIT-mediated control of wild pest populations. The efficacy of systematically engineered multiple pgSIT systems was demonstrated in *Drosophila* which consistently give rise to 100% sterile males (Kandul et al. 2019) and this concept can be envisaged to control the pest of honeybees using CRISPR.

Genetic modification using CRISPR based approaches has been carried out in honeybees (Kohno et al. 2016), and social wasps. In both cases, microinjection of honeybee eggs or larvae was required to achieve transformation. CRISPR/Cas9 system was applied to manipulate honeybee trypanosomatid (*Lotmaria passim). L. passim* is a unicellular eukaryotic flagellate parasite that inhabits the hindgut of bees, damages intestinal cells and diminishes host health and leads to colony mortality. Using the CRISPR/Cas9-induced homology-directed repair pathway, *L. passim* genes were replaced with drug (hygromycin) resistant gene, and establishing *L. passim* clone expressing Cas9, so that honey bee could develop pest resistance genetically (Qiushi et al. 2019). CRISPR/Cas9-mediated gene editing creates swift strides, directing towards pest management in honey bees and holds great promise for improvements in the health of honey bees and other critical pollinator species.

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Blister beetle: curse and boon at same time

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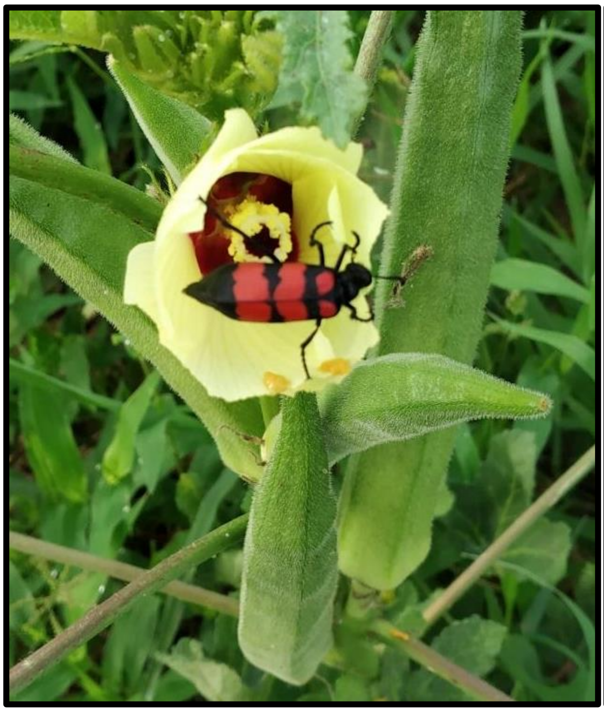
Blister beetles, so called for their defensive secretion of blistering chemical cantharidin, belong to the order: Coleoptera family: Meloidae. It is a notorious pest of many crops worldwide. Blister beetles in their adult stages hover around plants and chew tender shoots, buds and flowers inflicting damage to the crop. Damage is permanent and irreparable as it chews the productive and economical part of the plant. Cantharidin, a poisonous chemical, causes blisters on the skin when one attempts to catch it with bare hands.

Blister beetles undergo hypermetamorphosis, which includes the egg, larval, pupal and adult stages. Here, larval stages are different in forms and more than two types of larvae are present. Blister beetles are common field pests. They have a cylindrical, slender, elongated, conspicuously coloured body showing their toxicity of being a predator, inciting damage especially in pulses and oilseed crops (Hopkins *et al.,*). It is best known for its blister causing secretion released when injured or crushed showing limitation in mechanical control of this pest. This is a negative aspect of blister beetles but on the other hand it has a positive side too. Blister beetles are predators of grasshopper eggs. Locusts and grasshoppers belong to the same family Acrididae; order Orthoptera. There are around 6800 species of acrididae worldwide, out of which 19 species are considered as locusts (Gall *et al.,* 2019). Locust plague is known to cause destruction to vegetation from the time immemorial. Locusts are the most difficult insect to be controlled due to the high mobility of nymphal and adult stages. Application of insecticides is not practically feasible and economically effective. Locusts lay their eggs in soil in long elongated structures called egg pods (Hopkins *et al.,*) and eggs are the most vulnerable of all stages of insect growth. Though eggs of grasshoppers have many natural enemies and are predated by many insects, the larvae or grubs of blister beetles are most predominant (Severin *et al.,* 1917). Eggs of blister beetles are laid in the soil in masses, from which larvae hatches out in a span of 1-2 weeks. These larvae voraciously devour the eggs of grasshoppers also laid in the soil. Blister beetles could be hence used as a control agent of locusts.

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Ootheca: cradle carried by 'Super mom-roaches'

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The nuisance cockroaches cause in household environs is sometimes messy!During a cleanliness drive in our kitchen, Bengaluru (N 13.0149775, E 77.6070450) we spotted a German roach mom. The adult german cockroach, Blattella germanica is 10 to 15 mm long, brown to dark brown in color with two distinct parallel bands on the pronotum. Male roaches have thin and slender bodies, posterior abdomen is tapered, terminal segments of abdomen visible, not covered by tegmina while the female sports a stout body, posterior abdomen is rounded, entire abdomen just covered by tegmina. They lay multiple eggs that are contained in one single casing, called an ootheca (Fig.1), a protein case produced by their colleterial glands. The eggs are safe from predators and physico-chemical threats in the environment.

There are around six molts inclusive of five instars. This is when the rare sighting of a white cockroach, not albino but those preparing to shed their exoskeleton happens. All developmental stages actively forage for food and water. They seek refuge in crevices and kitchen appliances. Now, that's the concern to manage the menace with omnivorous appetite and a known vector of pathogenic bacteria (Menasria, 2014). A fertile female can produce up to five ootheca during their lifetime, each with 30 to 40 eggs (Valles, 1996) carried externally for about 24 hrs until hatching, illustrating parental care. The life cycle of the German cockroach adult is more than 130-150 days (Hill, 2002). There are multiple methods to manage these using insecticides as baits and sprays. But, a note of caution is that the German cockroach is resistant to several organochlorine, organophosphorus, carbamate and pyrethroid insecticides (Cochran, 1989). Improving sanitation, sealing cracks and crevices will have a significant impact on reducing the chances of infestation and population size.

Fig. 1. Female German cockroach, Blattella germanica (Linnaeus) with ootheca

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Insects: As a tool in forensic inquiries

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Introduction

With about two million of described species, insects comprise the largest metazoan class. They are found in almost all habitats. One such habitat providing an excellent food source for more or less specialized insect communities is vertebrate corpses. In addition to their ecological importance in decomposition, they also represent as an important tool in criminal investigations especially in estimating the time since death based on insect colonization on cadavers. Several flies, beetles, soil mites and other invertebrates are associated with cadavers, in particular, blowflies, Calliphoridae among the first to colonize on cadavers, which serve as a biological clock in measuring the time of death for two or more weeks. Such an entomologically-based estimate is more precise than the medical examiners, which is limited to the first 72 hours of death. Hence, utilization of naturally inhabiting insects and other arthropods in medico-criminal investigation is often termed as forensic entomology.

Blowflies are olfactorily attracted to remains within hours of death as both a source of protein for egg development and a site for oviposition. Insect succession patterns are also closely linked to the progression of carcass decomposition and as such, while a continuous process, decomposition can be defined into distinct stages which are linked to specific insect groups used as markers for the estimation of PMI. In addition it provides other valuable information concerning the circumstances surrounding the victim's demise, including the season of death, location of death, movement or storage of remains after death, specific sites of injury on the body, post mortem artefacts on the body, use of drugs, and can even crime, to a child neglect or sexual molestation case, as well as in the identification of suspects.

Stages of decomposition

Usually decomposition of human cadavers is classified into five stages in relation with the arthropod succession on the cadaver as fresh, bloated, decay, post decay and dry stage. In fresh Stage, after the putrefaction, the body begins to smell, different types of insects are attracted to the dead body. The insect that usually arrives first is the Diptera, in particular the Calliphoridae. The females lay their eggs on the body, especially around the natural orifices such as the nose, eyes, ears, anus, penis and vagina. In a bloated Stage, cadaver begins to swell due to excess gas production by putrefying bacteria. Adult blowflies are no longer attracted but large masses of maggots feeding externally and internally and predators and parasitoids of maggots arrive at the site in decay stage. The cadaver starts drying and a large number of maggots left the cadaver for pupation in case of post-decay stage. In the final stage (dry Stage) of decomposition skins and bones left. During this stage the insects have the ability to digest keratin, like dermestid beetles that attend the cadaver.

Insect succession on buried corpse

Payne *et al.* (1968) reported that during the fresh stage, ants especially *Prenolepis imparis* feed actively on blood and exposed moist skin at the mouth, abdomen and ears. Ants followed by diptera (*Leptocera spp* and *Metopina subarcuata*) dominant during bloat stage and Psychodidae dominant by the end of bloating stage. In the deflation stage, numerous maggots' feeds on the corpse which attracts the predators and parasites that feed on the fly maggots. This is followed by the disintegration stage where the larvae of Psychodidae, phorid and sphaerocerid are active around the remaining soft tissue. Mites, springtails, cryptophagid beetles and millipedes also appeared. The colonies of fungi and bacteria now cover the corpse. The maggots migrate from the carcass at the end of this stage. At the time of 30-60 days, mites *Caloglyphus* spp. and collembolan, *Hypogastrura armata* are the main scavengers. Finally, ants, collembola and mites are dominant fauna during the skeletonization stage.

Insect succession on immersed corpse

Simpson (1985) reported that decomposition is retarded in water because body heat is lost twice as fast as in air. He also gave valuable information on the fate of ectoparasites of potential forensic value. Fleas are drowned in about 24 hours but if immersed for only 12 hours they require about an hour to revive and after 18-29 hours immersion a period of some four to five hours. Body lice usually die in 12 hours following immersion. Blow fly larvae if already present on a body when immersed will not survive for long and if still alive may thus indicate recent removal from another site.

