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FEATURING

Aphids of Himalaya: Present status

Tête-à-Tête with Dr. T. M. Manjunath

Women in Entomology: Dr. Chitra Srivastava

Managing invasive rugose whitefly

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Editorial Board

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*Cover page: A mating pair of Syrphid (*Allobaccha* sp.) hovering in air, Bengaluru, 08.10.2020. By Saiteja Katta, University of Agricultural Sciences, Bengaluru.

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EDITORIAL

Sailing through pandemic: One Year of Indian Entomologist

The Indian Entomologist is now a year old. In retrospect, this unique venture of few enthusiastic young entomologists started as an experiment has performed exemplarily well. It has started a digital forum in the form of an informal platform for the upcoming and young entomologists. Some of its unique contents make this a novel approach so far never attempted by any professional group. In fact, it started playfully like an upcoming sportsperson will like to play along, without any barriers and with enough freedom, to bring out the inherent talent in the field that is ingrained in few volunteers. These have enabled putting together the knowledge that emanates from both experts as well as amateurs, as a unique experiment. The statistics over a year reveal that this digital output in entomology attracts more than 80% of new visitors every time, with page views being around 60%. These speak very well of the impact of this unique venture: "Indian Entomologist", and the outcome meets the objectives with which this venture got started. In fact, the page views have doubled in the last six months, revealing the ripple caused by this venture. Except for an unexplainable peak in May the viewing has been almost steady. As expected there had been viewers from all corners of India, indeed south India tops in the viewers, perhaps of the reason that insects, their causes, and effects are more pronounced here in view of the congenial weather favoring insects and their diversity. More than 5500 viewers had dug into the contents in more detail, which I guess is a big achievement taking into account the 2000 plus entomologists in the country, including Ph.D./ PostDoc researchers. The unique section which is becoming very popular is BLOG, it has gained a lot of momentum. Some blogs even reached more than 1000 reads and they are crisp and informative. Many young entomologists are encouraged to write blogs on the Indian Entomologists website and these blogs are regularly published without any time barrier.

In other words, it can be said that more than the active entomologists, nonentomologists too view this unique output of the Entomological Society of India. Myself being solely occupied and engrossed with the more professional Indian Journal of Entomology, I view this venture as a more thought-provoking outcome of the Entomological Society of India, for the upcoming generation. I take this opportunity to congratulate the movers and shakers of this unique venture. I also invite young entomologists to open up their thoughts and get involved in this unique endeavor.

Having deliberated upon the Indian Entomologist, let me ink a few words about the Covid 19 pandemic, as it has affected all walks of life. Covid 19 has got in our life for a full year by now, and naturally, its impacts are becoming more pronounced as we are learning to live with it. We entomologists also have acclimatized ourselves with all possible efforts and actions to tide over this unusual pandemic. In the last one year, I had an opportunity to hear from not only biologists, other life scientists, but also some entomologists continuously about how this pandemic got intertwined with our core activities including research. I am also aware of the handicaps and impediments many of us experienced in performing research. I also equally heard from many who were not upset to that much extent as many others. These latter lot of researchers perhaps believed in synergizing their field-oriented research with basic research, though not equally but at least or even to a small extent. Such a synergy is always possible in all walks of our entomology oriented research, for eg., in IPM if a researcher gives equal or the desired impetus to basic research in its components, synergy can lead to appreciable outcomes, and provide much better and valid outputs. I noticed that those who practiced this kind of synergy did not suffer like the ones who depended solely on field-oriented experiments during this Covid 19 pandemic. That is why, as a taxonomist, I had emphasized this in my editorial on locust research last time. Basic research must form the core of any research for tangible and sustainable outcomes.

No doubt all researchers are being impacted by Covid 19, and it is true with entomology too. That is why, the Entomological Society of India jointly conducted a "Webinar on Entomology 2020: Beyond COVID-19" at Hyderabad, along with Professor Jayashankar Telangana State Agricultural University, the Plant Protection Association of India, and Agri Biotech Foundation during 11-12 December 2020. It could be observed that Covid 19 impacted Entomology in many ways, and one of these was the impediments experienced by the entomologists in their research. That is why in the research funding meetings, we as a group of biologists are seeking moratorium/ support to overcome the negative impacts of the pandemic, especially with the timeline oriented research experiments. No doubt, this holds good for entomologists too. Covid 19 provides us a unique experience, and we must learn to use this to convert a challenge or a problem into an opportunity and still march ahead unscathed. I wish we learn such a lesson from this pandemic, to ensure our safe voyage in any activity. Indian Entomologist wishes all a safe and successful life journey beyond this Covid 19.

Dr. V.V. Ramamurthy
Editor in Chief, Indian Entomologist

Aphids (Hemiptera: Aphididae) in the Himalaya: present status

Samiran Chakrabarti

Abstract: Aphids, a group of hemipteran obligatory phytophgous insects have distribution throughout the world. Many species are pests of agricultural, horticultural and forest plants and vectors of plant pathogens. The Himalaya, a hot spot zone in India, has many favourable plant species for aphid infestation and many of them are endemic. At present 818 species of aphids with 398 endemic species, in 216 genera and 15 subfamilies, are known from different zones of the Himalaya. There are 76 gall inducing aphid species and these are dominant in Northwest Himalaya. Morphology of many galls is very species specific. Primary and secondary hosts of many species have been explored. Primary host ranges of the gall inducing species are narrow and specific. The Parasitoid and predator complexes are also rich and about 50% parasitoids of aphids here are endemic.

Key words: Diversity, distribution, endemism, host plants, aphid galls, predators and parasitoids.

Aphids are soft-bodied obligatory phytophagous sucking hemipteran pests drawing attention of entomologists throughout the World. Besides mechanical damage to plants, aphids also serve as the largest group of vectors of plant viruses (Eastop 1977, Chan et al. 1991, Ghosh et al. 2017). The damage is further compounded by fouling the host plant with honeydew (Fig. 2) that has an influence on predators and parasitoids. Honeydew also serves as a substrate for growth of fungal complexes that cause sooty mould which on one hand reduces the photosynthetic activity of plants, while on the other hand it reduces plant's aesthetic market value (Miller and Foottit 2009).

Aphids infest different types of plants that are important from the stand point of agriculture, horticulture and forestry. Of the 80 groups of vascular plants in the world only 8 lack aphids, and those groups represent only 3% of the plant species (Eastop 1978). There are little over 5000 valid species of aphids. Among these more than 250 species feeds on agricultural or horticultural crops (Blackman and Eastop 2000). Though this figure represents only approximately 5% of the world aphid fauna, yet the economic consequences of aphid damage are huge (Miller and Foottit 2009). Increased international trade and the consequent increased movement of commodities as well as the intimate relationship between aphids and their hosts have resulted in increased rates of introduction of aphids to different countries (Foottit et al. 2006).

Due to the feeding of aphids several symptoms and abnormalities such as discolouration, stunted growth, curling of leaves are found to occur in different host plants (Figs. 3-7). Perhaps the most interesting symptom of aphid infestation is the formation of galls on different parts of plant, such as leaf, petiole, leaf base and stem (Figs 8-13). As a result, normal growth and development of the affected parts and also the production of flowers and fruits are hampered and disturbed. So, the total yield of the infested plant is reduced.

It is necessary to explore biodiversity of a particular region to know its local fauna. Many aphid species are oligophagous and/ or polyphagous and have host alternations. They have complicated biology, cyclical parthenogenetic reproduction and life cycle pattern. These insects are also a good model for study in evolutionary biology. Where aphid faunas have been developed, the proportion of adventive species is also high. So exploration for aphid species in different areas from different host plants also helps to identify whether new adventive species has been introduced or not. Aphids, in general, prefer temperate climate. Although some species are cosmopolitan, most of them are restricted to countries of temperate region and/ or found in other countries where some areas have temperate climate.

Of the several mountain systems in India, the Himalayan range is the highest, longest, most wide and vast. The uplift of the Himalaya since late Cenozoic has strongly influenced the environment of this area and surrounding regions as well as the climate in Asia and across the globe (Shi and Li, 1988). In the Himalayan region many plants preferred by the aphids are present and some of them are endemic. This has attracted attention of aphidologists for explorations and studies of aphids here.

This account deals with the present status of aphid taxonomy in the Himalaya. The fauna in different zones of the Himalaya and their endemism have been analyzed. Informations of the aphid galls in the Himalaya, aphid-host plant association, aphid life cycle and the natural enemies of aphids of the Himalaya have also been provided in brief.

1. The Himalaya

The Himalaya is one of the youngest and highest mountain system of the world having life at higher altitudes compared to other mountain systems. The Himalayan range for its Tertiary origin has experienced Pleistocene glaciations and has continuous Post-Pleistocene uplifts (Mani 1974). It maintains its peculiarities, such as enormous massiveness, great elevations of the mountain regions, their trend-lines and their location in the middle of a vast continental mass. The Himalayan range (Fig. 1) extends from Mt. Nanga Parbat to Pamir Knot in the extreme northwest, while with a small curve of about 2500 km length to Namcha Barwa Peak in the east. It lies approximately between east longitude 72^0 and 90^0 and north latitude 27^0 and 37^0.

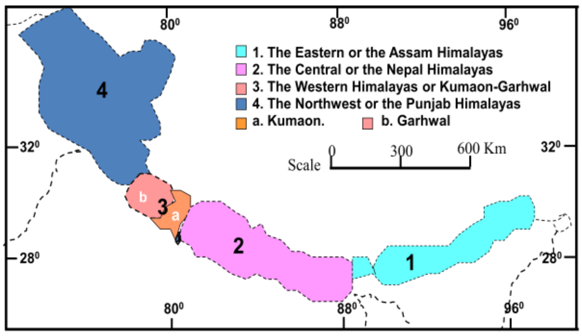
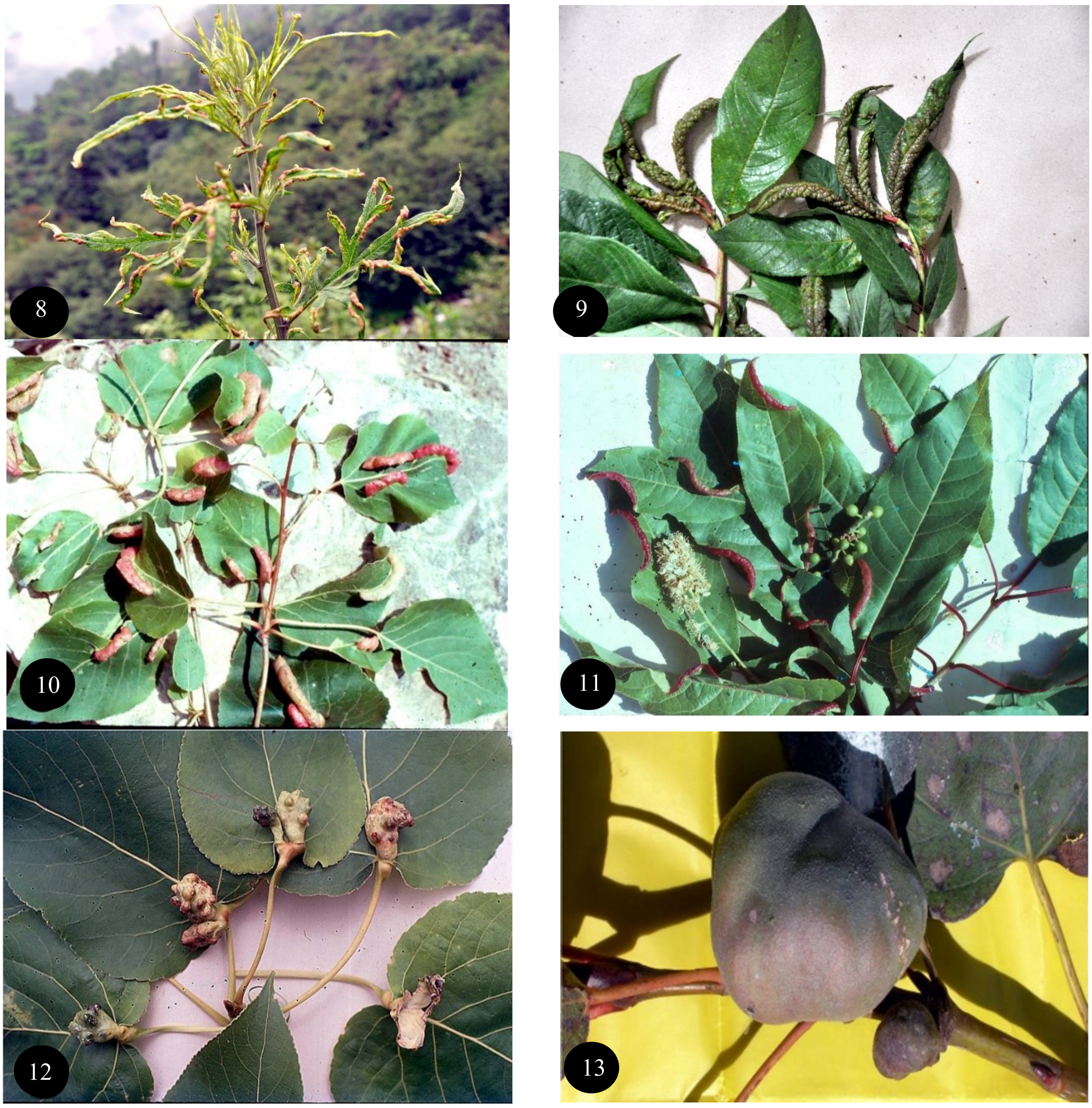


Fig. 1. Different divisions of the Himalaya.

The Himalaya, geo-morphologically as well as traditionally may be demarcated into Eastern Himalaya or Northeast Himalaya, Central Himalaya or Nepal Himalaya and North-west Himalaya. The Central

Figs. 2-7: 2. Honeydew on *Salix alba*; 3. *Sitobion rosaeformis* (Das) on *Rosa* sp.; 4. *Melanaphis sacchari* (Zehtner) on *Saccharum officinarum*; 5. *Cinara tujaphilina* (Del Guercio) on *Platycladus orientalis*; 6. *Mollitrichosiphum* (*Meta*.) *montanum* (v,d.G.) on *Alnus nepalensis*; 7. *Tuberlachnus salignus* (Gmelin) on *Salix alba*.