Factors influencing the insect succession on carrion

The geographical region of the country and type of terrain within a given country will affect the composition of fauna and rate of decomposition. In Polar regions available carrion fauna is less. While in tropical regions we can find a richer number of carrion feeders. The major factor controlling the oviposition and rate of development of necrophagous insects are temperature and humidity. The cold weather and rain inhibit the fly activity. The thermal death points for most of the carrion insects ranges from -15 ^{0}C to 30 ^{0}C. Some insects prefer light *i.e.* positively phototropic or may avoid the light *i.e.* negatively phototropic. This may affect the particular insects present on the corpse. It is well known that the two commonest genera of blow flies associated with carrion, bluebottles (*Calliphora*) prefer shady conditions and greenbottles (*Lucilia*) prefers sunlight. Different insects occur at different times of the year or day and are said to have different flight periods. A corpse exposed in the spring and summer will have a richer and different fauna from the one exposed in the winter when the faunal succession is absent. Corpse exposed during the winter, when no blowflies are about, will have smaller fauna consisting of ground level insects such as beetles. The competition may be either intra or inter specific. Early arrivals ovipositing on a corpse, especially blow flies will have advantages over late arrivals such as *Sarcophaga* and *Chrysomya spp.* Some dipteran larvae may be carrion feeders at the first and become predators in the second and third instars

Application of insects in forensic investigation

Estimating the minimum post-mortem interval: Post-mortem interval (PMI) refers to the time between the death and discovery of a corpse. There are several natural processes associated with decomposition, such as rigor mortis or livor mortis, that can be used to estimate the PMI, but many of these are reciprocal functions and become inaccurate in application very quickly. Furthermore, they are limited to the first 72 h after death. However, during that 72 h and well beyond, insects can be a very powerful tool for estimating the minimum time since death. Usually the first taxa to arrive on a body are flies, mainly blow flies (Calliphoridae), which can locate an odor source with great spatial precision and deposit their eggs on a corpse within minutes–hours of death. Larvae (often called ‘‘maggots’’) hatch from the eggs and feed on the underlying tissues. Decomposition as a result of insect activity in and on the corpse is a continuous process that can be measured, allowing accurate minimum PMI estimates to be made up to several months after death depending on the circumstances. The estimation of PMI is done by two means one is that by calculating the age of developing insects on a body, it is possible to calculate the time of colonization, which infers a minimum PMI ($PMI_{min.}$) *i.e.* the time when insects first colonized the body, rather than the actual time of death. Another important biological phenomenon that occurs on cadavers is a succession of organisms that thrive on the different parts.

Detection of drugs in insects (Entomo-toxicology): The potential use of insects as alternative samples for detecting drugs and toxins has been well studied. Fly larvae and pupae are often found on decomposing bodies. In such badly decomposed bodies, these immature stages and their remnants are not only useful for estimating the PMI_{min}. but they can also be used as a reliable substrate for toxicological analysis and can sometimes provide a more suitable bio sample without any decomposition interference. Most of the substances involved in drug-related deaths are detectable through analyses of maggot's opiates such as morphine and codeine, cocaine and benzoylecognine, amphetamines, tricyclic antidepressants, phenotiazines and benzodiazepines, steroids, barbiturates and several salicylates such as paracetamol. Drugs and toxins have also been detected through analyses of empty puparium cases and even beetle exuviae and fecal material.

Post mortem transfer: Post Mortem transfer refers to the movement of the body from one place to another after death. After death, a succession of fungi, bacteria and animals colonize the dead body. The substrate on which the body is lying also changes over time. Leakage of fluids from the dead body leads to the disappearance of certain insects, and other insects increase as the time goes. A forensic entomologist can then look for how long the body has been there by looking at the fauna at the body, and also estimate the time the body has been lying there by sampling soil insects underneath the dead body. If there is a difference in the estimates, and the analysis of the soil suggests a short PMI, and the analysis of the body fauna suggests a longer PMI, one can suspect that the body has been moved. One can also see that a body has been lying at a particular place long time after the body has been removed, both by botanical means, and by analysis of the soil fauna.

In investigation of contraband trafficking: Many arthropods are found together with stored products, even such products as narcotics and other drugs. Since illegal drugs are often made in one country, and sold in others, it can be important to find out where the drugs were produced. Sometimes, insects and other arthropods can be found together with the drugs. If these insects are determined, and the world distribution of the different insects are plotted on a map, one can by analyzing the degree of overlap, find out approximately where the drugs came from. If one looks at the biology of the insect species found with the drugs, one can also often say something about the surroundings where the drugs were produced or packed.

Link between the suspect and the crime scene: Sometimes there will be no clues of crime during that time entomological evidence plays an important role in linking between the suspect or victim to the crime scene. For example, mosquitoes (Culicidae) are widespread insects and those found at the crime scene can be a useful source of human DNA. DNA derived from mosquitoes helped in solving a crime.

Limitations

1. Delay in insect colonization lead to an underestimate of PMI: Several parameters can lead to a delay in colonization (e.g. the wrapping of the corpse, low temperature, rain, burial, or the inactivity of most flies at night) which can lead to an underestimate of PMI $_{min}$.
2. Effects of drugs and toxins on the rate of insect development may lead to errors in PMI estimates.
3. Myiasis can be a significant point of confusion, because the period of insect activity could be far longer than the actual PMI. The possibility of a pre-mortem myiasis infestation must always be borne in mind by forensic entomologists. If the infestation on a body was initiated before death, then assuming incorrectly that it started after death would clearly lead to an inaccurate estimate of PMI $_{min}$.
4. Misleading of postmortem artifacts by insects as antemortem injuries, Campobasso *et al.*, (2009) explained that the injuries made by *Solenopsis geminata* Hymenoptera ant can be easily misinterpreted as antemortem abrasions.

Conclusions

The forensic entomology is an emerging field in the forensic sciences and have a new discipline which needs to be emphasized, since it has become an important tool in criminal investigations of homicide, suicide, and other violent crimes. Insect evidence collected from the body of a victim, when properly collected and analyzed by trained forensic investigators, can provide valuable information like determination of post mortem interval, the toxicological examination of insects found on corpses may reveal the cause of death, identity of victim and even linking the suspect to the crime. Insects' databases are still needed for many parts of the world. Therefore, study of succession should be conducted in many parts of the world and regional data should be created.

Common insects occurring on dead bodies

	
Fig 1: House Fly, Wikipedia	**Fig 2: Black Blow Fly, BugGuide.Net**
	
Fig 3: Green Bottle fly, Wikipedia	**Fig 4: Blue Bottle Fly, Wikipedia**
	
Fig 5: Flesh fly, Wikipedia	**Fig 6: Hairy Maggot Blowfly, Wikipedia**
	
Fig 7: Humpbacked fly, Britannica.com	**Fig 8: *Metopina subarcuata*, BugGuide.Net**
	
Fig 9: Sap Beetle, BugGuide.Net	**Fig 10: Carrion Beetle, BugGuide.Net**
	
Fig 11: *Prenolepis imparis*, AntWiki	**Fig 12: *Hypogastrura armata*, Collembola.org**

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Nano pesticides - A promise for the future

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Nanotechnology is a science which deals with nanoparticles which are extremely small, with a size less than 100 nanometers (Kah, 2015). This technique is considered to be a breakthrough in the agricultural sector which can reform the current farming practice, especially in the agrochemical sector. The advent of a new type of pesticides like nanopesticides paved a way for ecologically sound pest management options which can be well integrated with sustainable agricultural practices.

Injudicious application of synthetic toxic chemicals led to environmental hazards, health problems, pesticide resistance, reduction in natural enemy population and pest resurgence which questions the uniqueness of conventional insecticides. One of the major drawbacks of old-generation insecticides is the insoluble active ingredient which needs more toxic organic solvents for better dissolution, thus eventually leading to ecological and health hazards (Sasson *et al.*, 2007).

Nano pesticides are intended to subdue the problems caused by old generation pesticides *via* low doses, low toxicity, increased pesticide efficacy, high stability and lack of toxic solvents. High efficacy is mainly achieved by the higher surface area of the particles compared to its size which resulted in more volume of chemicals in contact with the body of the pest and ultimately reduction in the amount of chemicals needed for the management (Kah and Hofmann, 2014).

Different types of nano pesticides are formulated all over the world which includes

1) Nanoemulsions

These are nanopesticides with the chemical molecules as nanodroplets, suspended in water along with surfactants. This type of chemicals can be used for both hydrophilic and hydrophobic pesticides. High stability is the major advantage of these compounds but has several disadvantages. High quantities of surfactant are needed, which is expensive and exhibits phytotoxic nature (Feng *et al.*, 2016).

2) Nano dispersions

Here, the pesticide molecules are dispersed as nano solid particles in water along with surfactants, whose polar region comes in contact with the liquid portion and non-polar region is attached to the solid pesticide molecule (Shah *et al.,* 2016).

3) Nano encapsulations

These are formulations produced by coating nano-sized particles over pesticide molecules which facilitate the release of pesticides in a more efficient way. This reduces the quantity of pesticides and also offers long term protection due to its slow release. Besides this, pesticide loss through leaching, volatilization and degradation can also be reduced (Shah *et al.,* 2016).

4) Solid Lipid Nanoparticle (SLN) formulation

SLNs are one of the vanguards of nanotechnology research and are characterized by a nano-sized solid lipid portion which shows an affinity towards lipophilic molecules. So these compounds can be used as carriers for botanical pesticides, exhibiting high stability and less degradation and thereby, overcome the limitations of botanicals (Shah *et al.,* 2016).

Some of the nanopesticides registered by Syngenta *viz.,* Banner MAXX, Subdue MAXX and Apron MAXX were nanoemulsions of systemic fungicides (Kah *et al.,* 2013).

Potential of nano pesticides

1) Higher efficacy compared to traditional formulations- Small size and higher surface area of nano pesticides led to increased wetting on the surface. It also promotes increased penetration into target tissues like waxy plant cuticle and insect integuments.
2) Improved stability- Conventional chemicals are prone to easy degradation in the environment which affects its efficacy. New nanoformulations exhibited enhanced stability against photodegradation and hydrolysis.
3) Controlled release of chemicals- The pesticide molecules are released at a slow pace which led to prolonged exposure to target organisms (Kah and Hofmann, 2014).

Risks associated with nano pesticides are a debating topic and researches are still going on regarding the toxicity and environmental fate of the nano compounds. Increased penetration of pesticides into the body and comparatively long periods of exposure may cause adverse impacts on non- target organisms.

Conclusion

Nano pesticides are a promising strategy which may revolutionize the current scenario of the agrochemical industry and lay the foundations for safe and sustainable agriculture. Even though, researches should be more focused on the environmental fate of these pesticides to overcome the prevailing controversy.

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A note on mimicking behaviour of common mormon *Papilio polytes*

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Common Mormon(*Papilio polytes)* is a swallowtail butterfly belonging to family Papilionidae known for their excellent mimicking skills. They are examples for "Batesian Mimicry" where the edible species mimics the harmful ones to protect themselves from being eaten. Mimicking in sub species *Papilio polytes romulus* reaches the pinnacle in peninsular India and Sri Lanka (K. Kunte, 2009 & Katoh, 2017) The females are found in three different forms, mimicking different species of the red-bodied swallowtails: The cyrus form which is the non-mimetic form resembles male that has a band of white spots on the hindwings, the stichius form which mimics the Common Rose(*Pachliopta aristolochiae)* and the romulus form which mimics the Crimson Rose(*Pachliopta hector)*. (K. Kunte, 2014)

Pachliopta aristolochiae, the Common Rose is one of the unpalatable models. They are toxic and distasteful due to which birds avoid feasting on them. The females of Common Mormon, known as masters of disguise, develop wing patterns similar to that of Common Rose to ward off predators. It was believed for decades that supergenes were a cluster of genes that was responsible for the changing wing patterns and polymorphism in butterflies. From a recent research by Dr. Krushnamegh Kunte, Wei Zhang and Marcus Kronfrost it has come to light that, it is just one gene called "doublesex" that is responsible for mimicking behaviour. This gene also performs various functions on manufacturing different proteins. (Wei Zang et al, 2017 and K. Kunte, 2014)

Figure 1: Female Common Mormon mimicking Common Rose

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Types of insect-plant interactions

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Long term coexistence had led to the evolution of different kinds of relationships between insects and plants. Ehrlich and Raven (1964) were the first to apply the term in the context of insect-host plant co-evolution based on their study of Monarch butterfly-milkweed plant interactions (Futuyma 2000). Co-evolution is a change in the genetic composition of one species in response to a genetic change in another species. Insect plant interactions are either antagonistic or mutualistic. Antagonistic relationships include herbivory, multitrophic interactions and plant predation on insects while mutualistic relationships include insect pollination.

Insects are known to damage plants in different ways either by feeding on them or transmitting harmful plant pathogens. Herbivory by insects causes injury to plants either directly or indirectly in their attempt to secure food. Direct injury either by chewing the leaf tissue like defoliators, leaf miners, borers, etc. or by piercing and sucking from various plant parts like aphids, jassids, etc. Indirect damage is either by disseminating plant diseases or either by transporting the harmful insects from one plant to another (David and Ramamurthy 2012).

In order to reduce insect attack, plants have evolved various defense mechanisms. Plants can differentiate physical damage and insect damage by recognizing their feeding pattern, chemicals present in their saliva and ovipositional fluids.

After recognition of insect pest attack, the information is conveyed through various signaling systems so as to evolve defense mechanisms to reduce herbivore pressure on them. These defense mechanisms may be present constitutively or they may be induced only after the herbivore feeding. The constitutive defenses are continuously present in the plant, but the induced defenses come into action after the recognition of the insect herbivore. Plants have evolved direct defenses and indirect defense mechanisms against insect herbivores. In the direct defense mechanism, plants rely on their own physical barriers or produce chemical compounds to repel or kill the insect. In "indirect defense" plants rely on other organisms to reduce enemy pressure. This is achieved by producing volatiles, extra floral nectar, food bodies and nesting or refuge sites.

In counter response, insects have also evolved different strategies to overcome plant defense mechanisms by detoxification of toxic plant chemicals or sequestering them and utilizing them for their own defense. Multitrophic interactions describe the ecological impacts of multiple trophic levels on each other: the plant, the herbivore, and its natural enemies, predators of the herbivore, hyperparasitoids of higher order predators, are considered. Carnivorous plants have evolved the mechanism to trap the insects to fulfill their nutrient requirement, as the soil in which they are growing is deficient in nutrients. The soils in which carnivorous plants grow, lack in nutrients. In order to supplement their food requirement, they can trap and digest other organisms. For this, they possess traps with special cells for digesting the prey and absorbing the resulting food.

Insects have also evolved mutualistic relationships with plants. Majority of the flowering plants are pollinated by insects and in return for pollen transfer, plants provide food to its pollinators in the form of nectar and pollen (Faegri and Pijl 1971). Insect pollinated plants have pollen with sculptured structure and are covered with sticky substances, so they can easily adhere to the insect body. Likewise hairs on the insect body aid in carrying the pollen from one flower to the next. In addition, various carnivorous plants are known that have developed mechanisms to trap and digest insects in order to supplement their food requirements (Temple 1993). Hence, relationships between insect and plant are very complex and dynamic.

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Orange yellow moth, *Aegocera venulia* (Cramer) (Lepidoptera: Noctuidae): First record from Ramanagara, Karnataka

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Boerhavia diffusa is a species of flowering plant in the four o'clock family which is commonly known as *punarnava* (meaning that which rejuvenates or renews the body in Ayurveda and locally called Kommesoppu. *B. diffusa* is widely used as a green leafy vegetable in many Asian and African countries. *B. diffusa* can be used as a fodder for livestock. The leaves of *B. diffusa* are used as a green vegetable in many parts of India. Having anti-inflammatory and expectorant properties, root acts as an anticonvulsant, analgesic, laxative medication. When rubbed in honey can be locally applied for cataract, chronic conjunctivitis and blepharitis. Useful for curing heart diseases, anemia and edema (or oedema), *Punarnava* is an effective remedy that reduces swelling and foul smell in skin disorders. Apart from the root, *Punarnava's* leaves are also consumed as a vegetarian dish to reduce oedema.

Punarnava (*B. diffusa*) is commonly attacked by an insect which belongs to the noctuid family. The adults of these groups are diurnal or crepuscular, mostly bright coloured, stout bodied insects consisting of simple antennae which are dilated distally. This genus is easily identified by the palpi with the 2nd joint clothed with longhairs, antennae strongly dilated distally. The type species of this genus is identified as *Aegocera venulia* (Cramer). The outbreak of this insect was noticed in the farmer's field of Bilagumba village in Ramanagara district of Karnataka state (12.7392° N, 77.2549° E). The insects were collected, described and illustrated herein. The objective of this paper is to provide additional information to the already known species of genus *Aegocera* from various parts of the world. *A. bimacula* was reported from the Sanjay Gandhi National Park and the Malshej Ghat of Maharashtra (Shubhalaxmi *et al*., 2011). *Aegocera venulia* is commonly called as orange yellow moth (Kalawate, 2018). This species has been reported for the first time from Karnataka.

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New record of *Agarwalencyrtus citri* (Agarwal) (Hymenoptera: Chalcidoidea: Encyrtidae) from the Indian states of Maharashtra and Nagaland

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The hymenopteran superfamily Chalcidoidea is one of the most species rich and biologically diverse groups of insects. The family Encyrtidae is one of the largest of the chalcidoid families. This family currently includes nearly 4,000 described species in 497 genera globally, 610 species in 142 genera from India (Hayat, 2006 & Noyes, 2019) and represents one of the most successful groups used in the biological control of agricultural pests worldwide, especially the biocontrol of mealybugs. Members of this family regularly attack the Sternorryncha families, Pseudococcidae and Coccidae, although other families such as Aphididae and Cercopidae may also serve as hosts. In the hemipterous family Pentatomidae and its closely related forms, only the egg stage is attacked.

***Diagnosis*:** Length, 0.5 mm. Legs, including coxae, yellow, at most with brownish suffusions on apices of fore and mid femora, basal two-third of mid tibia, apex of mid femur and basal one-third of mid tibia; mandible with one small tooth and a broad truncation; scutellum with striate-reticulate sculpture; propodeum medially about one – sixth length of scutellum, and medially weakly reticulate; antennal clava longer than pedicel and funicle combined.

This species is already recorded from Indian states of Andhra Pradesh, Assam, Bihar, Delhi, Jharkhand, Kerala, Meghalaya, Rajasthan, Tamil Nadu, Uttar Pradesh and Karnataka. In a recent study this species is newly recorded from Maharashtra and Nagaland.

Members of this genus are reported as parasitoids of *Planococcus citri* on *Citrus medica* Agarwal (1965) and *Tomosvaryella* sp. (Diptera) Hayat (1986).

Material examined**:** India, Maharashtra, Kolhapur district, Shivaji University, 6 ♀, 16.iii.2016, (N19º22.787' E77º46.951'), coll. T. Krishna Chaitanya and S. Manickavasagam, through Yellow Pan Trap (YPT). India, Nagaland, ICAR RC-NEH Region, Jharnapani, Medziphema, Dimapur, 3 ♀, 27.vi.2016, (N25º45.553' E093º50.450'), Coll. T. Krishnachaitanya, S. Palanivel and S. Manickavasagam, through YPT, EDAU, Annamalai University, Chidambaram, Tamil Nadu.

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Note on golden-spotted tiger beetle

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Tiger beetles, *Cicindela aurulenta* (Carabidae: Coleoptera) are known for being aggressive predators and for their fast running speed. In fact, the fastest species of tiger beetle can run at a speed of 9 km/h (5.6 mph). To put that into perspective, that's about 125 body lengths per second. They can be found in a wide range of sandy habitats, including near shorelines, river bars, sand dunes, mangrove fragments and forest trails and mostly observed in hilly forest areas of Nandurbar

Photo credit to Author: Dr. S. B. Kharbade (21^0 75'N Latitude and $74^0$12' E Longitude).




Note on painted grasshopper

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Painted grasshopper *Poekilocerus pictus* (Pyrgomorphidae: Orthoptera) is a large brightly coloured grasshopper found in the Indian subcontinent. Nymphs of the species are notorious for squirting a jet of liquid up to several inches away when grasped. It is also known as *Aak* grasshopper or locally in a few tribal areas called *titighodo.* The grasshopper feeds on the poisonous plant *Calotropis gigantea,* found on other host plants such as *Nerium* spp., *Cassia* spp., *Pongamia* spp. etc. Upon slight pinching of the head or abdomen, the half-grown immature form ejects liquid in a sharp and sudden jet, with a range of two inches or more, from a dorsal opening between the first and second abdominal segments. The discharge is directed towards the pinched area and may be repeated several times. The liquid is pale and milky, slightly viscous and bad-tasting, containing cardiac glycosides that the insect obtains from the plant it feeds upon. In the adult, the discharge occurs under the tegmina and collects as a viscous bubbly heap along the sides of the body

Photo credit to Author Dr. S. B. Kharbade

Brief review of *Haematorrhophus* spp. (Hemiptera: Reduviidae)

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Two thirds of heteropterans are herbivores and mouth parts are specially designed to feed on plant liquids and the remaining are carnivorous.

The family Reduviidae is the largest family of predaceous terrestrial hemiptera and a few are blood suckers. Some of them are pathogenic and transmit various diseases to man and animals. Bugs belonging to the family Reduviidae are commonly also called as 'Assassin bugs' feed on a wide range of small creatures and insects. Reduviidae is represented globally by about 6878 species and subspecies under 981 genera belonging to 25 subfamilies (Henry, 2009). Checklist reports of 465 species belonging to 144 genera under 14 subfamilies of the family Reduviidae were from India (Maldonado, 1990; Ambrose, 2006; Biswas *et al*, 1994, 2010). Reduviidae are small to large, robust or elongated, flattened, smooth hairy or spiny bugs ranging from 2 mm (*Holoptilus*) to large and extremely hardy (*Haematorrhophus*) 40 mm. Reduviids are abundant throughout the world and are voracious predators. Legs of Reduviidae show modifications and specialised structures adapted for their predatory habits and efficient prey capture. They have a relatively narrow neck, sturdy build, and formidable curved proboscis. The most distinctive feature of the family is that the tip of the proboscis fits into a rigid groove in the prosternum, where it can be used to produce sound by stridulation. Sound is made by rasping the proboscis against ridges in this groove stridulitrum (stridulatory organ). These sounds are often used to discourage predators. When harassed, many species can deliver a painful stab with the proboscis, injecting venom or digestive juices. The variable forelegs of these insects apparently reflect the correlation between the structure of the legs and the types of prey. The tibial pads or '*fossula spongiosa*' are a common feature in the forelegs or fore and middle legs of most of subfamilies of Reduviidae. They are generally found in tropical rainforest, semiarid zones and scrub jungles but mostly common in tropical rainforest ecosystems. Reduviid belonging to genus *Acanthaspis* actively feeds on honeybees and *Acanthaspis quinquespinosa* feeds on termites (Geetha Iyer, 2011).