Himalaya lies between the River Teesta in the east and the River Kali in the west. The major part of the Central Himalaya falls in Nepal. The Royal Kingdom of Bhutan is a part of the Eastern Himalaya. Northwest Himalaya can be demarcated into subzones. Occasionally, the part between the River Kali in the east and the River Sutlej in the west is known as Western Himalaya which is again demarcated into Kumaon in the east and Garhwal ranges in the west. The rest of the Northwest Himalaya west of the River Sutlej up to Indus valley falls in Himachal Pradesh and Jammu and Kashmir in India. The extreme west portion of Northwest Himalaya beyond Indus valley up to Nanga Parbat is now within Pakistan and identified as Pakistan Himalaya (Mani, 1974).



Figs. 8-13. 8. Leaf marginal galls of *Cryptosiphum artemisiae* Buckton on *Artemisia vulgaris*; 9. Leaf- curl galls of *Brachycaudus helichrysi* (Kaltb.) on *Prunus persica*; 10. Leaf caterpillar galls of *Epipemphigus imaicus* (Chold.) on *Populus ciliate*; 11. Leaf marginal galls of *Eumyzus pruni* Chakrabarti and Bhattacharya on *Prunus cornuta*; 12. Leaf base gall of *Pemphugus matsumurai* Monzen on *Populus ciliate*; 13. Stem galls of *Pemphigus mordvilkoi* Chold. on *Populus ciliate.*

Himalaya is also unique; the Eastern Himalaya is very rich floristically and is influenced by Sino-Japanese (Manchurian), Indo-Chinese and Malayan flora while the Northwest Himalaya is influenced by the Eurasian and Mediteraian flora (Rao, 1994). The Himalaya exhibits the terai, subtropical, temperate and alpine vegetations with the change of altitudes. Both Eastern and Northwest Himalaya have many endemic floras that have enormous influence on the prevalence, distribution and biology of aphids. Vegetations in the Himalaya are also influenced by the difference in rainfall and mountain slopes.

2. Historical perspectives

Buckton (1893) described *Oregma bambusae* (= *Astegopteryx bambusae*) from Dehradun, a foothill city of the Himalaya and later in 1896 he described *Pemphigus immunis* from Gilgit, Kashmir and *Pemphigus napeaus* from Darkot Pass, Kashmir. Cholodkovsky (1912) described three new species viz. *Pemphigus imaicus* (= *Epipemphigus imaicus*), *Pemphigus mordvilkoi* and *Pemphigus nainitalensis* from the Kumaon range of the Northwest Himalaya. Das (1918) (published posthumously by P. van der Goot) provided an excellent account of 40 species in 18 genera of aphids from Lahore, now in Pakistan which is actually situated in the Upper Indus valley. Aphid studies in the Himalaya got momentum since the Sixties of the last Century when a number of workers started exploring aphids particularly in Eastern and Northwest Himalaya [details documented in Ghosh (1974), Raychaudhuri (1980), Chakrabarti (2015)]. Other than the above accounts, reports of aphids from the Kingdom of Bhutan (a part of Eastern Himalaya: Chakrabarti et al. 2020 and personal data) and from Nepal (Central Himalaya: Das and Raychaudhuri, 1988) are worth mentioning. Aphids from Pakistan (Northwest Himalaya) were listed by Naumann-Etienne and Remaudiere (1995). Later, Remaudiere (2002), and Remaudiere and Binazzi (2003a, 2003b) and Kanturski et al. (2017) added several species to this list from here.

3. Methodology

Aphids are in general, collected directly from the plant surface using hand with the help of a soft camel-hair brush and preserved within 70-80% ethyl alcohol in ependrop vials or glass tubes with good stoppers. Associated predators, parasitoids and scavengers are also collected from the aphid colonies and preserved suitably. Rearing of immature of aphids and associated predators and parasitoids was performed for obtaining adult individuals, if required. Yellow Pan Traps (YPT) are employed, where possible, for collecting flying aphids.

Field records such as site of infestation, symptoms on the host plant, colour of aphid, colour of individual body part of the live specimen, habitat, associated organisms, their roles, population size, presence of wax on body etc. are also noted at the collection sites. The name of the host plant is to be noted. If it is not possible to identify at the site, sufficient plant parts should be collected to prepare herbarium for future identification. Field photographs of both aphids and their host plants are taken. Aphid samples after processing in KOH and subsequently passing through grades of ethyl alcohols, are finally mounted in Canada balsam. The prepared specimens are stored and arranged according to classificatory categories.

4. Results and Discussions

4.1 Aphid diversity

The Himalaya has very rich aphid diversity. So far, 818 species in 216 genera and 15 subfamilies (Table 1) have been reported from this mountain system and its foothills. Only 25 aphid species and 4 genera found in other areas of the Indian subregion (eg Peninsular, Gangetic plains and Indus valley) are missing in the Himalaya. Thus, the Himalaya comprises of 16.36% of the world aphid species and 97.14% of the total species found in the Indian subregion. The subfamily Aphidinae has 468 species (57.09% of the total species) in 111 genera and thus this is the most dominating subfamily in this area. Next to Aphidinae there come Greenideinae (85 species), Eriosomatinae (62 species), Lachninae (44 species), Hormaphidinae (52 species) and Calaphidinae (50 species), respectively. The number of species in different genera of the respective subfamilies have been provided in Table 1.

In spite of presence of same or similar host plants in some localities, the distribution of aphids is not homogeneous throughout the Himalaya. Eastern Himalaya (including Bhutan) has 481 species in 148 genera. Bhutan alone has 91 species in 55 genera. In Central Himalaya or Nepal Himalaya there are only 60 species in 27 genera known so far. While in Northwest Himalaya (including area falling in Pakistan) has 542 species in 177 genera. In the Northwest Himalaya within Pakistan 269 species in 107 genera have also been recorded. The aphid fauna reported from the different parts of the Northwest Himalaya such as, Kumaon-Garhwal, Himachal and Jammu and Kashmir zones also differ from each other. However, faunistic explorations and systematic studies are not uniform in all the parts of the Himalaya. The number of genera and species occurring in different subfamilies in these areas are given in Table 1.

The Central Himalaya has been explored lesser for aphid fauna compared to that in the Eastern and the Northwest Himalaya. The under mentioned 7 new species viz., *Aiceona himalaica* Miyazaki, *Aiceona parvicornis* Miyazaki (Anoecinae), *Dysaphis sharmai* Stroyan, *Dysaphis ramani* Das and Raychaudhuri, *Sinomegura nepalensis* Das and Raychaudhuri (Aphidinae), *Panaphis nepalensis* Quednau (Calaphidinae), and *Cinara saraswati* Das and Raychaudhuri (Lachninae) described from here are still reported only from this area and exclusively endemic till today (Table 2). *Prociphilus cornifoliae* Singh et al. (Eriosomatinae) which was described from here is also found in Manipur. Of the 60 species known from the Central Himalaya, 36 species are common to both Eastern and Northwest Himalaya. Rest of the 24 species (Table 2) are not evenly distributed, although 13 of the above species are endemic to the Himalaya. Only, 11 of the above 24 species are found in the Eastern Himalaya and only 2 species, *Diuraphis noxia* (Kurdjumav) and *Cinara tenuepes* Chakrabarti and Ghosh have been reported from the Northwest Himalaya. Space and time will not permit to discuss and describe the distribution and common occurrence of each and every species in different regions or divisions of the Himalaya. Table 1 shows that 542 species in 177 genera are found in Northwest Himalaya. Of these species, 74 species occur exclusively in this area west of the Indus River which is now in Pakistan. Among the species that are found in the Eastern and Northwest Himalaya, 210 species are common in both zones. It is further interesting to mention that at least 82 species are common between the Himalaya and the Qinghai-Tibetan Plateau.

The diversity of species in many genera is not homogenous in Northwest and Eastern Himalaya. Representatives of several

Table 1. Distribution of genera and species including endemic species in different zones of the Himalaya.

Subfamily	Himalaya		Eastern Himalaya		Central Himalaya		NW Himalaya		Pakistan Himalaya		Common species of Eastern & NW Himalaya
	Genera/ species	Endemic	Genera/ species	Endemic species	Genera/ species	Endemic species	Genera/ species	Endemic species	Genera/ species	Endemic species	
Aiceoninae	1/9	9	1/7	7	1/2	2	1/2	2	x	x	2
Anoeciinae	1/6	2	1/4	1	x	x	1/5	1	1/2	x	3
Aphidinae	111/467	209	75/265	109	6/22	x	105/348	147	63/177	29	143
Calaphidinae	22/50	29	14/30	21	6/6	1	18/31	18	11/17	7	13
Chaitophorinae	5/28	13	4/7	4	x	x	5/26	10	4/15	6	5
Drepanosiphinae	2/4	2	1/1	1	x	x	2/3	1	1/1	x	x
Eriosomatinae	19/62	31	12/27	14	3/3	x	16/47	20	13/29	11	13
Greenideinae	9/85	59	8/73	54	3/14	6	4/24	16	3/4	x	16
Hormaphidinae	24/52	21	19/40	17	4/6	1	11/18	5	2/2	1	5
Lachninae	15/44	19	10/23	7	4/7	2	10/31	14	6/18	12	10
Minadarinae	1/2	x	x	x	x	x	1/2	x	1/1	x	x
Phloeomyzinae	1/1	x	x	x	x	x	1/1	x	1/1	x	x
Phyllaphidinae	2/2	1	2/2	1	x	x	x	x	x	x	x
Saltusaphidinae	1/2	x	x	x	x	x	1/2	x	1/2	x	x
Thelaxidinae	2/4	3	1/2	1	x	x	1/2	2			x
Total	216/818	398	148/481	237	27/60	12	177/542	236	107/269	66	210

Table 2. Aphid species in Central Himalaya not found in all other zones of the Himalaya.

	Aphid species	Eastern Himalaya	Northwest Himalaya	Endemic in the Himalaya	Endemic in Nepal
	Anoecinae				
1.	*Aiceona himalaica* Miyazaki				Y
2	*Aiceona parvicornis* MIyazaki				Y
	Aphidinae				
3.	*Aphis glycines* Matsumura				
4.	*Aphis hardyi* Eastop				
5.	*Diuraphis noxia* (Kurdjumav)				
6.	*Dysaphis ramani* Das and Raychaudhuri				Y
7.	*Dysaphis sharmai* Stroyan				Y
8.	*Macrosiphoniella spinipes* Basu		P	Y	
9.	*Sinomegoura simplocosis* (VDG)				
10.	*Sinomegoura nepalensis* Das and Raychaudhuri				Y
11.	*Vesiculaphis caricis* (Fullaway)				
	Calaphidinae				
12.	*Panaphis nepalensis* Quednau				Y
	Eriosomatinae				
13.	*Prociphilus cornifoliae* Singh et al.		P	Y	
	Greeneidinae				
14.	*Eutrichosiphum passanae* (Okajima)				
15.	*Eutrichosiphum quercifoli* Ghosh et al.	P		Y	
16.	*Greenidea longicornis* Ghosh et al.	P		Y	
17	*Greenidea photiniphaga* Raychaudhuri et al.	P		Y	
18.	*Sumatraphis celti* Takahashi	P			
	Hormaphidinae				
19	*Ceratovacuna indica* Ghosh et al.	P		Y	
20.	*Pseudoregma alexandri* (Takahashi)	P			

21.	*Schizoneuraphis querciphaga* (Ghosh and Raychaudhuri)	P		Y	
	Lachninae				
22.	*Cinara saraswati* Das and Raychaudhuri				Y
23.	*Cinara tenuipes* Chakrabarti and Ghosh		P	Y	
24.	*Nippolachnus querciphaga* Ghosh and Raychaudhuri	P		Y	

P= Present. Y= Yes

genera missing in a particular area have been depicted in Table 3. Northwest Himalaya is unique with the representatives of several genera of Aphidinae, Eriosomatinae, Hormaphidinae, Phloemyz--inae, Saltusaphidinae and Thelaxinae, while its Eastern counterpart has interesting species of the genera belonging to Greenideinae, Hormaphidinae, Lachninae and Phyllaphidinae. Species diversity also varies in many genera between these two regions.

4.2 Endemic fauna

The Himalaya is the abode of many endemic plants. It also represents a high percentage of endemic aphid fauna as is found in many other groups of insects (Mani, 1974). As many as 398 species of aphid (48.65%) are endemic to the Himalaya. The distribution of endemic species in different subfamilies of aphids in different divisions of the Himalaya is presented in Table 1. Endemic species number also varies in different subfamilies. For example, all the 9 species of the genus *Aiceona* (Aiceoninae) found in the Himalaya are endemic. In Eastern Himalaya 7 species are found of which only 2 species are common with the Kumaon-Garhwal range of Northwest Himalaya. *Aiceona himalaica* Miyazaki and *Aiceona parvicornis* Miyazaki are restricted to the Central Himalaya only. No representative of *Aiceona* has been recorded so far from Bhutan, a part of the Eastern Himalaya. In the Himalaya, 69% of species of Greenideinae, 58% Calaphidinae, 51.85% Lachninae, 50% Eriosomatinae, 45% Aphidinae, and 40% Hormaphidinae are endemic. It has been noted that many such endemic species have restricted distribution even within the Himalaya. However, the subfamilies Minadinae, Phloeomyzinae and Saltusaphidinae have no endemic species in the Himalaya. Altogether 236 endemic species (43.54%) occur in Northwest Himalaya while 239 endemic species (49.27%) are found in Eastern Himalaya. Discussion on the distribution of the endemic species and their association with the host plants in the Himalaya is an interesting topic in aphid- plant association and evolution of aphids.

Endemism has a correlation with age and isolation of an area, and also with the diversification of its habitat. Such factors have a direct influence in the evolution resulting in the speciation of endemic forms as well as the preservation and survival of relic endemics (Kruckeberg and Rabinowitz, 1985). Endemism is influenced by the

Table 3. Representative of species of some genera missing in Northwest and Eastern Himalaya.