Haematorrhophus belongs to the subfamily Ectrichodiinae known for specializing on millipedes as prey (Heteropteran systematics lab 2010). They are capable of coping with the noxious defensive compounds (benzoquinones, organic acids, hydrochloric acid, phenols, alkaloids, quinazolinones, cyanogenic compounds, cresols and terpenoids) produced by many millipedes. Ectrichodiinae the fifth largest subfamily of Reduviidae (Hemiptera: Heteroptera), or assassin bugs, are engaged in a predator-prey relationship with millipedes. The group comprises more than 600 species in about 115 genera, making it a fairly large subfamily. (Green, 1925, Haridass & Ananthakrishnan, 1980 and Haridass, 1985). The bugs are also known for their aposematic coloration, often brightly colored metallic blue, red, or yellow. Species of this subfamily hide under leaf litter and sometimes boulders and hunt at night (Christiane *et.al* 2009). Females have wing reduction and extreme sexual dimorphism can be seen (Forthman *et.al.*, 2017).

Wingless female of *Haematorrhophus marginatus* (Reuter, 1873) in mango ecosystem, Nuzvid (16.7850^{o}N, 80.8488^{o}E)

Millipedes (Diplopoda) are a diverse group of arthro-pods that include 16 orders represented by approximately 12,000 species in 145 families (Sierwald and Bond, 2007). In 11 of these orders, millipedes are protected from predators by chemical defenses produced in glands that vary in number among orders and are located laterally or mid-dorsally in the diplosegments (Eisner *et al.*, 1978; Hopkin and Read, 1992). Communal predation was observed among conspecific nymphs, among groups of nymphs with a conspecific adult, and more rarely among adults. Immature ectrichodiines were rarely observed to engage in solitary predation. *Haematorrhophus* sp. feed on ventral posterior trunk or intersegmental membrane on ventral posterior trunk (Forthman and Weirauch 2012). Among which Genus *Haematorrhophus* Stal, 1874 consisting of 12 species are reported from India.

1. *Haematorrhophus foevalis* Murugan & Livingstone, 1995
2. *Haematorrhophus horrendous* (Kirkaldy, 1902)
3. *Haematorrhophus* (Physorhynchus) *javadiensis* Hegde, 1989
4. *Haematorrhophus malabaricus* (Distant, 1902)
5. *Haematorrhophus marginatus* (Reuter, 1873)
6. *Haematorrhophus nigroviolaceous* (Reuter, 1881)
7. *Haematorrhophus pedestris* (Distant, 1902)
8. *Haematorrhophus rubromaculatus* (Distant, 1902)
9. *Haematorrhophus ruguloscutelleris* Murugan & Livingstone, 1995
10. *Haematorrhophus segnis* (Bergroth, 1915)
11. *Haematorrhophus talpus* (Distant, 1902)
12. *Haematorrhophus tuberculatus* (stal, 1874)

The family Reduviidae is the largest family of predaceous terrestrial hemiptera and a few are blood suckers. Some of them are pathogenic and transmit various diseases to man and animals. Members of this family are commonly known as "Assassin bugs". These are small to large, robust or elongated, somewhat flattened, smooth, hairy or spiny bugs, which may vary in size ranging from 2 to 40 mm.

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Note on Swallowtail butterfly

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Scientific Name	:	*Pachliopta aristolochiae*
Order	:	Lepidoptera
Family	:	Papilionidae
Location	:	College of Agriculture, Nandurbar, Maharashtra, India
Latitude, Longitude	:	21^{0} 75'N Latitude and 74^{0}12' E Longitude
Host Plant	:	*Aristolochia* spp., *Thottea* spp., *Bragantia* spp., *Dioscorea* spp. Etc
Insect Information	:	*Pachliopta aristolochiae*, the common rose Indian butterfly, is a swallowtail butterfly belonging to the genus *Pachliopta*, the roses, or red-bodied swallowtails. It is a common butterfly which is extensively distributed across south and southeast Asia. It is very common almost all over the plains of India, and is not threatened as a species. During and after the monsoon it is extremely abundant.
Photo credit to Author	:	Dr. M. S. Bharati




The milkweeds grasshopper, *Poekilocerus pictus* (Fabricus, 1775)

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"All locusts are grasshoppers, but all grasshoppers are not locusts (Acrididae)". Locusts have a behavioural phase called the gregarious phase when they congregate into thick swarms to feed on green plants including all crops available causing famine. "Locust Warning Organization" at Jodhpur, Directorate of Plant Protection Quarantine and Storage, Government of India, Ministry of Agriculture & Farmer's Welfare monitors the swarms of the locusts like the recent one of *Schistocerca gregaria*. The present observations is on the Painted Grasshopper *Poekilocerus pictus* (Fabricus, 1775) (Orthoptera: Pyrgomorphidae) (Fig. 1) on the milkweed, *Calotropis procera* (Asclepiadaceae) in Abu Road, Sirohi, Rajasthan. Grasshoppers were found feeding on the host plant (Fig.2), 4-6 individuals were spotted on each plant including mating pairs. These grasshoppers were around 6dm in length and exhibited yellow and blue aposematic coloration. *Calotropis* sps. Serves as a main host to *P. pictus*is which feed on the plant leaves and its considered as minor pests on it. (https://www.nbair.res.in/Databases/insectpests/Poekilocerus-pictus.php) The grasshopper is also reported on other hosts such as wheat, papaya, citrus, castor, brinjal, mango and others. Cytogenetic investigations on grasshopper chromosomes in India were initiated with observations on the spermatogenesis of *P. picta* (Asana and Makino, 1934). Males of this group are highly useful as laboratory animals to demonstrate the phenomenon of meiosis (spermatogenesis) to students in universities and colleges across India. As an African quote "The restless grasshopper only finds rest in the gizzard of a bird", they are a good food source for reptiles, birds and mammals and serve as a part of the food chain.

Fig. 1. Adult *Poecilocerapictus*

Fig. 2. Damage of *Calotropis procera* by *P. pictus*

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Webinar report

'The Agrobiodiversity Index in India: Leading the path for other countries'

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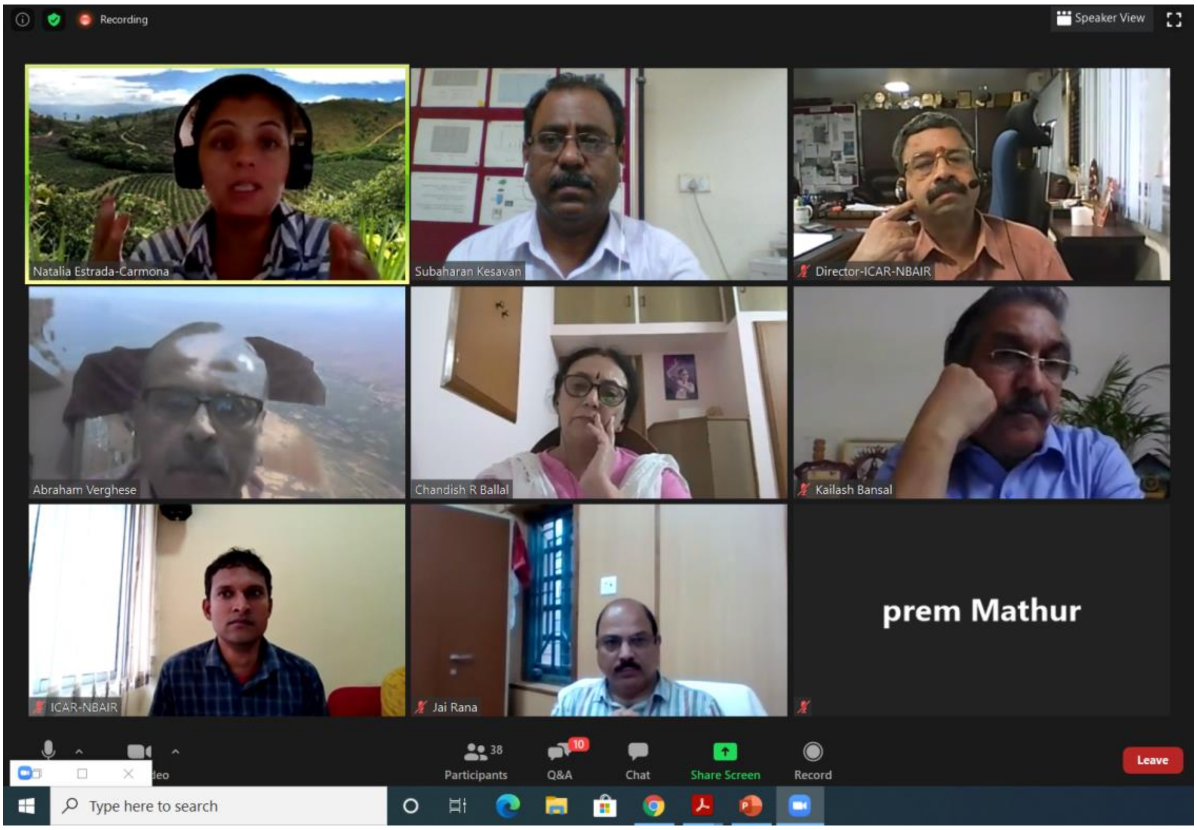
ICAR-NBAIR in collaboration with the Alliance of the Bioversity International and CIAT, India office organised a webinar on ‘‘The Agrobiodiversity Index in India: Leading the path for other countries as a part of ICAR – NBAIR Town Talk Series 003 on 17.8.2020. During the introductory remarks by Dr. N. Bakthavatsalam, Director, ICAR–NBAIR Bengaluru, emphasized the need to have a wholistic agrobiodiversity index (ABDI) tool to measure agricultural biodiversity and identify measures to achieve diverse, resilient and sustainable food systems. The speaker for the day Dr. Natalia Estrada Carmona, Associate Scientist, The Alliance of Biodiversity and CIAT, Italy delivered a talk on 'The Agrobiodiversity Index in India: Leading the path for other countries. She highlighted the role of Agrobiodiversity Index and its aim to empower public and private decision-makers to know what we grow, eat and conserve. She elaborated on the skeleton of agrobiodiversity index with three measurement categories viz., market and consumption, production and genetic resources including 22 indicators and 55 sub indicators, respectively. The sub-indicators like ex situ & in-situ conservation of diversity viz., seed banks, species diversity, seed diversity and varietal diversity as the major parameters of genetic resources for the estimation of ABDI.

The importance of text mining towards achieving the progress and time line under agrobiodiversity conservation and use was emphasized. She also informed that consultations were in progress with countries to develop a holistic methodology for the estimation of ABDI. Considering the robust database available with India, she believed that India can lead in in developing agrobiodiversity index with the source of datasets available with various bureaus under the ICAR. The need to focus upon the indirect intangible measures that contribute to the index like crop species or varieties consumed in diets, farm management efforts leading towards sustainable agriculture was highlighted.

The panellist for the webinar were Dr. Abraham Verghese and Dr. Chandish Ballal (Former directors of ICAR-NBAIR) Dr. Bansal, Former Director, ICAR - NBPGR, Dr. Jai C. Rana, Bioversity International. The webinar was attended by scientists from ICAR institutes, AICRP Biocontrol centres and faculty fromState Agricultural Universities. The programme was chaired by Dr. N. Bakthavatsalam, Director, ICAR–NBAIR and coordinated by Dr. Jai C. Rana, country representative, Alliance of the Bioversity International and CIAT. The NBAIR scientific team, Kesavan Subaharan, M. Sampath Kumar, Amala Udayakumar, M. Pratheepa and M. Mohan organized the webinar.



Webinar report

Making Smallholder farming climate resilient

Amala Udayakumar, Kesavan Subaharan, M. Pratheepa, M. Mohan and N. Bakthavatsalam*

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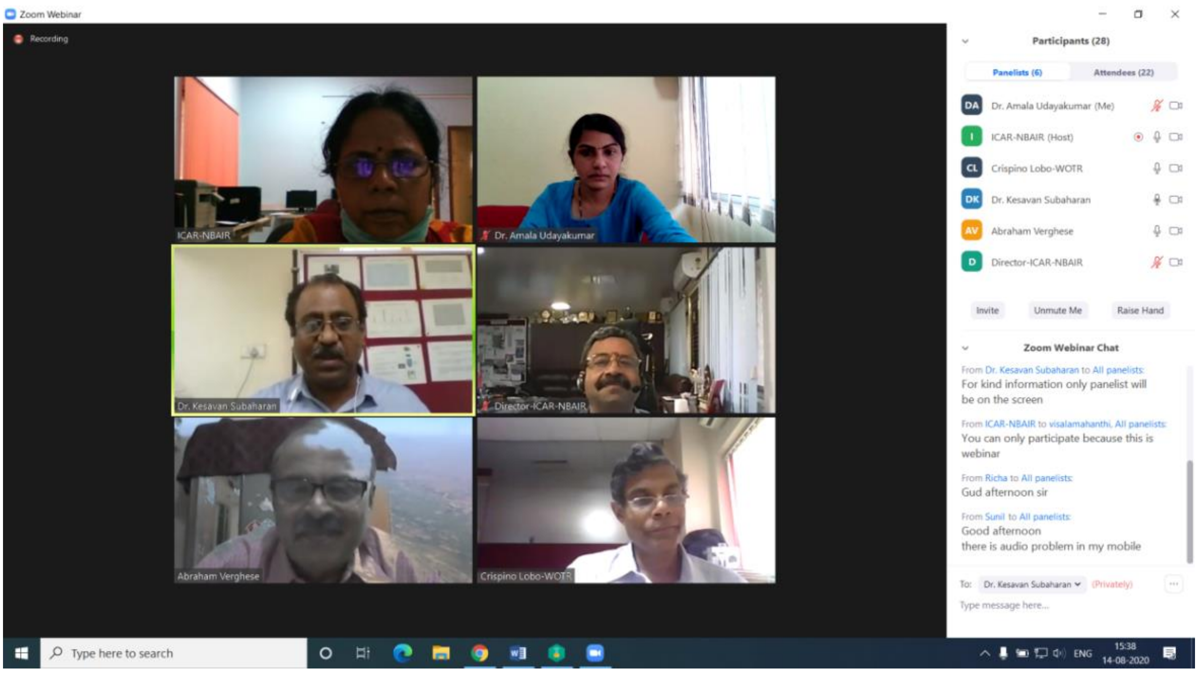
Corresponding author: Bakthavasalam.N@icar.gov.in

Water is becoming a scarce commodity in rural and urban areas. In rural areas in addition to water being used for human consumption a great proportion of it is used for raising crops. With the shift in climatic condition and over exploitation of surface and ground water, farming activities tend to have a grim situation in the days to come. Hence, there is a need to understand the water requirements and devise strategies to have a system in place to help the small farmers to adopt approaches that are climate resilient. On this ICAR - NBAIR organized a webinar on 'Making Smallholder Farming Climate Resilient' under the banner of Town Talk Series 002 on 14 August 2020. The webinar was attended by former Directors of ICAR NBAIR, Dr. Abraham Verghese and Dr. Chandish Ballal. The webinar had the participants drawn from ICAR institutes, State Agricultural Universities and research scholars. Dr. Kesavan Subaharan, organizing secretary welcomed the gathering.

In his introductory remarks Dr. N. Bakthavatsalam, Director, ICAR–NBAIR highlighted the concept of watershed development and the need to generate novel ideas that could benefit the present scenario of precision agriculture. The speaker for the day Mr. Crispino Lobo, Founder, Watershed Organization Trust (WOTR), Pune delivered a talk on 'Making Smallholder Farming Climate Resilient'. He discussed the need for watershed development and the farmers participatory approach to achieve the goal. The case studies of watershed projects in Maharashtra were discussed by him. The involvement of the village community in the project had made them profit from the project as the information related to water availability for the locality was spelt out in a notice board and it also provided them with the information on the crops to be raised considering the water availability. He elaborated upon the concept of water budgeting, water stewardship and the role of WOTR in transforming the living of village people across the country through participatory watershed development, ecosystem restoration and climate resilient sustainable agriculture with an action plan towards the concept of 'More crop per drop'. The concepts of water budgeting and water stewardship were the pathways to manage water scarcity under rainfed conditions.

He stressed upon the needs of incorporating water stewardship approach into existing soil and water conservation programmes. He explained the concept of the existence of water levels in different aquifer layers underground and the important role of check dams for recharging the groundwater regime.

Other strategies adopted in climate resilient agriculture was a mobile app based agromet advisory service developed by WOTR Pune in collaboration with India Meteorological Department, Pune, ICAR-Central Research Institute for Dryland Agriculture, Hyderabad and Mahatma Phule Krishi Vidyapeeth, Pune. The agromet advisories are delivered through messages by WOTR, Pune to guide farmers with location specific agro-advisories correlating particular crop growth stages with weather parameters to improve agricultural productivity and crop protection. The advisories are crop health, production and farmer specific using block level weather forecasts provided on a daily basis by IMD, Pune. WOTR, Pune also publishes crop weather-based calendars for the benefit of farmers. The advisories are delivered to the farmers through different modes using wallboards, advisory posters, farmer’s field schools in collaboration with local government institutions and departments.. A total of 36 participants from NBAIR and AICRP BC centers participated in the webinar. The programme was chaired by Dr. N. Bakthavatsalam, Director, ICAR–NBAIR and organized by Dr Kesavan Subaharan, Dr. Amala Udayakumar, Dr. M. Mohan and Dr. M. Pratheepa.



Webinar on fruit fly menace and its awareness: Report on 7th fruit fly awareness day

Shantanu Jha
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While 4400 species of fruit flies (Diptera: Tephritidae) have been known worldwide, 200 species are pests of different crops. The genus *Bactrocera* comprises 500 species of 28 subgenera mostly distributed in Asia, South Pacific, and Australia. Due to its broad host range, high dispersal, and wide distribution, it causes enormous damage to many economically important crops including fruit and vegetable crops.

A novel initiative, Fruit fly awareness Day (FAD) was started on 8th August since 2014 under the aegis of Association for Advancement of Plant Protection, Mohanpur, West Bengal. This year 7th FAD was celebrated through virtual mode where stupendous 162 participants including fruit fly workers, farmers, students, agri-input dealers participated in the program. The eminent scientists such as Dr. Abhraham Verghese, Former Director of ICAR-NBAIR, Bengaluru, Dr. N. Bakthvatsalam, Director, NBAIR were the key speakers of the programme. Professor, Shantanu Jha, secretary of AAPP in his introductory remarks briefly stated the background and genesis of the programme. He also stressed upon the menace of the fruitful problems and its impact on the quality of harvested produce and the growers.

Dr. Verghese inaugurated the programme with a presentation on management of fruit flies- way forward and stressed upon area-wide integrated pest management (IPM), male annihilation technique (MAT) with bait traps, modified sanitation, improved traps (viz., alcohol-free, insecticide-free and slow-release impregnation) and their commercialization (more than 28 licensed and non-licensed firms), and growing tolerant variety like Langra and EC 95862. He reiterated area-wide IPM activities that could be intensified through extension agencies like KVKs, ATC, NGOs, etc. He also mentioned the adoption of fruit fly management technology in tribal areas of Odisha. He highlighted the role of taxonomists for species identification from NBAIR and cautioned invasive alertness of species introduction from neighboring countries like Bangladesh and Sri Lanka.

Dr. Bakthvatsalam highlighted the importance of female attractants for the management of fruit flies. He cited the experience of action of European Union to ban Indian mangoes and vegetables due to the infestation of fruit flies. He shared his experience on mango fruit fly, *Bactrocera dorsalis* that damages up to 59% in mango and 57% in guava. Other species like the melon fruit fly, *Bactrocera cucurbitae (Coquillett)*, which has 81 host plants, causes up to 100% damage in vegetables under farmers' field conditions. He also elaborated the importance of parapheromones like methyl eugenol, cuelure and trimedlure that are responding to many economically important species; *B. dorsalis*, *B. ocipialis*, *B. papayae*, *B. philippinesis*, *B. zonata*, *B. correcta* are attracted by methyl eugenol, *B. kandiensis*, *B. trivalis*, *B. cucurbitae* by cuelure and *Ceratitis capitata* by trimedlure.

He shared his experiences for the development of enhanced attractant of mango fruit fly using a combination product that gives more 2.5 times catches than that of methyl eugenol. Thus the number of traps suggested at the rate of 5 per acre instead of 10 per acre as with methyl eugenol for similar efficacy. He also suggested a combination of chemical attractant and yellow sticky traps that showed catches efficiency 40% of females. For the management of *B. cucurbitae* infesting cucurbits, a modification of fruit fly dispenser using alcohol and insecticide-free formulations for organic production system have proved effective. Further, he mentioned a liquid formulation of methyl eugenol that could have a long-lasting effect on mango orchard.

He also presented results of combination dorsalure and bisexual attractant for mango, guava (Taiwan rose), orange (Coorg mandarin) with the installation of 5 dorsalure with 5 bisexual traps per acre at fruit setting period with 2 or 3 dispenser replacement for its effective control. While for bitter gourd, cuelure traps and bisexual attractant @ 10 per acre proved effective at different farm trials. He presented a list of female fruit fly baits such liquid hydrolyzed proteinaceous bait, ammonium acetate + putrescene, ammonium acetate + putrescene + trimethylamine, banana (1kg), carbofuran (10g) + yeast (10g) + citric acid(5g), Jaggery + dichlorovos (1%),sugar and ICN enzymatic yeast hydrolysis (3:1) and proteinex + 5% ammonium acetate. He also cited many commercial protein lures in the world market but only Anamed splat as paste formulation is available in India.