Northwest Himalaya	Eastern Himalaya (including Central Himalaya)
Aphidinae *Akkaia, Brachysiohoniella, Kaochiajoa, Scleromyzus, Taiwanamyzus*	*Aphidura, Aspidophorodon, Brachyunguis, Chaitaphis, Cryptaphis, Chakrabartiella, Longicaudus, Eichinaphis, Ephedraphis, Eucarazzia, Myzaphis, Nasonovia, Neotoxoptera, Nudisiphon, Obtusicauda, Spinaphis, Tumoranuraphis, Wahlgreniella, Xerobion*
Eriosomatinae: *Chaetogeoica, Formosaphis*	*Baizongia, Kaburagia, Salvum, Thecabius, Gharesia, Kaltenbachiella, Schizoneurella*
Greenideinae: *Allotrichosiphum, Anomolosiphum, Cervaphis, Greenidedoidea, Sumatraphis*	
Hormaphidinae: *Euthoracaphis, Glyphinaphis, Heminipponaphis, Indonipponaphis, Machilaphis, Metanipponaphis, Parathoracaphis, Schizoneuraphis, Sinonipponaphis, Thoracaphis, Tuberaphis*	*Aleurodaphis, Doraphis, Hamamelistes, Pseudessogella*
Lachninae: *Eulachnus, Sinolachnus*	
Other subfamilies *Kurisakia, Taiwanaphis*	*Mindarus, Phloemyzus, Saltusaphis, Neothelaxes.*

geographic area, ecological breadth and isolation (Carlguist, 1974). Since aphids are obligate plant parasites, to study the distribution of endemic fauna in the Himalaya its unique microclimatic factors as well as the altitudinal variation in distribution of host plants should be taken into account (Chakrabarti, 2009).

5.3 Aphids as gall inducers in the Himalaya

Galls include a variety of structural abnormalities or deformations ranging from simple curling, folding and rolling to complex deformities with definite shape and size displaying distinct tissue differenciation (Mani, 1964). Among arthropods, some insect taxa of the order Diptera, Hymenoptera, Hemiptera, Thysanoptera, Lepidoptera and Coleoptera, and some mite taxa, Eriophyoidea and Tenuipalpidae induce galls on their host plants. Hemipteran galls are of open type and induced by some members of Aphidoidea, Psylloidea and Coccoidea. In the superfamily Aphidoidea some species of aphids and majority of adelgid and phylloxerid species can induce galls on their host plants.

Aphid are specialist gall inducer. They stand next to Cecidomyiidae (Diptera) and Eriophyoidea (Acari) and Cynipoidea (Hymenoptera). Not all aphid species induce galls on their primary host plants. Nevertheless, a gall inducing aphid species cannot induce galls in all stages of their life. In aphids, the first instar fundatrices (developing from hibernating eggs) can only induce galls on specific host plants (primary host) at a specific period (time) and at a specific site. Other subsequent morphs and individuals may help in increasing the size of the gall but are unable to initiate a new gall. If a fundatrix is released on its secondary host plant it cannot initiate a gall. Only 10-20% of the total aphid species of the world are known as gall inducer (Remaudiere and Remaudiere, 1997).

In spite of rich aphid diversity in India, particularly in the Himalaya, only 76 species have so far been found to induce galls on their host plants. Chakrabarti (2001) has provided a list of such species. These species are restricted to only 4 subfamilies *viz.,* Aphidinae, Calaphidinae, Eriosomat--inae and Hormaphidinae. All these species are known from the Himalaya. Table 4 depicts the distribution of 76 gall aphid species in different zones of the Himalaya.

It is worthy to mention that the species of the subfamilies Greenideinae and Hormaphidinae are mostly distributed in East and South-east Asia including India and infest many tree species. Galls have never been found induced by any greenedeine aphids anywhere. Gall inducing hormaphidine aphid species are also least known from India although many gall inducing species of this group have been reported from other countries. This may be due to the fact that most of the species of hormaphidine aphids in India have been collected from their secondary hosts only. The plant genera viz., *Distylium* and *Styrax* are the principal primary hosts of many genera of hormaphidine aphids but these have not been surveyed properly. Several species of the above two plant genera are found in Khasi Hills in Meghalya and also in other northeast Indian states, in addition to Bhutan and Myanmar (Brandis, 1906). If properly flora of these regions would be explored, the primary hosts and galls of many hormaphidine aphids may be found out.

5.4 Aphid gall morphology

Aphid induced galls are cataplasmic (irregular growth i.e., leaf-fold, leaf-roll, leaf-spiral, leaf pouch etc) or prosoplasmic growth (with a definite shape, colour, duration of gall phase/ stage and orientation which are specific for each species). Aphid galls are open type. The galls induced by

Table 4. Number of gall inducing aphid species in the different zones of the Himalaya.

Family/Tribe	Total species	Endemic species	Kumaon-Garhwal	Himachal-Jammu Kashmir	Pak	Eastern	Central
Aphidinae	31	16	31	13	14	8	5
Eriosomatinae							
Eriosomatini	13	3	12	5	9	1	1
Fordini	6	1	6	1	3	2	-
Pemphigini	20	11	17	6	6	1	-
Calaphidinae	2	2	2	1	-	1	-
Hormaphidinae	3	-	2	1	-	-	-
Total	76	33	70	27	32	13	1

Pak= Pakistan part of the NW Himalaya, Eastern= Eastern Himalaya, Central= Central Himalaya

the species in Aphidinae (Figs 8, 9, 11) and Calaphidinae are all cataplasmic in nature. Though some galls in subfamilies Eriosomatinae and Hormaphidinae are cataplasmic, yet majority of them are prosoplasmic (Figs 10, 12, 13). The galls are induced on different parts of leaves or stems. Even when on the same plant species several such galls are induced by different aphids, these may be distinguished from each other by the morphology and other biological characteristics of the galls. For example, as many as 12 different species of aphids induce galls on leaf base, petioles, lamina and stems of *Populus ciliata* (Figs 10, 12, 13) but these are distinctly different and the aphid species can be identified even in the field on the basis of gall morphology. Similar different types of galls are also induced on plant species in the genera like *Hydrangea*, *Prunus, Pistacea* and *Ulmus.*

Although the gall morphology of one aphid is specific, there are a few examples where a particular aphid may induce two different types of galls (dimorphic). *Prociphilus himalayensis* Chakrabarti induces ‘leaf-curl galls’ initially when leaves are very young and later it induces ‘leaf-fold galls’ when leaves are quite mature (Banerjee and Chakrabarti, 1993). Similarly, *Eumyzus prunicolus* Medda and Chakrabarti induces ‘leaf-curl galls’ initially and later a different type of ‘leaf-caterpillar’ galls ((Medda and Chakrabarti, 1986).

5.5 Aphids and plant association in the Himalaya

Aphids being obligatory phytophagous develop intimate relation with their host

Table 5. Host association of different genera of Eriosomatine aphids in the Himalaya.

Aphid tribe/ genera	Primary host plant	Secondary host plant
Fordini	-	-
Forda	*Pistacea* spp.	Poaceae
Geoica	*Pistacea* spp.	Poaceae
Baizongia	*Pistacea* spp	Poaceae
Pemphigini	-	-
Epipemphigus	*Populus* spp.	*Polygonaceae*
Pemphigus	*Populus* spp.	Different dicotyledons
Prociphilus	*Caprifoliaceae, Oleaceae*	Conifers
Thecabius	*Populus* spp	*Rananculus* spp., *Salix* spp.,
Eriosomatini	-	-
Eriosoma	*Ulmus* spp.	Pyroidea, Rosaceae Grossullariaceae
Kaltenbachiella	*Ulmus* spp.	Lamiaceae, Polygonaceae
Tetraneura	*Ulmus* spp	Poaceae

plants. They are good plant taxonomists (Eastop 1978) and can select specific host plant. Host association is correlated with their life cycle and cyclical parthenogenetic reproduction (Chakrabarti 2007). Many aphids alternate between woody primary and herbaceous secondary host plants improving the exploitation of favourable food resource in different seasons of the year. The ability to utilize two different plants thus plays an important role in selecting the fitness of a species (Mackenzie and Dixon 1991).

Only few studies on host specific aphid studies have been conducted in the Himalaya. Chakrabarti and Banerjee (1993) provided an account of host associations of heteroecious aphids in Northwest Himalaya. Host associations in gall aphids, particularly primary hosts association, are very specific and restricted. Host plant catalogues of Indian aphids are available (Raychaudhuri, 1983, Chakrabarti and Sarkar 2001). Chakrabarti (2007) has provided accounts of host association in gall inducing aphids in the Himalaya. Host associations with primary and secondary hosts in some genera of gall inducing eriosomatines aphids are provided in Table 5.

5.6 Life cycle of aphids

Host alternation is an ancestral feature in aphid biology with woody plant as primary host and herbaceous plants as secondary hosts. Aphids produce different morphs (polymorphism) on these plants. Evolution of different types of life cycles such as loss of host alternation, loss of primary host, loss of secondary host, suppression of some morphs including sexual cycles, acquisition of new host plants are endless complexities of variations (Moran, 1992; Wool, 2004; Chakrabarti, 2007). The type of life cycle is closely related to the behavoiur of that species whether it is either autoecious (non-host alternating) or heteroceous (host-alternating) and reproductive pattern i.e. parthenogenetic (anholocyclic) or cyclical parthenogenetic (holocyclic). When these two phenomena combine in the life of

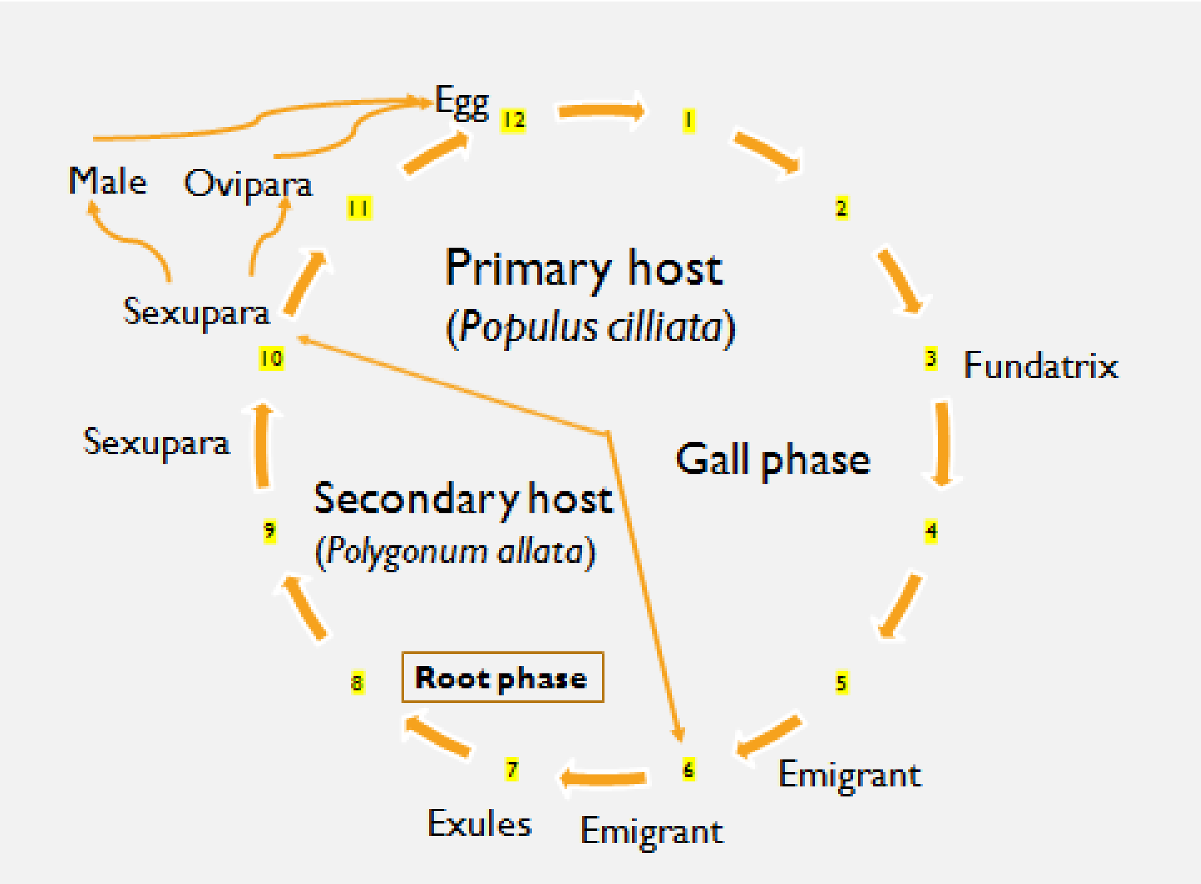


Fig. 14. Heteroecious holocyclic life cycle of *Epipemphigus imacus* (Chlod.) in Joshimath, Uttarakhand (Numbers in the figure designate months).

aphids, the biology and and life cycle become complex.

Very little work has been conducted on the biology and life cycle of aphids in the Himalaya. Studies on the biology and life cycle of *Brachycaudus helichrysi* (Kaltenbach), *Eriosoma lanigerum* (Hausmann) and *Myzus persicae* (Sulzer) in the Himalaya were conducted only on one host. So far, biology and life cycle of only two host alternating aphid species in the Himalaya, *Epipemphigus imaicus* (Cholod.) and *Prociphilus himalayensis* Chakrabarti were studied in Joshimath, Uttaranchal and their both hosts were confirmed through conducting host transfer experiments (Banerjee and Chakrabarti, 1993; Chakrabarti and Banerjee, 1993). The life cycle pattern of *E. imaicus* is presented in Fig. 14. Different modifications in the life cycle pattern, particularly in gall inducing aphids have been observed during field collections and detailed study on their biology may provide many more informations.

5.7. Parasitoids

Parasitoids of aphids are mainly belonging to hymenoptern families Braconidae and Aphelinidae. Rao (1969) made systematic bio-ecological studies on parasitoids during 1964 to 1969 primarily on five aphid species, *Acyrthosipon pisum* (Harris), *Aphis gossypii* Glover, *Brevicoryne brassicae* (Linn.), *Lipaphis erysimi* (Kaltenbach) and *Longiunguis* (=*Melanaphis*) *sacchari* (Zehntner). Besides recording several aphidiid parasitoids on the above aphids, he found 2 aphelinids. Bhagat (1980) gave an account of 53 species in 13 genera including 11 new species mainly from Kashmir in Northwest Himalaya. He further recorded 11 hyperparasitoids from these primary parasitoids. Stary and Ghosh (1983) provided accounts of 72 species in 25 genera of aphidiids from the India. Raychaudhuri (1990) gave a historical account of aphid parasitoid studies in India and mentioned about 122 species of aphidiid parasitoids in 20 genera from more than 100 aphid species occurring in India and has provided details of 87 species in 17 genera that occur in Northeast India. Das (1988) explored parasitoids of aphids in the Garhwal range of Northwest Himalaya, recorded 34 species in 14 genera including 10 new species and studied bio-ecology of 2 species, *Aphidius matricariae* Haliday and *Kashmria aphidis* Stary and Bhagat. Chakrabarti and Debnath (2009) mentioned about 114 aphidiid and 2 aphelinid parasitoids on about 175 aphid species in Northwest Himalaya and mentioned that 50 aphidiid parasitoids are endemic in the Himalaya. Das and Chakrabarti (2018) gave an account of bio-ecology of 11 species of hyperparasitoids in 8 genera of 5 hymenopteran families on aphid parasitoids from the Garhwal ranag of Northwest Himalaya.