He mentioned another approach of proteinex attractants with chemosterilants in which females were fed with protein hydrolysates with chemosterilants and found decreased fruit fly incidence. He also reported research progress with gamma octalactone based attractant and aromatherapy where males are sterilized through radiation, exposed to air blown methyl eugenol, and the released male are preferred by females and thus substantial reduction of egg-laying in the field. He emphasized the integration of parasitoids (*Psyttalia* spp., *Biosteres*, *Diqachasmimorpha* sp., *Pseudocolia*, *Trubliographa*, S*yntomopus* sp., *Euryen* sp., *Spalangai* sp., *Opius fletcheri, Fopius arisanus*) with pheromones technologies and usefulness of Mexican strain of entomopathogenic nematode (*Steinernema* sp.) for the management of fruit flies. Finally, he concluded his talk highlighting the future prospects of fruit fly management through production of large quantities of cheaper cuelure or methyl eugenol, commercial production of traps and lures, area-wide IPM with MAT, village level production of dispenser and encouragement of youth and women in large scale production of dispensers. He envisioned for standardization of sterile insect technique, female attractants, ovipositional attractants, Gamma octalactone, mass awareness programs among farmers, and integration of other technologies.

Mr. Rakesh Pashi, Research Scholar, Department of Agricultural Entomology, Bidhan Chandra Krishi Viswavidyalaya, West Bengal presented his research works on Chinese citrus fly, *B. minax*, a notorious pest of mandarin orange in Darjeeling and Kalimpong districts of West Bengal. He shared his observation on the distribution and bio-ecology of the pest from this region, and reported fruit fly damage in mandarin orange to the extent of 75%. He also recorded more infestation in the mid-altitude in contrast to low and high-altitudes of the region. Aside from Darjeeling mandarin (*Citrus reticulata*), the fruit fly species attacks sweet orange (*Citrus sinensis*), rough lemon (*Citrus jambhiri*), rangpur lime (*Citrus limonia*), and

Kinnow mandarin (*Citrus reticulata*). His presentation covered morphology, bioecology, spatial distribution, and management of *B. minax*. Finally, he suggested the application of azadirachtin 0.03% @ 5ml/l during June-July along with good sanitation measures for its effective management. He observed that tillage practice along with irrigation during March could be highly effective to reduce adult emergence of *B. minax*.

Webinar report on “Moth diversity, ecology and conservation”

Mukta Kukreja, Sumishal Monterio, Merlyn Bernadette and M. Jayashankar
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An international webinar on “Moth Diversity, Ecology and Conservation” which coincided with National Moth week was organised by the Natural Science Association (NSA), Department of Zoology, St. Joseph’s College in association with A Rocha India on the 24th of July 2020. It attracted over 900 participants from different parts of the country and from International platforms as well. The covid times have provided opportunities to host such online webinars. This event was conducted on Microsoft Teams and live broadcast over YouTube and Instagram. Dr. M. Jayashankar (NSA Co-ordinator) briefed the audience about the National month and the reason to organise the webinar.

A Snapshot of atlas moth during the session

This webinar included two sessions led by eminent persons in the field of moth biology, the first being Dr V. Subhalaxmi who has aptly been given the title **“***Moth lady of India"***,** after passionately pursuing 25 years of entomological research with specialisation in moths. She founded three entities; Ladybird Environmental Consulting, iNaturewatch Foundation and Birdwing Publishers. She rose to fame after writing India’s first field guide on Indian Moths. The session commenced at 2:00 pm with an opening address rendered by Anukriti Shaw (NSA) and a brief introduction of the speaker was given by Dr. Viyolla Mendonce. Dr. Subhalaxmi, spoke on the topic “Denizens of the Dark Dynasty” — Moths — Jewels of the Night. Her speech gave the audience a complete overview of Indian Moths, ways to distinguish between Moths and Caterpillars, Techniques used in mothing (moth-watching) and laid utmost emphasis on defence mechanisms and survival strategies used by moths. Her talk was followed by an interactive Q&A session moderated by Mr. K.S Shivakumar, the questions asked during the session was an indicator of the engagement of the participants with the speaker. The vote of thanks was rendered by Ms. Pratibha R D.

Rev. Prem Mitra, Chairman, A Rocha India welcomed the guest for the second session and highlighted A Rocha India initiatives involving young researchers. Dr. Sabitha Thomas introduced the second speaker, interestingly; an alumnus of SJC, Mr. Nitin R, a Ph. D scholar at the University of South Carolina, USA who was invited to speak at the second session. The technical glitch also provided an opportunity for noted entomologist Dr. Abraham Verghese (Former Director, NBAIR) who highlighted the ecological roles of moths. The second session was on the topic - Moth Ecology and Evolution. Mate location, Co-evolution between moths and flowers citing the classic example of the Darwin moth, obligate mutualism in Yucca moths. Nitin also spoke on echo-location by bats and how moon moths jam the signals. He also highlighted aposematism in moths. The speaker encouraged the participants to engage in findings and contribute their records for further research purposes. After successfully overcoming the technical glitches, an elaborate Q&A session extended till 8:15 pm.

The discussion session was moderated by Dr. John Paul and a vote of thanks was given by Dr. Kavya Krishnappa. Student volunteers from NSA actively involved in organising the event. The complete video is available on NSA youtube channel.

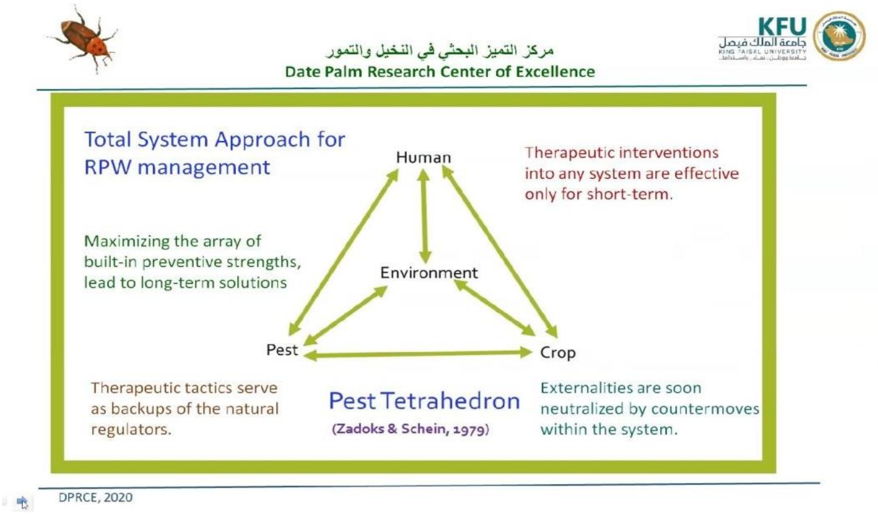
Dr. V. Subhalaxmi passionately holding a moth

Mr. Nitin R in his work station

International webinar report on advances in red palm weevil research and management

Rashmi, M.A
*Regional Plant Quarantine Station, Bangalore,*560024 *India*

The Don Bosco College of Agriculture, Goa, India affiliated to Goa University, had organized an International Webinar on 'Advances in Red Palm Weevil Research and Management' on 8th September 2020. Global date production is 8 million tons out of this 77% is produced in gulf Middle East and North Africa. Red Palm Weevil is a common pest in Asia, Italy and Europe with destructive results. This pest has significantly expanded geographically from its origins in Southeast Asia during the last decades. RPW is causing widespread damage to the date palm tree and other cultivated plants. The spread has resulted in significant economic and environmental consequences and is considered the most destructive insect pest of date palm in the Middle-East.



This virtual conference brought together professionals that have been working on RPW to understand the biology and ecology of this warm-climate pest and reduce its spread to prevent future economic and environmental damages.

Gaps and challenges in components of current RPW integrated pest management strategy were discussed such as early detection, developing and implementing phytosanitary measures, pheromone trapping and data collection of weevil captures, removal of several infested Palms, lack of effective biocontrol agents in field, slow development of new applicable field technologies, poor farmer participation in the control scarcity of that on social economic issues overdependence on use of chemical pesticides, Re-examining of entire paradigm of therapeutic approach. The Covid-19 impacts on date palm were also brought into the picture the problems in the availability of skilled workers at critical time in production, challenge in accounting of disease by farmers and field workers, provision of personal protective equipment, provision of suitable housing facilities on farm, increase of production cost, and decrease of marketing opportunities of dates. Traditional means of production mainly depend on labor.

Alleviations of COVID -19 impact and future recommendations were suggested such as mechanization of the date Palm sector, adoption of smart agriculture, sustainable pest management in date Palm, improvement infrastructure as of date Palm plantation.

Topics discussed were

1. Advances in RPW – IPM in Coconut by Dr. Chandrika Mohan, ICAR-CPCRI, Regional Station, Kayangulam, Kerala, India.
2. Current Challenges of RPW Management and Impact of COVID 19 Pandemic on Global Date Palm Production by Dr. Hamadttu EI-Shafie, Date Palm Research Center of Excellence, KFU, Al-Ahsa, Saudi Arabia.
3. Evolving trends in Semio-chemical Mediated technologies against RPW by Dr. Jose Romeno Faleiro, Former FAO consultant, Goa.
4. A Global view about RPW with focus on Saudi Arabia and other G20 countries by Prof. Hassan Al-Ayedh, KACT, Riyadh, Saudi Arabia.
5. Another conception of preventive and curative treatments for the control of RPW by Dr. Michel Ferry, Phoenix Research Station, Spain.

PROFILE

Dr. Geetha, G. Thimmegowda, SERB N-PDF, TIFR-National Centre for Biological Sciences (NCBS), Bangalore, India

Discovering and nurturing talent are two drivers in human resource development in science. Never say no to anyone showing interest in any field of science. This convention of mine has many stories. But the one I report here is of one who strode into entomology without any 'insecty' background and to begin with Dr Geetha, G. Thimmegowda has been making waves globally for her work on the effects of urban pollution on the Rock bee, *Apis dorsata*. As a contribution of NICE Lab, NCBS, the paper "*A field-based quantitative analysis of sublethal effects of air pollution on pollinators*" in PNAS has been receiving repeated accolades and hits. (PNAS August 25, 2020 117 (34) 20653-20661;https://doi.org/10.1073/pnas.2009074117).