5.8 Predators

Predators of aphids mainly belong to the order Coleoptera (Chysomelidae, Coccinelidae), Diptera (Syrphidae, Cecidomyiidae), Hemiptera (Anthocoreidae) and Neuroptera (Chrysopidae and Hemerobiidae). In addition, several spiders and few lepidipteran larvae ((Lycaenidae) are of minor importance. However, most of the works on aphid predators in the Himalaya are restricted to the exploration of different groups of predators and feeding potentialities of one or a few species of coccinellids, syrphyids and neuropterans. Debnath (1991) recorded 25 coccinellid, 8 anthocoreid, 10 chrysopid, 2 hemerobiid, 14 syrphyid, 1 chaemaemyiid and 14 spiders from Garhwal range of Northwest Himalaya and studied the bio-ecology of some of them. Chakrabarti et al (2012) provided accounts of 78 species of coccinellids, 13 species of syrphyids, 4 species of chysomelids and 2 species of lycaenids feeding on 122 aphid species in Eastern Himalaya and North-east India.

6. Conclusion

The Himalaya is a biodiversity hot spot, rich in various insect and plant species. Aphids here, represent about 16.5% of the world aphid fauna. Many areas and localities have not been explored yet. Further surveys will add many more species to the present data. The taxonomical history of Aphidoidea indicates that extensive works on the development of stable classification systems up to generic and specific levels are necessary at present. Analysis of data, enriched with more and more species would help to investigate the introduction, migration and establishment of new species, more and more precisely. This is true particularly for adventive species. Such surveys need an awareness of flora also, as lives of aphids depend on plant types. Studies on biology and life cycles of aphids are neglected fields. Elaborate knowledge on these fields at infraspecific level will throw light on many taxonomic problems of this polymorphic parthenogenetic species group. Since management of aphids using natural enemies is advocated throughout the world, serious attention should also be paid to the exploration and utilization of parasitoids and predators. Molecular taxonomy of aphids is another important field to be explored thoroughly. People need correct and immediate identification of pests as well as their natural enemies. Such informations as discussed above may strengthen the correct identification of an aphid species.

Acknowledgement

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John O. Westwood's Cabinet of Oriental Entomology (1848)

Anantanarayanan Raman

Abstract: The present article reminds us a mid-19th century volume written on Indian insects — the Cabinet of Oriental Entomology — by John Obadiah Westwood, a University of Oxford academic, in 1848. This less-than 100-page volume is more of an illustrative catalogue of different insects Westwood had received for examination and description from several of his friends residing in India and nearby islands, such as Ceylon (Sri Lanka) and those of Indonesia. This 88-page book includes 42 pages of superb hand-colour illustrations of insects and the plants they are associated with, most from the Indian subcontinent and a few from Indonesia and Ceylon (broadly East Indies), in addition to scientific descriptions of them. This work was one among the many steps on which later Indian entomological science trekked and flourished. The names of many insects referred in this book have been changed over time for specific reasons. Although the names of some of the insects and associated plants have been wrongly spelt, the *Cabinet of Oriental Entomology* includes valuable remarks on the biogeography and affinities of the referred insects, and also to what we refer today as 'biological diversity'.

Key words: Colour illustrations, 19th century, East Indies

Johann Gerhard König [JGK] (1728-1785) trained as a surgeon and disciple of Carl Linnaeus at the University of Uppsala (Sweden). JGK while serving with the Danish Mission at Ŧarangampãdi (11°1'N, 79°51'E) published the 'first' entomological scientific paper in India entitled the *Naturgeschichte der sogenannten weißen Ameise* (The natural history of the so-called white ants) in the natural-science journal *Beschäftigungen der Berlinischen Gesellschaft Naturforschender Freunde*, Berlin, in 1779. Dru Drury, a British merchant, an insect enthusiast, and a friend of the Danish entomologist Johann Christian Fabricius, published a 3-volume book in 1773, in which he refers to insects collected in Bengal and Madras regions of India (Drury, 1773). The Drury volumes include delightful illustrations, but the text used in it follows an obscure description style, based on dimensions. Six decades later, John Obadiah Westwood (JOW), entomologist and palaeographer attached to the University of Oxford, edited and republished the Drury volumes by revising notations and including valid binomials, in 1837.

From the second half of the 19th century, the biology of the Indian subcontinent attracted many European amateur and professional natural historians. Notable among them was Joseph Dalton Hooker — better remembered as a botanist — who came to India and trekked the Himalaya accompanied by a large troupe of assistants, documented the botany, zoology including entomology, geology, and anthropology of sections of the Himalaya (Hooker, 1854).

Many European natural historians never travelled to India but received specimens and illustrated them with notes. Edward Donovan and Dru Drury would be good examples, who documented and made illustrations of insects of the Indian subcontinent by obtaining specimens from European museums and Europeans residing in India. Charles Kerremans, a Belgian, published a work on the Buprestidae of India in the later decades of the 19th century (Kerremans, 1892). In my previous article (Raman 2016), I have listed several such European amateur and professional entomologists, who studied Indian insects in the 19th and early decades of the 20th centuries.

In the present article, I will talk about a mid-19th century volume on Indian insects, the *Cabinet of Oriental Entomology* (Figure 1) by JOW and published by William Smith, London, in 1848. This 88-page volume is an illustrative catalogue of different insects JOW received for examination and description from India and nearby islands, broadly referred then as the East Indies. Before we go into the details of this slim book, a short biography of JOW would be in order.

John O. Westwood

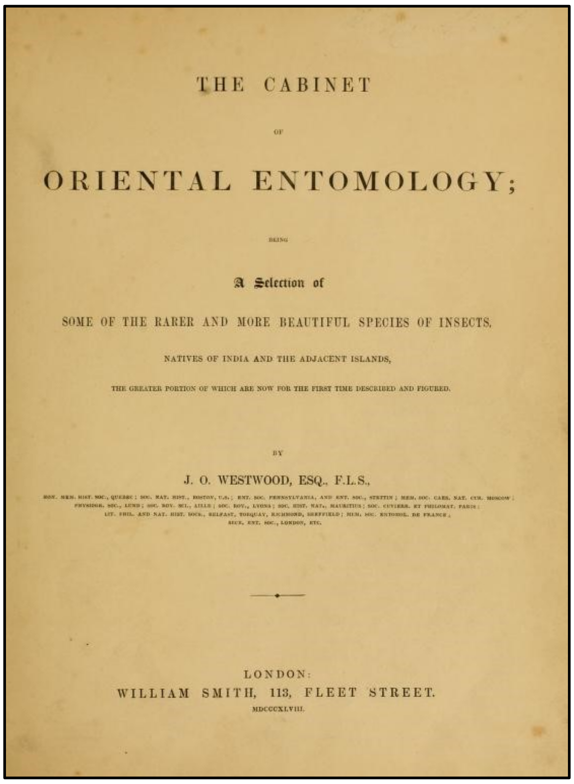
JOW (22 December 1805-2 January 1893) further to being an expert entomologist and a palaeographer, professed extraordinary artistic talents. He added to entomological knowledge by providing enchanting illustrations of insects. He was a professor at the University of Oxford (Figures 2, 3). He strongly supported the Creation theory. He supported William Macleay's quinarian perspective of animal and insect evolution (Westwood, 1839–1840). Although JOW had never travelled extensively, insect specimens — especially the larger, curious, and colourful species — came to him in London, sent by travelling European naturalists and collectors from all over the world. For an extensive note on JOW's life, please read a note on JOW by Bernhard Wandolleck (1864–1930) in 1893, a dipterist attached to the Royal Museum of Zoology, Anthropology, and Ethnography, Dresden (today, Museum für Völkerkunde Dresden).

JOW worked mostly on the taxonomy of the Hymenoptera yet maintaining an interest in general entomology. The following list of his books indicates his passion in general *Entomology: The Entomologist's Textbook* (1838), *An Introduction to the Modern Classification of Insects* (1839–1840), and *Arcana Entomologica* (1845). He was a work associate and a close friend of Frederick William Hope (1797–1862), and in that context of professional camaraderie, JOW published the *Thesaurus Entomologicus Oxoniensis* (1874).

The Cabinet of Oriental Entomology

In the preface (p. 1–2), dated 1 January 1847, JOW indicates:

"The object of the Work now offered to the notice of the Entomologist and lover of Nature in general is to present a Series of Figures of some of the rarer and more splendid species of Insects which have within these few last years been forwarded to England, from the various districts of India and adjacent islands. ... The present work, however, is proposed to be rather a pictorial


THE CABINET

OF

ORIENTAL ENTOMOLOGY;

BEING

A Selection of

SOME OF THE RARER AND MORE BEAUTIFUL SPECIES OF INSECTS,

NATIVES OF INDIA AND THE ADJACENT ISLANDS,

THE GREATER PORTION OF WHICH ARE NOW FOR THE FIRST TIME DESCRIBED AND FIGURED.

BY

J. O. WESTWOOD, ESQ., F.L.S.,

LONDON:
WILLIAM SMITH, 113, FLEET STREET.
MDCCCXLVIII.

Fig. 1. Cover page of the Cabinet of Oriental Entomology by John Westwood (1848).

illustration of the larger and more splendid species; and, as such, it is hoped, that, by finding its way to the table of an Indian drawing-room, it may gain more converts to the study of a science full of curiosity, and awaken an interest in the objects of pursuit, thus supplying an engaging occupation to our Indian friends."

Fig. 2. JOW in his 40s (Source: http://www.stsepulchres.org.uk/burials/westwood_ john.html. Fig. 3. JOW in later years (Source: https://artuk.org/discover/artworks/ professor- john-obadiah-westwood-142122/search/keyword:westwood).

He acknowledges the support he got from a few of the British residents in India, who supplied him specimens of insects from India. Colonel John Bennett Hearsey (1793-1865) and Major Robert Jenkins (1828-1857) of the Bengal Army, John Forbes Royle (1798-1858), Superintendent of the Saharanpur Botanical Garden, and William Henry Benson, a Bengal Presidency civil servant, Calcutta, who was also an amateur

Table 1. Numbers of species described and illustrated

Coleoptera	—	72
Orthoptera	—	25
Neuroptera	—	10
Lepidoptera	—	58
Homoptera	—	10
Diptera	—	5

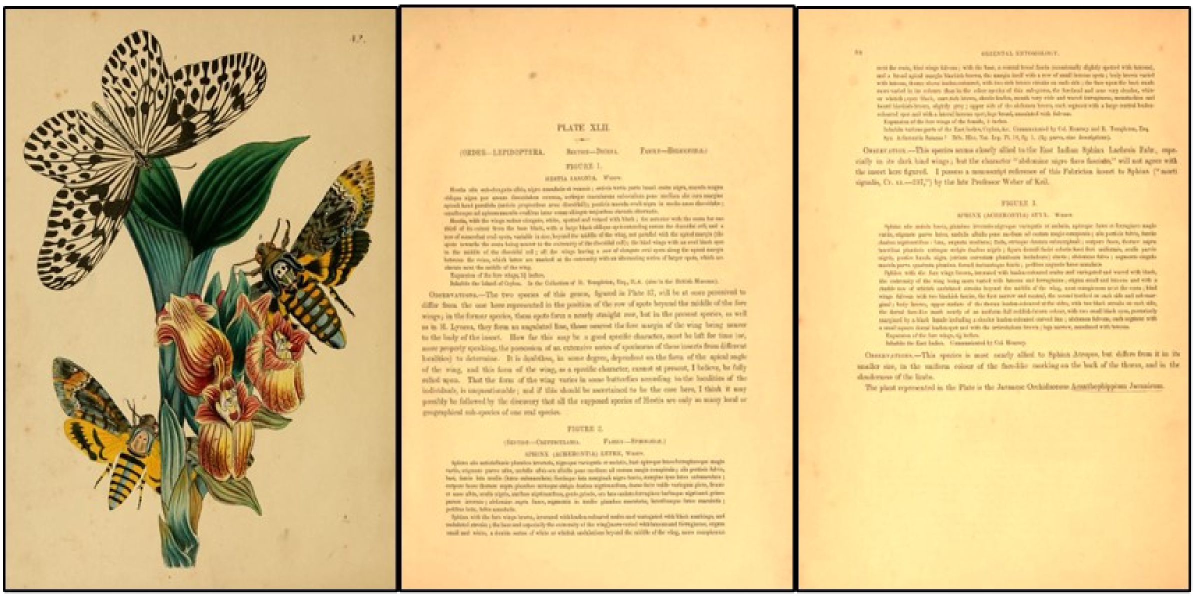


Fig. 4. Illustration (and notes), Plate II. *Papilio icarius* (Lepiodptera: Lycaenidae) on *Dendrobium moniliforme* (Orchidaceae).

Malacologist are the names that could be identified. He thanks Captains Boys, Hutton, and Robinson, possibly of the Bengal Army, and two more, Templeton and Downes, who could not be determined as to their affiliations.

This book includes 42 pages of colour illustrations of 180 species of insects, obtained mostly from the Indian subcontinent and a few from Indonesia and Ceylon supplemented by short descriptions (Table 1).

The section ‘Description’ also includes ‘Observations’, a highly useful section referring to the biogeography of that particular species and relationships with allied insects and groups. The illustrations, made by JOW are precise and brilliantly hand-coloured, worthy of being collectors’ items. Without re-describing the details supplied by JOW, in this article, I have included two sets of pages of illustrations and descriptions of Plates II and LXII, thus leaving the reader to infer the quality of supplied information. The

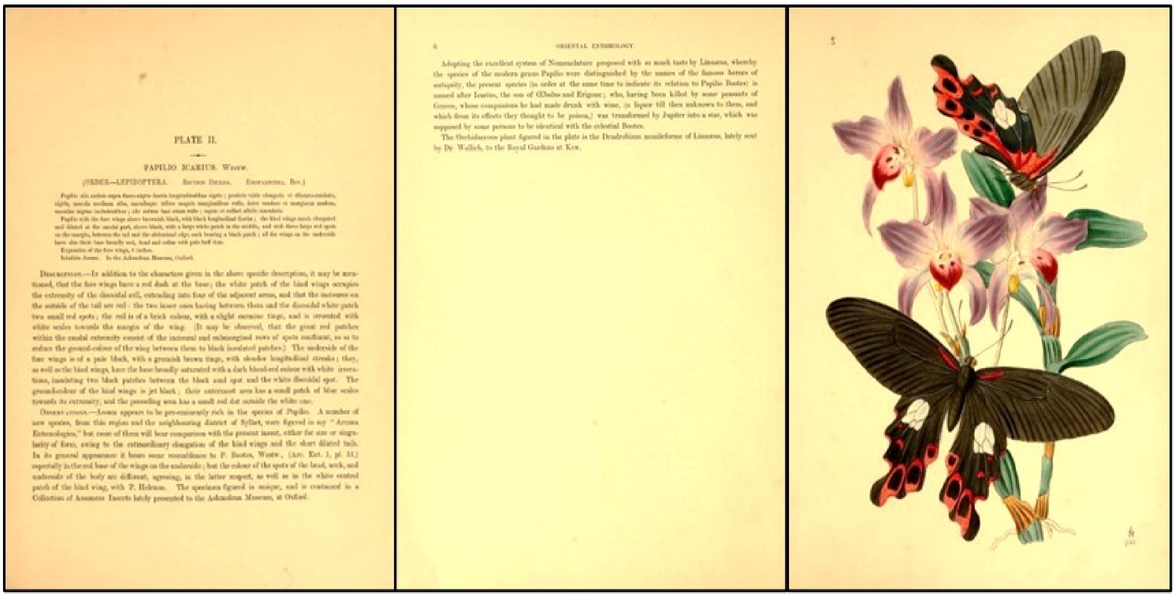


Fig. 5. Illustration (and notes), Plate LXII. *Idea iasonia*, *Euchromia lethe*, and *Acherontia styx* associated with *Acanthephippium javanicum* (Orchidaceae).

Plate II (Figure 4) refers to *Papilio icarius* (presently *P. icarus*) (Lepidoptera: Lycaenidae) shown hovering on an impressively sketched *Dendrobium moniliforme* (Orchidaceae). The Plate LXII (Fig. 5), on the contrary, refers to three Lepidoptera, *Hestia iasonia* (presently *Idea iasonia*) (Nymphalidae), *Sphinx (Acherontia) lethe* (presently *Euchromia lethe*) (Erebidae), and *Sphinx styx* (presently *Acherontia styx*) (Sphingidae) shown associated with *Acanthophippium javanicum* (=*Acanthephippium javanicum*) (Orchidaceae). The Plate LXII (Fig. 5) refers to the species JOW got from Indonesia and Ceylon (Sri Lanka).

Conclusion

The present article is a pointer to infer Indian entomology in the 19th century. Done by a British entomologist, this work, further to similar others made by foreign entomologists and natural historians, indeed paved the way for Indian entomological science to prosper. Of course, names of many insects have changed over time for obvious reasons. Names of some of insects and associated plants have been wrongly spelt in JOW's *Cabinet of Oriental Entomology*. Notwithstanding such omissions and errors, this book notably sheds light on the biogeography and affinities, further to and importantly to what we refer today as 'biological diversity'.

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"BIOLOGICAL CONTROL IS THE MOTHER OF ALL PLANT PROTECTION MEASURES"

Tête-à-tête with Dr. T. M. MANJUNATH

INDIAN ENTOMOLOGIST TOOK PRIVILEGE IN INTERVIEWING SUCH AN ILLUSTRIOUS ENTOMOLOGIST AND A BIOCONTROL PIONEER WHO IS HAILED AS THE 'FATHER OF COMMERCIAL BIOCONTROL AND IPM IN INDIA'

Dr. T. M. Manjunath is an illustrious Agricultural Entomologist with over five decades of research and executive experience, both in the public sector as well as in national and multi-national private organizations. Born on 11th June 1939 and brought up in Bengaluru, he was a student of Central College and obtained his B.Sc. degree from Mysore University in 1961. He started his career also in 1961 and later, while being in service, he opted for Agricultural sciences and obtained his M.Sc. degree in Agricultural Entomology from the Anand Campus of Gujarat Agricultural University and Ph.D. degree, also in Agricultural Entomology, from the G.K.V.K. campus of University of Agricultural Sciences, Bengaluru. During his long career, he served in four reputed organizations and had a diverse work culture, but he adjusted to it admirably, added his own and distinguished himself.

In the early part of his career at Commonwealth Institute of Biological Control (CIBC) and subsequently at University of Agricultural Sciences (UAS) - Bangalore at its Regional Research Station, Mandya, Dr. Manjunath worked extensively on biological control of a variety of crop pests that included those of rice, sugarcane, cotton, maize, coconut, vegetable and fruit crops, weeds, etc. from different parts of India. He discovered and studied a large number of parasitoids and predators, over a hundred being new records, and contributed to laying a strong foundation for biological control and IPM. He is one of the pioneers in biological control in India. Subsequently, he worked on biopesticides, pheromones, integrated pest management (IPM), insect resistant transgenic *Bt*-cotton and other related areas. He initiated work in these areas at a time when these were barely explored, relentlessly tried to popularize them and made several pioneering contributions.

In 1981, Dr. Manjunath took a bold step. He resigned his job at the Agricultural

University and established 'Bio-Control Research Laboratories' (BCRL) of Pest Control India Ltd. at Bengaluru which is India's first-ever commercial insectary dedicated to mass-production and supply of biological control agents and pheromones. He developed innovative mass-production, packing, pricing, marketing and application techniques for several promising biocontrol agents which included *Trichogramma, Bracon, Goniozus, Spalangia, Chrysoperla, Cryptolaemus, Chilocorus, Nephus* and Nuclear Polyhedrosis Viruses (NPVs). A semi-automatic *Corcyra* production technology developed by him turned out to be a game changer in mass-production. He designed a new Pheromone Funnel Trap which became quite popular. He has put in enormous efforts to popularize these products among farmers. Never before these were produced, marketed and adopted on such a large scale throughout India and it created a huge demand which paved the way for emergence of a new biopesticide industry, starting from the mid-1980s. In recognition of his pioneering contribution, the biopesticide industry has hailed Dr Manjunath as the 'Father of Commercial Biocontrol and IPM in India'.

Another significant contribution that came from Dr. Manjunath was when he served as one of the key members of the Monsanto-Mahyco team that was responsible for regulatory approval of *Bt*-cotton in India in 2002. *Bt*-cotton is the first-ever GM crop cultivated in India and he is one of those who strived for its scientific outreach and successful adoption, It was a breakthrough in cotton bollworm management and a turning point in Agricultural biotechnology.

He is an author of over 130 research papers and six books. He has delivered innumerable lectures, including many keynote addresses, at national and international symposia as well as at schools, colleges and farmers fora in India and other countries. Throughout his career, Dr. Manjunath has maintained close contacts with academic institutions, research organizations, private sectors, farmers and other stakeholders. He continues to do so even now.

Dr. Manjunath has served and continues to serve in several Expert Committees constituted by FAO (*Food & Agriculture Organization*), WHO (*World Health Organization*), ICAR (Indian Council of Agricultural Research), DBT (Dept. of Bio-Technology), Govt. of Karnataka, various universities and other organizations, focusing on issues related to policies and research. His expertise was also utilized in China, Nepal, Portugal, Sri Lanka and other countries for developing their technical programs on biological control and IPM. He recently (2019/20) set up a biological control laboratory for United Phosphorus Ltd. (UPL) at their premises at Vapi in Gujarat (India).

Dr. Manjunath has received several awards/honours in recognition of his 'Commendable Lifetime Contribution to Biological Control and IPM'. These were received from: Plant Protection Association of India (1994); Institution of Agricultural Technologists & UAS-Bengaluru (1995); National Academy of Agricultural Sciences & Indian Agricultural Research Institute (2015); Society for Biocontrol Advancement (2017); World Bio Protection Forum (2019); T.B. Fletcher Award from Dr. B. Vasantharaj David Foundation (2020); 'Outstanding Alumni Award' from the Alumni Associations of UAS-Bangalore (2015), Gujarat Agricultural University

(2018) and Mysore University (2020). He has also received 'Manager of the Year' award in 1990 and 'Excellent Performance Award in Research and Business' in 1993 from Pest Control (India) Ltd. for the services rendered at BCRL. In 2002, he received 'Special Recognition' from the CEO, Monsanto Company, USA, for his contribution towards successful Introduction and Stewardship of *Bt*-cotton in India as one of the key members of the team.

He is a Fellow of the Entomological Society of India, a Fellow of Plant Protection Association of India, a founding member and past president of Entomology Academy of India, a founding member of Society for Biocontrol Advancement, and a founding life member/past officer bearer of several other professional societies. Throughout his career, Dr. Manjunath has shown an unusual zeal to venture into novel or under-explored areas of pest management that have greater practical relevance and championed the cause of integrated pest management. His colleagues and friends consider him as an exemplary combination of scientist & administrator, an unforgettable motivator and a guide, a perfectionist, and an outstanding communicator who can adapt and reach out to audiences at any level. At 82, Dr. Manjunath continues to be as committed and active as ever, He says "I am retired, but not tired."

Dr. Kolla Sreedevi, Associate Editor of IE, interacted with Dr. T. M. Manjunath and the excerpts of the discourse are presented below. Some of his 'Words of Wisdom' are highlighted in italics and blue.

Dr. K. Sreedevi (KS): You started your career in biological control way back in 1961. What was its status then?

Dr. T. M. Manjunath (TMM): I started my career at the Indian Station of Commonwealth Institute of Biological Control (CIBC), one of the major units of Commonwealth Agricultural Bureau (CAB, London), in 1961. Its Indian headquarters was located at Bengaluru (then Bangalore) in the same premises as that of the present NBAIR and its functional research stations were spread across the country depending upon the crops/research projects. Biological control was barely known at that time. In the

1960s, Govt. of India was aggressively promoting family planning and it was a buzzword then. Looking at the sign board displayed on the compound facing the main road (Bellary Road), most people used to mistake it as 'Commonwealth Institute of *Birth* Control.' Some others thought that it is an institute meant to deal with *wealth* related to *common* financial issues (common wealth).

KS: What did you work on in the initial years of your career?

TMM: Since biological control of crop pests and weeds was almost an unexplored area, CIBC submitted several interesting projects on major crops and was able to get funds mostly from the US PL-480 scheme. Those projects included exploratory surveys for natural enemies, studying their bio-ecology, evaluation of their efficacy, developing techniques for culturing them and several other aspects related to biological control. I had the opportunity to work, often concurrently, on several such projects from different parts of India (Bengaluru, Guwahati, Shillong, Jorhat, Bhubaneshwar, Dehra Dun, Anand, Andaman, Lakshadweep, etc.) dealing with pests of rice, sugarcane, cotton, maize, coconut, vegetable crops, tea, forest trees and other crops as well as aquatic and terrestrial weeds.

KS: Was it not very demanding to work on several projects at the same time? What was your experience?

TMM: In CIBC, the work culture was different. Since we were dealing with live insect cultures, officially the working days included all the seven days in a week, with Saturday, Sunday and all general holidays being half-day. We used to spend more than half-a-day almost daily in fields, making large collections of insect pests for discovering and studying their natural enemies. A wealth of information on several crops/pests came out from such pioneering efforts from different parts of India and CIBC established a distinct niche for itself not only in India but also it put India on the global map of biological control. Thus, CIBC laid a strong systematic foundation for biological control in India. Indian Council of Agricultural Research (ICAR), Indian Agricultural Research Institute (IARI), Directorate of Plant Protection, Quarantine and Storage (DPPQ&S), Agricultural Universities, etc. further strengthened biological control. I was fortunate to have been associated with this technology right from such an early phase and exposed to its various facets which gave me an opportunity to learn and contribute to its growth. I thoroughly enjoyed my work. Even now, after nearly 60 years, biological control continues to be my first love.

KS: In your view, what are the most significant aspects of biological control?

TMM: I strongly hold the view that *biological control is the 'Mother of all Plant Protection Measures'* considering that more than 95% of herbivores are kept under perpetual check by the action of their natural enemies. Such silent contribution is seldom realized and appreciated. It is only when certain insects escape the impact of such natural control due to various factors, they become major pests and attract our attention. Then we intervene and try to restore the balance in favour of natural enemies by conservation, augmentation or introduction, or by taking any other control measures. Another significant aspect of biological control is the outstanding successes obtained with the control of several notorious pests and weeds through classical biological control. It may be rare, but when successful, it is highly sustainable and incomparable.

KS: What made you to leave CIBC and how did your career progress further?

TMM: Most of us had to leave CIBC as, with the closure of PL-480 and other projects, it was facing an uncertain future. At that time, I joined University of Agricultural Sciences, Bangalore, in 1976 and was posted at its Regional Research Station (RRS) at V.C. Farm, Mandya, to work on All India Coordinated Research Project on Rice under ICAR. Besides working on the prescribed experiments which included screening of rice cultivars and insecticides under this scheme, I also worked on sugarcane, ragi (pearl millet), coconut, etc. In fact, I established a laboratory at RRS for production of parasitoids for control of coconut black-headed caterpillar which had become a serious pest in several parts of Karnataka. I was quite happy working in the university and enjoyed the campus life.

T. M. Manjunath at the CIBC lab, 1963

KS: You were the first one to establish a commercial biocontrol insectary in India. How did it happen?

TMM: While I was working in the university, Pest Control (India) Limited approached me repeatedly to join them and establish a commercial biocontrol unit. Initially I was hesitant, but finally accepted the offer, resigned my job at the UAS-B, and established 'Bio-Control Research Laboratories' (BCRL) at Bangalore in 1981 which is India's first ever commercial insectary dedicated to commercial production and supply of selected biological control agents.