Geetha first met me in 2010 at the entomology division of ICAR-Indian Institute of Horticultural Research with a Masters in Biochemistry. However, she wanted to work on insects! I have always been conditioned to first prefer students with an entomological or zoological background. So my first response was in the negative. But, Geetha's strong determination and conviction that she wanted to be only in the entomology division melted me. So I decided that she brings in biochemistry into insects and registered for a Ph.D. I found a fellowship for her from NABARD and Dr. N.K Krishna Kumar accepted to be her guide. Her project in NABARD was on reaching out to rural farmers but her Ph.D was an additional work on *Myllocerus*, both of which she did with zeal and merit. One thing that stood out from the beginning was that she was a "superwoman" (as she is known in NCBS).

One of her major tasks in molecular studies on *Myllocerus* was to rear the weevils, which was tough as the grubs are root feeders while adults are defoliators. This required a two stage rearing procedure which she standardized on her own. This impressed both Dr. Krishna Kumar and I.

After her Ph.D on molecular characterization of *Myllocerus*, she joined NCBS in 2016 with Dr. Shannon Olsson and in a matter of four years she caught international attention. The links to her papers are given above and you will be able to judge what her output is. We at IE are proud that Dr Geetha, one of our editors, is a top-notch young entomologist, now internationally renowned. She designs the IE as she has a flair for soft designing. Being an accomplished photographer including SEM, and equipped with aesthetic and professional outlook, she will be a good photo-editor of 'Insect Lens' section of IE.

I had the privilege of mentoring her for nearly a decade now, in several dimensions and I can attribute her success to her personal nature of being cool, calm, calculated, honest and focussed.

Dr Geetha, IE wishes you the BEST in future.

Dr. Abraham Verghese

Dr. Rashmi, M.A

Society for Biocontrol Advancement, Dr Abraham Verghese's Award

for

Best Ph.D thesis in Entomology (Bioecology, Biosystematics, Biocontrol and Biotechnology)

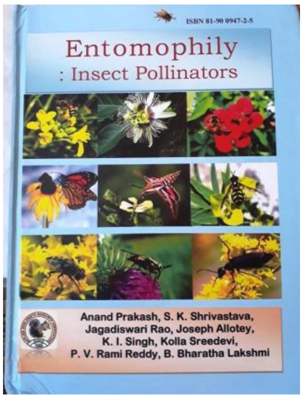
Award for the year 2019-2020 was shared by Soumya B R, Jain University, Bengaluru, Karnataka and Kariyanna B, College of Agriculture, UAS Raichur, Karnataka.

Soumya B R, Jain University, Bengaluru

Thesis title: Biodiversity and seasonal incidence of lepiodpteran pest complex of mango with special reference to mango leaf webber (*Orthaga exvinacea* Hampson) in Karnataka

Book Review

Entomophily: Insect Pollinators



Title: Entomophily: Insect Pollinators

Authors: Anand Prakash, S. K. Shrivasthava, Jagadiswari Rao, K. I. Singh, K. Sreedevi, P. V. Rami Reddy and B. B. Lakshmi

Publishers: Applied Zoologists Research Association, Bhubaneswar, India

ISBN : 81-90 00947-2-5

Pages: 498

Price: Rs. 1500 in India (Hard bound) US$ 60 (outside India)

Year : 2019

The coevolution of flowering plants and insect pollinators dates back to several million years and is still evolving. Globally, about 90% of the total flowering plant species are cross pollinated and of them 85% are pollinated by insects. Thus 'entomophily' deserves to be an area of intense research to understand and appreciate the ecosystem services provided by the insect pollinators. Often, the contribution of pollinators is taken for granted and crop production packages prescribed by different universities ignore them as valuable inputs of agriculture. In India, different organizations like ICAR Institutes, SAUs and KVIC bodies have been working on honey bees and other pollinators but the information generated is scattered and there are not many comprehensive publications to depict the progress of research in insect pollinators. In this direction, the Applied Zoologists Research Association (AZRA) took initiative in bringing out a book entitled "Entomophily: Insect Pollinators".

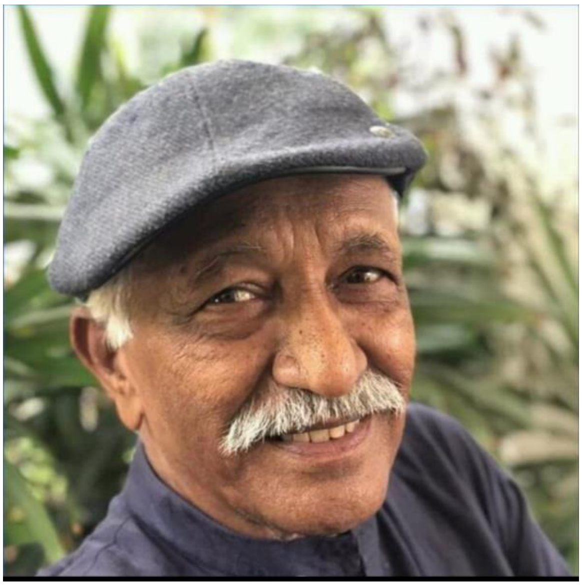
This voluminous book (just short of 500 pages) covers various aspects of pollinators, like biology, diversity, foraging ecology, contribution to fruit or seed set in different cross pollinated crops, effect of pesticides etc. under 15 clearly divided chapters. Each chapter is preamble with an abstract. The authors also took care to include chapters on emerging areas like impact of climate change and genetically modified (GM) crops on pollinators. The authors had put in commendable efforts in collecting, compiling and presenting the information in lucid manner. The data in many chapters are sourced from the reports of network projects like ICAR-All India Coordinated Project on honey bees and pollinators, thus making it highly authentic and representing developments from across the country. In the chapter on "Conservation of insect pollinators", modules recommended by globally reputed organizations like FAO and International Pollinator initiative (IPI) have been listed and strategies to conserve and augment both wild and managed pollinators were outlined. Habitat loss and large scale use of insecticides are mentioned to be major factors contributing to pollinator decline besides other threats like pests and diseases, climate change and rapid loss of crop diversity in large areas.

The information provided is also supplemented with beautiful colour photographs at relevant places. All authors seem to have considerable years of experience in pollinator research which is evident from the references cited thus making it a contribution of competent people in the theme of the book. Though the book is in text book mode, references were listed at the end which would be of immense help to research scholars and scientists to use the information and explore original papers for detailed information, if needed.

The book is highly useful to graduate and postgraduate students, research scholars, researchers, policy makers and extension personnel. It would be a valuable addition to libraries of all Agricultural universities, ICAR Institutes and Krishi Vigyan Kendras (KVKs).

Dr. Abraham Verghese
Former Director, ICAR-NBAIR, Bengaluru
Editor-in-Chief, Insect Environment

Obituary



Dr. B. N. Viswanath
(12 July 1943 - 9 August 2020)

As an undergraduate student at the University of Agricultural Sciences, Bangalore, way back in 1973, I had the privilege of being initiated into entomology by Dr. Viswanath. As part of the course requirement we had to rear any insects from eggs to adults to understand metamorphosis and submit the different stages in vials, and adults as pinned, for evaluation. Many of my smart classmates, who found these creepies repulsive, picked the different stages straight from field and submitted. Teachers could identify the not-reared mostly by the absence of the cast skin! But, I enjoyed rearing. Converting a portion of my bedroom into an 'insect lab' much to the chagrin of the family, I reared several species of lepidopterans (egg to adult) and a few bugs. I put them in 'injection' vials (small injection bottle of those days with rubber stopper) and each with diluted alcohol (given by Jadav, the entomology attender with grumblings; for I took the maximum, unlike students who needed only < 10 ml). These I showed to the class teacher Vishy Sir, as he was fondly called. Looking at me with appreciation and surprise he asked, 'You reared all these?" "Yes," was my proud reply.

He took me to Dr G. P. ChannaBasavanna*, the head of entomology, who was surprised with the half a dozen or so rearings I did. 'You have entomology in you so you should become an entomologist," he said with a smile. That was in 1973. And in 2020 I can look back and say: "*Sir, I obeyed you*!"

*(An editorial tribute to Late Dr G. P. ChannaBasavanna which appeared in Insect Environment 2000 issue is reproduced in this issue)

Dr ChannaBasavanna said that I need to rear more insects and gave me a slot in the laboratory along with post graduate students. This was a recognition indeed, thanks to Vishy Sir who regularly used to visit my rearing table and bring others to see how this 'young boy" coped with rearing. Vishy Sir was actually unwittingly igniting and switching on my insect career.

He was a different teacher. He had a style, flamboyance about him, loved his cigarettes, dressed smart, wore often a ‘jewel thief’ cap and spoke English well. He impressed me.

Once in a test he corrected a crucial spelling. He said this is not a minor pest, but a major one, but it is a *miner*! Even now, when I see or read about several miners (*Tuta* being the latest) I think of dear Vishy Sir.

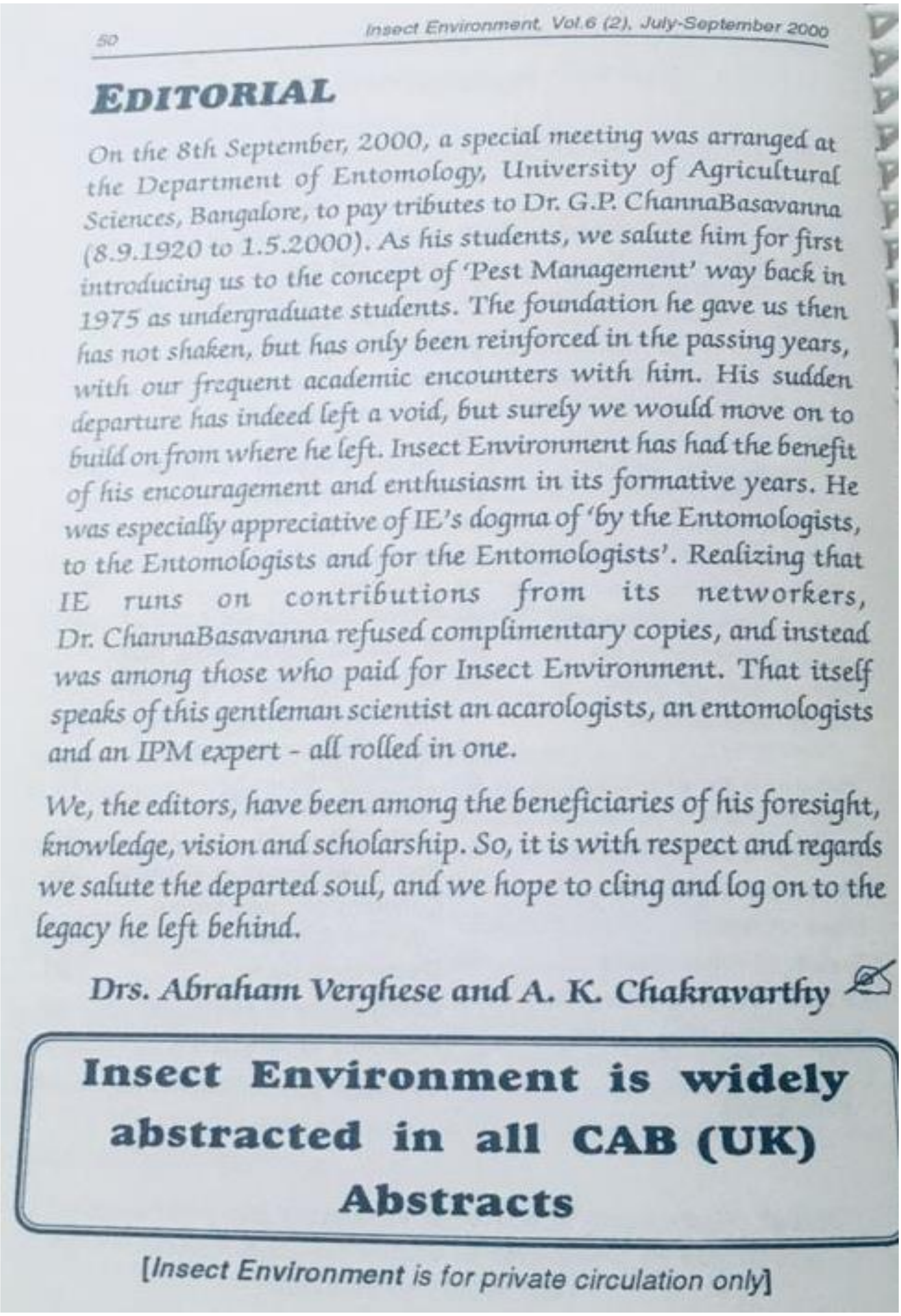
When he quit his job after 16 years of teaching, to take to videography- something which suited his flair and aptitude and subsequently to terrace garden, I became a little melancholic, for generation of students after me would miss a teacher of absolute class.