KS: What were the challenges faced in managing a commercial insectary?

TMM: First of all, I had to start everything from the scratch! Production, packaging, pricing, dosage, brand names, marketing – everything was a new experience. For the *Trichogramma* cards produced at BCRL, I gave the brand name 'Tricho Card' which is now used by most people as a common name! *I would rate mass-production and marketing as the toughest challenges in biocontrol.*

KS: What were the problems encountered in mass-production?

TMM: Mass production of the required quantities of parasitoids and predators, their timely supplies and releases are very challenging and filled with tension. Generally, when the lab production is at its peak, there is no adequate demand and when there is high demand, the production declines. *It is a huge challenge to match the production and demand.*

The paradox is that the pest insects, be it *Helicoverpa,* pink bollworm, *Spodoptera,* mealybugs, scale insects or any other, which multiply so rapidly in fields and cause serious crop losses in spite of our taking various control measures, refuse to multiply similarly in the laboratories even if we provide and pamper them with all the comforts and nutritious diets. In a biocontrol insectary, 80-90% of our efforts go towards mass production of host insects (i.e., pests) rather than parasitoids or predators. Another frustrating experience is related to *Corcyra*. While we are mass producing *Corcyra* to be used as a factitious host and when the production is at its peak, its larval parasitoid, *Bracon hebetor,* somehow manages to enter the culture rooms and bring about its complete control in 3 to 4 weeks, thereby upsetting all the production plans. This is an embarrassing example of a successful biological control taking place at a wrong place! This also shows that insects have their own mind and are adamant. *Insects multiply only where they want to multiply and when they want to multiply, not where and when we want them to! It is a huge challenge to alter it.* Thus, commercial production is beset with numerous challenges which have to be managed with preparedness. I was able to manage and make BCRL a commercially viable unit for 16 years from 1981 to 1997 with only a minimum, but highly committed staff. *Skilled workers are the backbone of a commercial insectary.* Besides parasitoids and predators, we were also producing NPVs as well as pheromone traps and lures. These not only supplemented business, but also helped in promoting integrated pest management**.** *I have experienced the stress and success, or the tensions and thrills of commercial production.*

KS: Was not marketing these products a big challenge?

TMM: Marketing was/is truly challenging, especially at a time when the plant protection domain was/is dominated by chemical pesticides. Further, since parasitoids and predators are live insects with definite life cycles and shelf-life, these cannot be mass-produced in advance and stored for a long time, It is safer to produce these against confirmed advance orders. In other words, *the products are to be sold even before they are produced!* It is easier said than done. Sudden cancellation of confirmed orders would be a bane, resulting in financial loss as well as precious biocontrol agents. Another challenge is to make the farmers understand the value of each biocontrol agent and how it works. Thus**,** *the products are to be sold along with the technology.* This calls for great communication skills. Nevertheless, following our untiring efforts, many progressive farmers from all over India became our customers, especially sugarcane, grape, cotton and coconut growers. I used to meet and interact with them personally to explain and convince them. Creating awareness and on-farm demonstrations are the key drivers.

A major turning point came when the Directorate of PPQ&S, Govt. of India, gave funds to various state governments to purchase biocontrol agents and pheromones and provide these to farmers at a highly subsidized rate for direct field applications in an attempt to promote IPM. This created a huge demand and assured market. Initially, BCRL was the only dependable supplier, but gradually it paved the way for emergence of a new biopesticide industry. Never before these were produced, marketed and adopted on such a large scale in India. BCRL played a pioneering and crucial role in this endeavour.

KS: Recently, the biopesticide industry hailed you as the 'Father of Commercial

Biocontrol and IPM in India.' How did you feel about it?

TMM: It is most gratifying and I am very thankful to them. A few of the youngsters who came in contact with me in the mid-1980, forayed into biopesticides and pheromones, being inspired by BCRL. They are now major players in the industry and doing very well. I admire their commitment and perseverance. I wish someone takes up the production of macrobials as well.

"Mass-production and marketing are the toughest challenges in biocontrol"

KS: Why there are not many commercial producers of macrobial biocontrol agents?

TMM: As explained, it is a very tough job filled with tension at every stage and unless one has a passion for it, it may not be attractive. *Commercial biocontrol insectary should be treated as a passionate scientific adventure rather than a mere business venture.* After nurturing for 16 years, I left BCRL in 1998 to move on with my career, but was thoroughly disappointed that the production of parasitoids and predators was discontinued there after a year or so.

KS: What prompted you to leave BCRL later?

TMM; Monsanto, the USA-based largest agricultural biotechnology company, wanted to establish a research centre in India at Bengaluru. It was a big news, especially as they wanted to initiate research on agricultural biotechnology including *Bt*-cotton. One day, most unexpectedly, they approached me to join them. My immediate response was 'no' as I was emotionally attached with BCRL. But they persisted and came up with a very attractive offer which I finally accepted. I joined Monsanto in 1998 and was involved in establishing their Monsanto Research Centre at Bengaluru. It gave me an opportunity to work on agricultural biotechnology in general and *Bt* cotton in particular. It was another new opportunity for me to learn and contribute.

KS: The introduction of Bt cotton met with a lot of opposition. What are your views on such opposition and the technology itself?

TMM: History has shown that whenever any new technology or product is introduced, be it Bt- cotton or any other, it always faced opposition by a section of the people. They are specialized in criticizing and protesting. However, Bt-cotton has proved beyond doubt that this technology is safe, effective against bollworm control and advantageous to farmers. The fact that presently more than 95% of the total cotton area in India is occupied by Bt cotton, being cultivated by over seven million farmers, is a testimony to its merit. It gave us a lot of satisfaction.

KS: Do you think biotechnology has a major role to play in agriculture and in what way it can benefit biological control?

TMM: Yes, *biotechnology has the potential to find solutions to several biotic and abiotic stresses* which might be beyond the reach of other technologies. It does not mean that it is a silver bullet for all problems. We need to exploit other options as well.

Transgenic *Bt*-cotton technology has already proved that it can very effectively control cotton bollworms and drastically bring down the application of chemical insecticides

"There should be two levels of research goals: long term goals for the institutions while short term goals for individuals"

thereby help conserve natural enemies. This technology is compatible with all other plant protection measures and can serve as a major component of IPM. *Biotechnology can also be exploited to enhance the quality traits of biological control agents.*

KS: You are one of those who, along with biological control, championed the cause of Integrated Pest Management (IPM) right from the 1960s and 1970s. What are your views on IPM?

TMM: IPM is the most sensible and practical approach. We must realize that every technology was relevant to that particular period and had its own impact. No technology should be over-used or abused. *No matter how powerful a technology is, it cannot solve all the problems and also it cannot last forever.* The problems do not remain the same and, therefore, research is a dynamic area. Every technology, be it traditional or modern, has its own merit as well as limitations and we should try to exploit it depending upon its suitability to a given situation. The most prudent approach is to take advantage of each technology wherever suitable and integrate it with other technologies so as to solve a problem and get maximum benefit. This is the broad philosophy of IPM. I have always emphasized that *Integrated Pest Management is nothing but 'Intelligent Pest Management',* the acronym (i.e., IPM) remaining the same.

IPM is not biased towards any particular technology. On the other hand, it is all inclusive, be it cultural, mechanical, biological, chemical, GM technology or whatever.

KS: There are certain lobbies which are strongly opposed to the use of chemicals, genetic modification technologies, etc. What is view on this?

TMM: There is no need for us to worship or decry a technology just because it is traditional or just because it is modern. Our choice should be based on its suitability to a given situation. Those who believe in any particular approach, may follow it if it is beneficial them. But, there is no need to form a separate lobby for chemicals, biologicals, GMOs, organics, etc. and condemn or boycott other technologies. It would tantamount to creating a 'caste system' in science. *There is scope for 'secularism' or 'co-existence of all technologies' in science also* as recommended in IPM, with major focus being on environmental safety.

KS: You have worked both in the public as well as private sectors. May we know the major difference between the two?

TMM: They are entirely different and both are important. The public research institutions mostly concentrate on basic research and try to publish their findings as early as possible. It is more of academic and publication-oriented. On the other hand, in private sector, the research is more 'product-oriented' and their emphasis is on patenting, production, practicality and business rather than on publishing. If there is mutual understanding and cooperation between the two sectors leading to Public Private Partnership, it would be a win-win situation for both.

KS: Your suggestions for the younger genearation and future research?

TMM: There seems to be a lot of duplication of research programs in various public institutions. This can be avoided. I feel that *there should be two levels of research goals: long term goals for the institutions while short term goals for individuals*. Long term goals should tackle more difficult problems which may take several years to accomplish. It should be a team effort and ensure continuity of work even if certain members of the team move out. Another suggestion is that the *scientists of younger generation, who are no doubt very talented, should be challenged to come out of the 'comfort zone'* and try to do research on seemingly difficult areas so as to exploit their full potential. It will be more useful if they concentrate on research that has more practical relevance. It should be realized that however strong a lock may be, it has to have a key to be useful! Similarly, however tough a challenge may be, the skill lies in finding a solution with commitment and perseverance.

KS: Can we get an insight into your other activities beyond research and the most favourite activity/stress busters?

TMM: I am deeply interested and involved in social, educational and cultural activities. I have been a member and a Melvin Jones Fellow (MJF) of Lions Clubs International since 1981 and participating in various community service activities. I am one of the donors and the Managing Trustee of 'Krishi Vidya Nirantara' (KVN), an educational trust that provides financial assistance to deserving students of agriculture. I am the Chief Patron of 'Drishti Art Centre' at Bengaluru which is dedicated to promote Bharatanatyam and other classical arts. Besides, I have always been interested in theatre. I have acted in more than 50 dramas and authored myself four Kannada plays. I love watching cricket matches, films and a few selected TV programs. I watch almost daily for about 30 mts. videos of songs from Hindi, Kannada, Tamil or Telugu movies before going to bed. In other words, I am interested in almost everything!

KS: Before we wrap up, please tell us what were the most exciting or satisfying parts of your career?

TMM: One of the most exciting parts was that I had an opportunity to work on biological control, biopesticides, pheromones, integrated pest management, insect resistant transgenic *Bt* cotton, etc. when these areas were barely explored and that I was able to learn and make some significant contributions during their growth phase, leading to increased adoption. In fact, I have grown along with these technologies. Another satisfying aspect was that whether it was PCI or Monsanto, I did not apply for a job. They approached and offered me the coveted jobs on their own which I consider as a great recognition. Similarly, I received several lifetime achievement awards. I did not apply for any of them. It gives me a great deal of satisfaction. Yet another satisfying aspect was that wherever I worked, be it CIBC, UAS-B, BCRL or Monsanto, I was very well looked after and I thoroughly enjoyed my work. Above all, I was truly blessed to have started my career at CIBC under such an inspiring and a stalwart like Dr. V. P. Rao whom I consider as my role model followed by Dr. T. Sankaran. Similarly, Mr. N. S. Rao and later Mr. Anil S. Rao of PCI were very understanding and encouraging for starting and managing BCRL. I had wonderful colleagues in all the organizations who have become lifelong friends. We continue to be in touch even now. There has not been a single day, while in service or later, when I felt bored or tired of working. I am as enthusiastic as ever. As I generally say "I am retired, but not tired."

Concluding remarks by KS:

It was a sheer delight and privilege interviewing a legend like Dr. T. M. Manjunath. It was an enriching experience listening to his rich and decades of varied experiences interspersed with interesting anecdotes. There are several 'Quotable Quotes' or 'Words of Wisdom' expressed by him on biological control, commercial insectary, mass-production and marketing, integrated pest management, biotechnology and *Bt*-cotton, institutional and individual goals, need to come out of comfort zone, secularism in science and various other aspects related to plant protection as well as his multifaceted interests beyond science. One can learn a lot from these. For me, it is a memorable experience which I am going to cherish for a long time.

The interview is conducted by Dr. Kolla Sreedevi. She is working as Pr. Scientist at Division of Germplasm Collection and Characterisation, ICAR- NBAIR, Bengaluru. She is working in the field of Insect Biodiversity and Systematics especially Scarabaeidae and Cerambycidae (Coleoptera); Insect Ecology, biogeography, molecular characterization. She is also an Associate Editor of IE.
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Biological control: Success story of managing invasive Rugose Spiraling Whitefly in Kadiyam nurseries of Andhra Pradesh, India

N. B. V. Chalapathi Rao, B. S. Ramani and B. V. K. Bhagavan

The increasing demand to gain more production by adopting new technologies and changing agricultural practices results in new hazards to environmental health that are readily able to cross borders. This free trade and movement of plant materials across political and geographical borders has led to the introduction of certain plant, insect and pathogen species to new localities. These species are causing enormous damage to biodiversity and the valuable natural agricultural systems upon which human kind depends. The direct and indirect health effects are increasingly becoming serious and the damage to nature and environment is often irreversible. The effects are often exacerbated by global change and chemical and physical disturbance to species and ecosystems.

Recently, Rugose Spiraling Whitefly (RSW), *Aleurodicus rugioperculatus* Martin (Hemiptera: Sternorrhyncha: Aleyrodidae) entered India infesting coconut plantations across Kerala, Tamil Nadu, Karnataka and Andhra Pradesh. Presently, infestation of RSW increased over the time and spread across the southern states and even spread too far-off states like Assam, Gujarat and extending its host ranges at greater level which could be due to its polyphagous nature (Fig. 1).

Immature stages of RSW produce profuse quantity of wax filaments. Furthermore, RSW produce honey dew which results in development of sooty mould. The severity of infestation ranged between 40-60 % in coconut and 25-40 % in banana (Selvaraj *et al.,* 2016). Rugose spiralling whitefly was initially reported from Miami-Dade County, Florida, United States of America from gumbo limbo, *Burera simaruba* (L.) as a pest. However, it was originally described from Belize in 2004 on coconut (Martin, 2004) where its natural population was reported. This whitefly is believed to have originated from Central America and distribution of this pest in Central and North America is limited to Belize, Mexico, Guatemala and the United States (Evans, 2008). In the continental United States, the first established population of RSW was reported from Florida in 2009, and since then its distribution range has expanded considerably within the state and subsequently, it has spread to 22 other countries in Central and South America, including Florida, USA. India is the only country in the Oriental region where the whitefly has been introduced. Initially, this whitefly was observed in several coconut farms in the Pollachi area of Coimbatore district, Tamil Nadu and first

Fig. 1. Eggs, Nymph and Adult RSW.

reported in Kottayam from Kerala during July – August 2016 (Sundararaj and Selvaraj, 2017). The pest has also been recorded at Kadiyam nurseries in Coastal Andhra Pradesh during October-November, 2016. The possible entry to Andhra Pradesh may be by coconut seedlings obtained from nurseries in Tamil Nadu and Kerala.

Kadiyam nurseries located in the coastal Andhra Pradesh in East Godavari district is credited with more than 100 years of antiquity. The nursery sector comprising 1555 hectares of land with about 1500 floriculture nurseries with an annual turnover of more than 200 crores has earned a brand value of floriculture nursery industry in Andhra Pradesh. Kadiyam nurseries are a combination of small, medium and large nurseries comprising of wide variety of indoor plants, outdoor plants, seasonal plants, ornamentals plants, medicinal plants, fruit crops, apart from the production of plants congenial to local situation, they also import plants from different parts of India and on the other side, the nursery owners also export the plants to different parts of the world like Singapore, Malaysia, China, Thailand, Arabian and European countries. Growth and development of Kadiyam as a cluster of floriculture nurseries is not an individual effort, but it is an effort of all the stake holders involved in its bloom, primarily the floriculture nursery owners at Kadiyam (Uday Bhaskar *et al*., 2020). The latest bottle neck in the form of RSW compounded the existing hurdles like operating as an unorganized sector, lack of control over the transactions, organizational disparities among the nurseries.

Host range of Rugose spiraling white fly

Rugose spiraling whitefly is a polyphagous pest feeding on a wide range of host plants including palms, woody ornamentals, and fruits (Mannion, 2010). Florida Department of Agriculture and Consumer Services (FDACS), Division of Plant Industry (DPI) records from 2009 to 2015 identified rugose spiraling whitefly on at least 118 plant species, which include a combination of edibles, ornamentals, palms, weeds, as well as native and invasive plant species (Stocks, 2012). Further, host plants recorded from 2009 to 2012 at Florida shows that 22% of RSW affected hosts were palm species, 16% were gumbo limbo, 10% were *Calophyllum* spp., 9% were avocado, 4% were black olive, and 3% were mango varieties (Francis *et al.*, 2016). Within the family Arecaceae (palms), 44% of host records were from coconut. Based on incidence records, these plant species can be considered as primary or preferred hosts of this pest. However, all plant species reported have not been documented as true hosts of the pest and may not require management. A total of 17 plant species under 11 families were recorded as preferred hosts of *A. rugioperculatus* at Kerala (Shanas *et al.*, 2016).

In Kadiyam nurseries the sale of various ornamentals and fruit plants belonging to different families is one of the prime activities and further majority of nursery plants are grown under coconut palms shade. The sooty mold produced due to whitefly feeding and its subsequent blacking of undersurface leaves is also a cause of concern as sooty mold deposited on ornamentals gives a poor appearance and not readily accepted by the consumer. The import and export of various plant material especially infested ornamentals and fruit plants is another cause of concern pertaining to spread of rugose spiraling whitefly to other parts of the state and the country. The host preference of A. *rugioperculatus* in Kadiyam region was recorded by scoring the presence of live egg spirals on leaf and categorized as low (10 egg spirals/ leaflet), medium (10-20 egg spirals/leaflet) and high intensity (>20 egg spirals/ leaflet) and the host range recorded as per its incidence is detailed below (Table 1).

Keeping in view the wide diversity of host plants and as hub of nursery activity sustaining lakhs of people a planned management strategy was formulated in consultation with Department of Horticulture, Government of Andhra Pradesh to educate, enlighten and adopt strategic mechanism to prevent spread the rugose infested plant material from Kadiyam nurseries and to successfully implement the pesticide free recommendations advocated. To show case the impact of pesticidal free management approach in rugose spiraling white fly management the following on farm research activities was carried out in Kadiyam nurseries itself to show and validate the package recommended against RSW.

An observation trail to study the efficacy of spraying of Azadirachtin 10,000 ppm @ 1ml on rugose spiralling white fly was carried out in coconut plantations in Kadiyam mandal. Three sprays were conducted on five palms with Azadirachtin 10,000 ppm @ 1ml at 20 days interval. The average number of spirals per 10 leaflets in 5 palms before spray was 65.37±2.15 which was reduced to 29.52±1.48 (medium intensity) after first spray, 12.63±1.27 spirals per 10 leaflets was observed after 2^{nd} spray and 9.45±1.13 spirals per 10 leaflets after third spray. So, it clearly indicated that the regular spraying of Azadirachtin 10,000 ppm can reduce the intensity of whitefly incidence (Table 2) without resorting to chemical insecticides. This demonstration convinced nursery growers and large-scale spraying of coconut palms on borders and nursery plants at need-based interval with Azadirachtin 10,000 ppm @ 1ml was done.

Table 1. Incidence and intensity of *A. rugioperculatus* on various plants in Kadiyam nurseries of Andhra Pradesh

S. No	Common name	Scientific name	Spirals per leaflet/leaf	Intensity
1	Coconut	*Cocos nucifera*	>30	High
2	Oil palm	*Elaeis guineensis*	>30	High
3	Cocoa	*Theobroma cacao*	<10	Low
4	Banana	*Musa* sp	10 -20	Medium
5	Indian shot	*Canna indica*	10 -20	Medium
6	Seethaphal	*Annona squamosa*	Spirals on entire leaf	High
7	Curry leaf	*Murraya koenigii*	Spirals on entire leaf	Medium
8.	Jack fruit	*Artocarpus heterophyllus*	Lower no of spirals	Low
9	Papaya	*Carica papaya*	<10	Low
10	Yam	*Colacasia* sp	<10	Low
11	Mango	*Mangifera indica*	Lower no of spirals<10	Low
Ornamentals				
12	Bird of paradise	*Strelitzia reginae*	<10 (Low)	
13	Fish tail palm	*Wodyetia bifurcata*		
14	Spider lily	*Lycoris* sp		
15	Areca palm	*Chrysalidocarpus lutescens*		
16	Cabbage tree	*Pisonia alba*		
17	Rose apple	*Syzigium malaccense*		
18	Heliconia	*Heliconia stricta var. Iris Red*		

Table 2. Effect of Azadirachtin 1% EC on rugose spiralling whitefly:

Mean no. of egg spirals per 10 leaflets in 5 palms			
Before spray	After 1st spray	After 2nd spray	After 3rd spray
65.37±2.15	**29.52±1.48**	**12.63±1.27**	**9.45±1.13**

Efficiency of yellow sticky traps in attracting rugose white fly

Use of locally made yellow sticky traps (yellow colour tarpaulin sheet used for fish pond bunds purpose available and sufficient to prepare 10 traps of 1 m x 1 m size smeared with castor oil at seven to ten days interval) (Fig. 2) was promoted instead of commercially available A4 size yellow sticky traps. The locally prepared yellow sticky traps were durable and cost effective. These yellow sticky traps were wound around coconut palm trunks at 5 feet height (Fig. 3) and alternatively hung in between the lanes by tying to two poles. The adults, pupae and spirals of RSW per 20 leaflets in lower whorl coconut leaf were counted and compared to those on palms where sticky traps were absent. The observations from Vijaya Durga nursery, Kadiyapulanka, East

Godavari revealed that the palms with yellow sticky traps recorded 18.00±1.81, 37.90±3.11 and 14.70±0.91 number of adults, pupae and spirals per coconut leaf, respectively. While the palms without yellow sticky traps had a significantly high number of adults, pupae and spirals. The number of adults, pupae and spirals per leaf on yellow sticky trap installed palms at Sri Satyadeva nursery were 9.90±1.45, 42.15±5.54 and 16.05±1.91, respectively. Further, the palms without yellow sticky traps recorded significantly high number of 69.10±3.16 adults, 97.90±3.50 pupae and 25.95±1.05 egg spirals per leaf (Table 3).

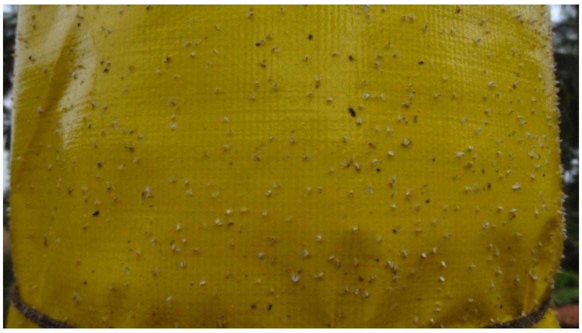

Fig. 2. Indigenously developed yellow sticky trap with RSW

The results of these two experiments show that the azadirachtin 1% and yellow sticky traps had significantly reduced the number of whiteflies per palm than the control palms. However, the RSW infested palms have to be monitored continuously for the population buildup of RSW. The yellow sticky traps need frequent maintenance by cleaning and application of castor oil and the Azadirachtin sprays has to be given in 15 to 20 days interval.

Biological control

Field release of parasitoid *Encarsia guadeloupae* and its establishment

Parasitoids *viz., E. guadeloupae* Viggiani (Hymenoptera: Aphelinidae) was known to parasitise *A. rugioperculatus* while Poorani and Thanigairaj, 2017 reported *Encarsia dispersa* Polaszek parasitizing *A. rugioperculatus* in surveys conducted at Tamil Nadu. A heavy parasitisation ranging from 40 to 70% was recorded on banana alone by *E. guadeloupae* (Poorani and Thanigairaj, 2017). The survey conducted by Selvaraj *et al.* (2016) recorded 20–60% parasitism of *A. rugioperculatus* by *E. guadeloupae* on coconut in Tamil Nadu and Kerala. Among the two parasitoids, *E. guadeloupae* was more predominant, causing 60–70% overall parasitism while *E. dispersa* was found in much fewer numbers and the extent of parasitism was <5% (Poorani and Thanigairaj, 2017). The surveys in Andhra Pradesh and especially in Kadiyam nurseries revealed absence of this parasitoid. Hence, with special concentrated efforts the parasitoid consignments of *E. guadeloupae* were regularly obtained from ICAR- CPCRI, Kasargod, Kerala, ICAR-NBAIR, Bangalore and TNAU, Tamil Nadu and released in the white fly infested nurseries in 2017, 2018, 2019 and by 2019 this parsitoid established excellently and more than 50 per cent parasitisation of RSW pupae was recorded (Fig.4 & 5). The establishment of the parasitoid was very low in the initial years of release but by 2019-20 the rate of parasitisation increased.

Field evaluation of *Isaria fumosorosea* (NBAIR Pfu-5) against rugose spiraling whitefly carried out by ICAR-NBAIR, Bangalore in association with DRYSRHU

Field experiments were conducted in Madavaraidupalem in Kadiyam mandal, East Godavari district, and Kalavalapalli village in West Godavari district, Andhra Pradesh (two gardens) during November-March, 2018-19

Fig. 3. Yellow sticky traps wrapped around the trunk of coconut palm

Table 3: Population of adult RSWF, Pupae and number of spirals in palms with and without yellow sticky traps.

Vijaya Durga Nursery, Kadiyapulanka , East Godavari			
	Adults	**Pupae**	**Spirals**
With Yellow sticky trap	18.00 ± 1.81	37.90 ± 3.11	14.70 ± 0.91
Without Yellow sticky trap	66.50 ± 4.32	88.20 ± 6.06	26.30± 1.08
Sri Satya Deva Nursery, Kadiyapulanka, East Godavari			
With Yellow sticky trap	9.90 + 1.45	42.15+ 5.54	16.05 + 1.91
Without sticky trap	69.10 + 3.16	97.90 + 3.50	25.95 + 1.05

(Average for 20 leaflets in lower whorl coconut leaf (Mean± SE))

to field evaluate the efficacy of *I. fumosorosea* against RSW revealed that *I. fumosorosea* Pfu-5 reduced the egg hatching (62-78%), caused mortality on early nymphal instars (52-68%) and late nymphal instars (48-63%) with overall reduction upto up to 60-79% at different location. The fungus killed all the developmental stages of RSW under field conditions however during high temperatures there is a comparatively lower suppression of eggs (18.6%), nymphs (20.3%) and adults (9.45%) at a temperature of >35^{0}C. The promising results with *I. fumosorosea* Pfu-5 sprayings were obtained in Kadiyam region as regular sprays were carried out by all nursery men at 10 to 15 days interval with high jet sprayers and were adopted as a low cost alternative to Azadirachtin10000 ppm. Especially the spraying operations were initiated very early in the season as and when initial RSW population was observed (below 5 spirals per plant) in the month of September itself and the initial sprays coupled with collective spraying operations created more impact and successfully arrested and reduced RSW population build up.

Fig. 4. Paralysed (blackish) and unparalysed (light brown) RSW Pupae

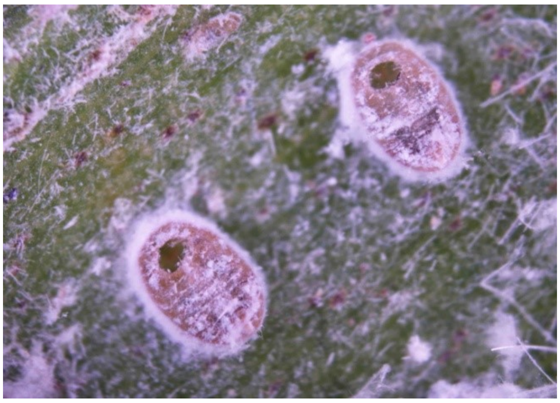

Fig. 5. Parasitoid emergence hole in RSW pupae

Predator *Pseudomallada astur* against Rugose spiraling white fly

The natural population of *P. astur* was observed feeding on the eggs and nymphs of RSW at Kadiyam and Kadiyapulanka villages of East Godavari, Andhra Pradesh. The *P. astur* grubs were collected from nursery at Kadiyapulanka. These grubs were reared at parasite breeding station, Horticultural Research Station, Ambajipeta using corcyra eggs. The grubs were reared in individual vials until pupation and then adults were transferred into the adult rearing cages. Adult insects were reared on artificial protein rich diet which is provided in semisolid paste. This diet consisted of equal parts of yeast, fructose, honey, Proteinex R and water. The adults lay eggs on the brown sheet provided on the lid of the rearing cage. The adults were collected on daily basis and transferred into fresh rearing cage with fresh food. From the old cages, the brown paper sheets along with *P. astur* eggs were removed and made into small pieces with 5-10 eggs. These small cuttings were clipped on the underside of RSW infested coconut leaves. The eggs of *P. astur* are available in the HRS, Ambajipeta and priced at Rs. 150 for 1000 eggs.