Felicitation to Dr. B. N. Viswanath at Institute of Agricultural Technologist (IAT), Bangalore, 2019 (Next to him is his wife)

The last I met him was at the Institute of Agricultural Technologist (IAT) Bangalore in 2019, when they felicitated him for completing his 75th year. The citation at IAT spoke volumes. Here was a talented man- an entomologists, horticulturists, photographer, film producer, friend of students- all rolled into one. He also won the hearts of many urbanites with his professional terrace garden trainings. To me and many entomologists he was also a class gentleman, with an air of self-respect, and undiminished love for all.

Vishy Sir may your memory live on………

Dr Abraham Verghese



EDITORIAL

On the 8th September, 2000, a special meeting was arranged at the Department of Entomology, University of Agricultural Sciences, Bangalore, to pay tributes to Dr. G.P. ChannaBasavanna (8.9.1920 to 1.5.2000). As his students, we salute him for first introducing us to the concept of 'Pest Management' way back in 1975 as undergraduate students. The foundation he gave us then has not shaken, but has only been reinforced in the passing years, with our frequent academic encounters with him. His sudden departure has indeed left a void, but surely we would move on to build on from where he left. Insect Environment has had the benefit of his encouragement and enthusiasm in its formative years. He was especially appreciative of IE's dogma of 'by the Entomologists, to the Entomologists and for the Entomologists'. Realizing that IE runs on contributions from its networkers, Dr. ChannaBasavanna refused complimentary copies, and instead was among those who paid for Insect Environment. That itself speaks of this gentleman scientist an acarologists, an entomologists and an IPM expert - all rolled in one.

We, the editors, have been among the beneficiaries of his foresight, knowledge, vision and scholarship. So, it is with respect and regards we salute the departed soul, and we hope to cling and log on to the legacy he left behind.

Drs. Abraham Verghese and A. K. Chakravarthy

Insect Environment is widely abstracted in all CAB (UK) Abstracts

[*Insect Environment* is for private circulation only]

An editorial tribute to Late Dr G. P. Channa Basavanna which appeared in Insect Environment Volume 6(2), July- September 2000 issue is reproduced in this issue.

Insect Lens

Anax parthenop

Author: Pinjala Abhaydeep, Abhaydeep986@gmail.com

***Place**: MSR North city Bangalore*

We might live in a world where dragons are mythical.... well we surely live in a world where Dragonflies are real.

These are the only existing dragons that can fly in the world. Being able to fly in any direction at 60 miles per hour and having the ability to can change direction within a blink on an eye titles them as the helicopters of the insect world. They have been around for about 300 million years and Prehistoric dragonflies were much larger and could have had a wingspan of 2 ½ feet! (This might have been because of the abundance of oxygen content in that period). These are carnivorous insects that feed on anything from mosquitoes to flies and they always catch their prey in mid-air. Just another dragon thing!!

Dysdercus cingulatus

Author: Geeta Mohan, Mount Carmel College Autonomous,
Bengaluru 560052, Indiageeta.mhn@gmail.com

Dysdercus cingulatus is commonly known as the red cotton stainer or red cotton bug. It is a species of true bug belonging to the family Pyrrhocoridae. Adults of *Dysdercus cingulatus* are 12-18mm long. Transverse white bands can be seen in the collar, just behind the head and on the underside along the margin demarcating each thoracic and abdominal segment. Legs are dark red. I found a single red cotton bug in my urban garden in Bengaluru city which prompted me to write this small note.

Rock bee colonies on white rock

Author: Dr. Stephen Devanesan, All India Coordinated Research Project on Honey Bees and Pollinators, Kerala Agricultural University, devanesanstephen@gmail.com

Place: Rajagiri, Idukki district of Kerala

Eggs of green lacewing, *Chrysoperla zastrowi* sillemi (= carnea)

Author: Sojwal Shalikram shinde Post Graduate Institute, Mahatma Phule Krushi Vidyapeeth, Rahuri, Ahmednagar, Maharashtra

Place: Field of AICRP on Vegetable Crop, Mahatma Phule Krushi Vidyapeeth, Rahuri Ahmednagar

***Adrama* from the family of fruit flies Tephritidae.**

Author: Hemanth Kumar H M MES Degree College, Malleshwaram,Bangalore

arjunkunungo@gmail.com

Location: Belur, Karnataka (13.150492,75.86554)

Some species like Adrama determinata have been reported to cause damage to tea seeds.

Charaxes schreiber **(Godart, [1824]) – Blue Nawab**

Author: Kalleshwara swamy CM, College of Agriculture, University of Agricultural and Horticultural Sciences (UAHS), Shivamogga-577 204, Karnataka, India

Location: Butterfly park, Belvai in Moodabidri Taluk of Dakshina Kannada District

Oecophylla smaragdina* on *Oryctes rhinoceros

Author: Dr. Stephen Devanesan, All India Coordinated Research Project on Honey Bees and Pollinators, Kerala Agricultural University, devanesanstephen@gmail.com

Place: Rajagiri, Idukki district of Kerala

***Pachliopta hector*, the Crimson Rose**

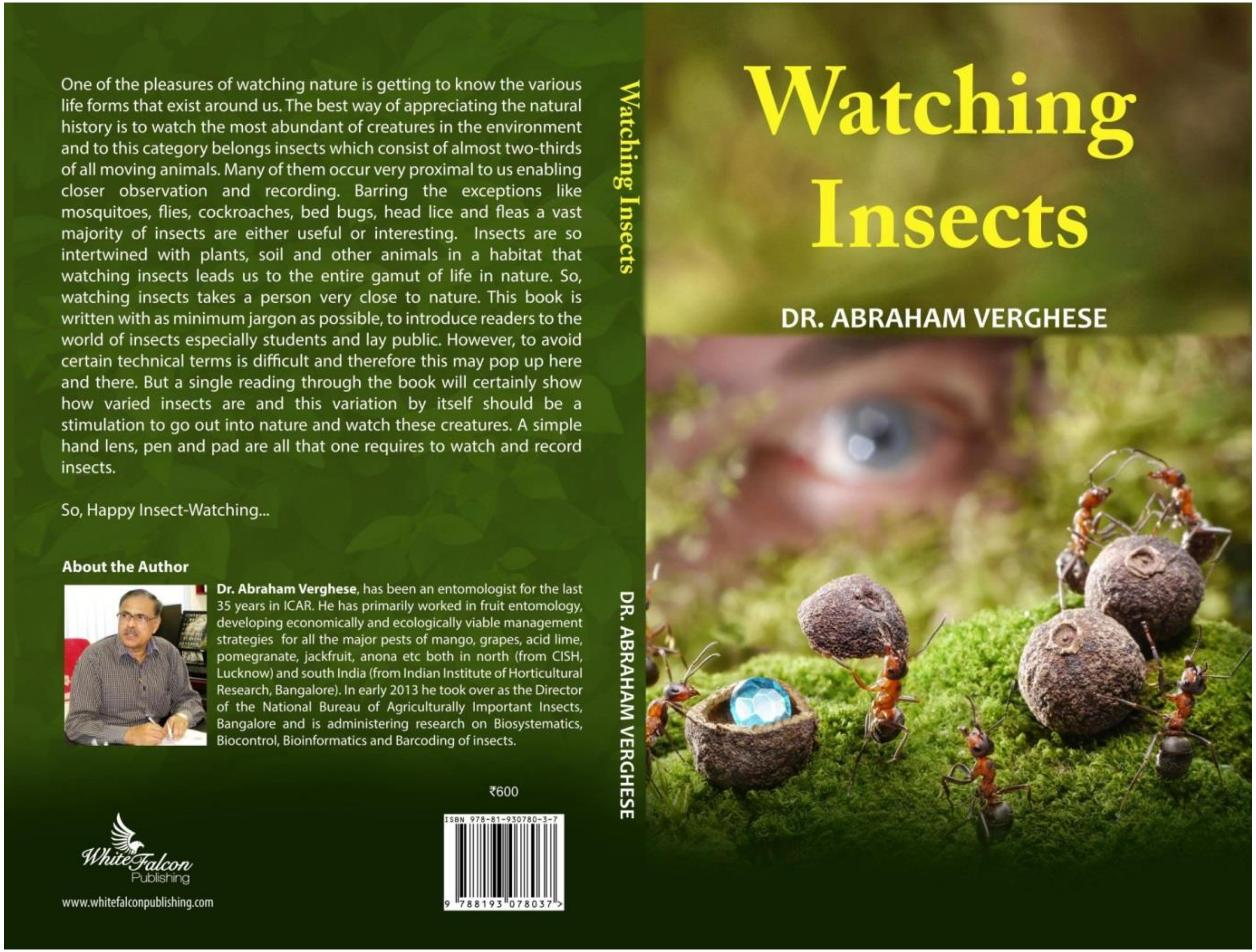
Author: Kalleshwara swamy CM, College of Agriculture, University of Agricultural and Horticultural Sciences (UAHS), Shivamogga-577 204, Karnataka, India

Location: Butterfly park, Belvai in Moodabidri Taluk of Dakshina Kannada District

Dipteran Fly

Author: Pinjala Abhaydeep, Abhaydeep986@gmail.com
***Place**: MSR North city Bangalore*

Product Announcement



*Available online on amazon and flipkart