Though this predator is found in good numbers in field an augmentative release of this natural enemy is thought to provide a greater impact as the population of RSW was generally high during the favourable season with multitude of plant hosts. Accordingly, large scale multiplication of *P. astur* was carried out in bio control lab Ambajipeta and in 2018-19 about 3,47,000 eggs were supplied and in 2019-20 about 21.40 lakhs eggs were supplied to plantation farmers and nursery growers were also in forefront in taking consignments of this predator eggs and clipping them in their nurseries regularly. Good buildup of this predator population was observed over the years in the nurseries strengthening the base of biological control.

Capacity building programs to nursery growers on farm production of *Isaria fumosorosea* (NBAIR Pfu-5)

As large-scale production of *I. fumorosea* and field supply by the government institutes was very difficult hence, training programs on self-production of entomopathogenic fungus *I. fumosorosea* were conducted to progressive nursery growers of Kadiyam region on production of this fungus on broken rice in their own farm at a low cost. A nucleus culture of the fungus was supplied to the needy nursery farmers and the nursery growers were assured of quality check of the fungal stock produced by them. The nursery growers were provided with a production kit and pamphlet as ready reckoner to encourage them for producing these fungi. On farm training and demonstrations were also conducted on preparation of spray fluid, mode of spraying and precautions to be taken during spraying at regular intervals and the field impact of entomopathogenic fungus was also shown through sample collections

Strengthening extension network: Utilisation of the staff (Village Horticulture assistants and Agriculture assistants) working in Rythu Bharosa Kendras (RBKs)

The government of Andhra Pradesh has come up with a new concept of Rythu Bharosa Kendras (Farmer Assurance Centres) at village level to have a platform at the village level to improve the services of government in qualitative and quantitative terms especially to deliver the farm advisory services and have Dr. YSR Horticultural University as technical partner. The VHAs and VAAs employed in Kadiyam region were thoroughly trained in promoting management of RSW in nurseries of Kadiyam region. The constant guidance to VHAs and VAAs by Assistant Director of Horticulture and local Horticultural officer along with scientists of research station brought the extension system more closely to nursery community of Kadiyam region. The Village Horticulture assistants and Agriculture assistants role was pivotal in monitoring the status of RSW and assisting in carrying out timely sprayings and supplying stock culture of entomopathogen *I. fumasorosea*. Their constant vigil and supervision was instrumental in managing the RSW incidence in this region effectively.

Awareness through print and electronic media

The local print and electronic media actively disseminated all information pertaining to the activities taken by University and Horticulture department in managing RSW and reached the unreached nursery growers.

The free movement of the plant material from one place to another is unavoidable accordingly the chances of introducing alien insect pests and diseases are also high posing threat to biodiversity of the introduced region. Against RSW the management strategies of spraying of Azadirachtin 1% EC, installation of yellow sticky traps, conservation biological control using *E. guadeloupae* coupled with need based releases of predatory insect *P. astur* and utilizing entomopathogenic fungi *I. fumasorosea* as another spraying option offered a integrated package for managing RSW. Ultimately awareness campaigns and programmes, including practical demonstrations conducted regularly showed a tremendous impact at grass root level in effectively managing RSW in Kadiyam nurseries paving way and giving impetus for pesticide free management approach and showcasing strength of biological control once again.

Management strategies recommended for RSW in Andhra Pradesh

1. Avoid transportation of coconut seedling or any other ornamental plants from pest infested areas to new un infested areas
2. Release of *P. astur* @ 100 to 150 eggs / palm during low incidence and up to 300 eggs/ palm during medium incidence for at least 10 per cent of infested palms particularly in those plantation where spraying is not feasible
3. Re-distribution of *E. guadeloupae* in RSW infested areas
4. Avoiding Pesticides spray
5. Spraying Azadirachtin @ 1% @ 1 ml per litre along with detergent powder @ 10 gms two / three sprays at 15 -20 days interval.
6. Foliar application of entomopathogenic fungi *I. fumosorosea* @ $1x10^8$ spores/ml (5 gm /litre along with sticker 2 ml/litre)
7. Intermittent Jet water spray at fortnightly intervals
8. Installation of yellow sticky traps on palm trunk to attract adult white flies and regular smearing with castor oil at 7 to 10 days interval
9. Community based approach for management.

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The help received from ICAR- CPCRI, Kasargod, Kerala, ICAR- NBAIR, Bengaluru, Karnataka, ICAR – IIOPR, Pedavegi, Andhra Pradesh are gratefully acknowledged. The Department of Horticulture, Government of Andhra Pradesh and all the nursery growers who cooperated in this study are gratefully acknowledged. Thanks to Coconut development board, Kochi, Kerala for sanctioning TMOC project for large scale production of bio-agents against RSW.

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In conversation with Dr. Chitra Srivastava

Although not so ambitious but most energetic, highly motivated, consistent and hardworking Dr. Chitra Srivastava speaks to associate editor Dr. Bhagyasree on her successful journey in the field of entomology.

Dr Chitra Srivastava currently helping the system as Emeritus Scientist (Entomology), basically she is from Prayagraj (earlier Allahabad) city. She superannuated in the post of Head, Division of Entomology, IARI, New Delhi. She is an able scientist with rich research, teaching and managerial experience of over 33 years in the field of insect toxicology and storage pest management. She has demonstrated excellence in Insect toxicology particularly for management of stored grain insects and has made significant contribution in solving emerging problems of insecticide resistance and management of storage insect pests through several externally funded research projects. Her work on 'use of alternate methodology i.e., use of carbon dioxide to kill insect pests in storage' has been acclaimed a great deal and adjudged noteworthy. She carried out extensive research to identify some insecticidal plants (*Clerodendron infortunatum, Lantana camera*, *Andrographis paniculate, Milletia pachycarpa, Gymnema sylvestre, Vinca rosea*, *Gloriosa superba* etc) extracts as potential component for IPM which proved deleterious to insect pests. Also undertaken various bioefficacy studies of new series of formulations against insect pests wherein 31 substituted hydrazines of nalidixic acid hydrazide showed insecticidal properties against Lepidopteran and coleopteran insect pests. Bioefficacy of new compounds viz., 3-substituted -3,4-dihydro-1,3-benzoxazines, N-alkyl-N-(1-(2-hydroxyphenyl) ethyl amines and Isoxazole derivatives were also evaluated by her against *S. litura* and pulse beetles and all showed good insecticidal activity. Further, she has also evaluated toxicity of various novel insecticides against different populations of BPH (*Nilaparvata lugens*). Efficacy of CO2 was found to protect wheat seed against storage insects. She obtained several out agency/foreign aided research projects and generated enough funds to carry out 'Stored grain and Insect Toxicology' research work and produced/trained better human resource.

Actively engaged in teaching PG courses on 'insecticide toxicology' and 'storage insects management'. Guided for eighteen (14) Ph. D. and five (5) M.Sc. theses at PG School, IARI. Out of them, two of them were adjudged as 'Best thesis of PG School of IARI', 2 for 'IARI Gold Medal' and another one was given 'Dr S. Pradhan Memorial Award'. Many of her students have succeeded in ARS and are serving in different ICAR institutes, some are working as Assistant/Associate Professors in SAUs, one (1) student is serving under Indian Forest Service (IFS) and another from Iran is serving as Assistant Professor in Shahid Bahonar University of Kerman, Iran. She is a most acknowledged faculty and has been actively engaged in teaching PG courses on ‘insecticide toxicology’ and ‘storage insects management’. In the year 2007, she herself was adjudged as ‘Best Faculty’ and bestowed with ‘Best Teacher Award’ for excellence in teaching in Entomology.

Her focus to students is to provide quality education with skill development. Made significant contribution and published bulletins, research papers, review articles, symposia papers and popular articles. She is editor/co-editor of 10 books/bulletins, author of several chapters in different books, over 140 peer refereed research journals and several symposia papers, training manuals, patents and over popular articles. Her diverse published research papers highlight her contributions. Dr Chitra Srivastava is a life member of several scientific societies. She earned ‘Fellowship' of Indian Entomological Society of India (FESI) and Society of Plant Protection Sciences (FSPPS). She is on Editorial Board and Referee of many reputed peer reviewed National/International research journals related to plant protection. She has par excellence interpersonal and communications skills, and possesses high level of initiative, strategic judgment and adaptability and resourceful person with a sustained record of achievement and innovation. She had demonstrated competency in research or discussions; project management, including teaching and guidance. Dr. Chitra is an eminent scientist, we are glad we have opportunity to know about her journey.

Bhagyasree S.N. (BSN): Thank you for speaking to Indian Entomologist magazine, how did you pursue career in Entomology, especially in toxicology and storage pest management?

Dr. Chitra Srivastava (CS): It was both choice and chance, I like insects the most which fascinated me to understand the unique behaviour of wide diversity of insects. I did my Doctoral work on “Studies on the haemolymph free amino acids and proteins of *Achoea Janata* and the effect of junenoids on them. “from prestigious University of Allahabad. While pursuing there for my Ph.D program, I was fascinated to work in IARI, New Delhi. Luckily, I was married to an ARS scientist which motivated me to write for ARS Examination and fulfil my dream to move to IARI, New Delhi. His constant motivation, prompted me and I appeared for ARS 1985 examination (my first and last chance) and got selected, In the meanwhile, I was offered Post Doc Fellowship of ICAR (those days it was difficult as it used to be given very few people only across the country taking all agricultural discipline into consideration) under Dr. K. N. Mehrotra. Really, it was very difficult thing and extremely rare to get at that time. Under his able guidance, I started working on evaluation of Plumbagin against lepidopteran pests and learnt a great deal. During the period I had learnt how to do bioassay, as it was new to me. I had to leave Post Doc Fellowship in between since I had to join ARS Service during February 1986 at IARI New Delhi. After joining it was difficult for me to get posting in the Division of Entomology and thus, I didn’t get posting in Entomology Division in the beginning. I was posted in RPC section of Central office, involved in scientific project management. But as I explained earlier, I had huge interest in research and teaching in Entomology, hence, being at Central Office (non-research position), I was continuously requesting authorities to put me in research in Division of Entomology. Dr. S. K. Sinha the then Director, IARI was kind enough and he agreed to my request and transferred me the Division. I was first posted to work in Earthworm project, as I was basically from Zoology background, there I worked on effect of herbicide on earthworms. I was always interested to work on toxicological experiments like Resistance and Residues, later I was shifted in Insecticide resistance to storage insects project in association to Dr. JD Saxena. Initially,, I worked along with very good seniors like Dr. RK Bhatnagar and Dr. J D. Saxena where I had full freedom to work as well as to learn a great deal. I was also associated with Dr. S Dhingra, who was really a hard task master, a brilliant teacher. I learnt a lot from her. I thus, learnt a lot from my seniors. This way my dream fulfilled and my journey started from zoology to entomology and then to toxicology.

"Happiness and satisfaction with whatever we have is very important for healthy life"

BSN: Who is your role model in personal and professional life?

CS: It's my MOTHER, both personally and professionally, she was a teacher in Psychology, she was not from modern family, ours was big joint family, she was married at an early age after completing her XII standard (Intermediate examination). My mother apart accomplishing every household chores, she balances joint family extremely well. She hails from Lucknow and she used to go to college in "Tanga" covered with curtains as girls were not allowed to show their faces at that time. My father's thought was progressive, and he persuaded her to complete further studies. After completing her postgraduation, she opted for a job of teaching in an Intermediate College in Prayagraj. She coped up family responsibility and her profession very well. She was liked by her students a lot. She fulfilled her responsibility of daughter-in-law of a joint family extremely well, looking after everything, that really, we can't even dream and imagine today. I wish I should have strength like her.

BSN: Its great hearing about your mother, I wish young working generation has to learn a lot from the women like your mom. How did you balance your personal and professional life, usually in working women life career and biological clock goes in opposite direction, how did you cope up with that?

CS: Dear Bhagyashree, when I was writing ARS exam, I had a son, after getting selected in ARS, my elder daughter was born. My husband and his family were very cooperative and supportive, they helped me looked after everything so well. My in-laws stayed with us to look after my children. Thus, I could able to manage and balanced my professional and personal life very well.

BSN: What a working woman should possess to have balance and healthy life?

CS: Adjusting nature!!! I was not much ambitious. Getting the position as Head (Entomology), ICAR-IARI, was very big thing for me and what I thought in Allahabad was fulfilled. I am extremely satisfied and happy about my accom-plishments. Happiness and satisfaction with whatever we have is very important for healthy life. And I am lucky, I worked with very good colleagues and students. My students owned my lab as their lab and always felt responsibility, take care of everything in lab as their own. This attitude of my students also supported me in a great way to balance the professional life. My students are really my assets.

BSN: What are the biggest challenges or hurdles you have come across while working as a Head, Division of Entomology, ICAR-IARI, New Delhi?

CS: Am lucky, I always had support of my colleagues and other staff members and didn't face any problems or hurdles in the division. In IARI, working is very systematic. I could handle everything smoothly without any hinderance. The technical and administrative staff also supported me so much. Dr. Subhash Chander, Professor (Entomology) was also very supportive and he cooperated a great deal. Because of all the support from senior and junior staff, I have not faced any hurdles.

BSN: As toxicologist, what do you say, is pesticide usage boon or bane to attain sustainability in agriculture? Are they really causing cancer, neurological defects and chromosomal aberrations?

CS: I would say it's a boon, but we have to use cautiously and judiciously, else production will be affected. To attain food and nutritional security, use of pesticides are necessary. Right pesticide and right dose are extremely important. So, we should do need based application in IPM.

BSN: What is your opinion on impact of recent ban?

CS: Government of India proposed a blanket ban on the use of 27 generic pesticides, causing real concerns among the farmers, scientists and the industry. Though only 27 pesticides are proposed to be banned but along with them will go 134 formulations also. These pesticides are registered for protection against wide range of pests and diseases in 74 crops. Such sudden ban on these commonly used generic pesticides, in the absence of suitable alternatives may have negative impact on production also.

BSN: As a storage entomologist, you have worked with farmers, and rural women a lot, with your experience why do you think managing storage pest are difficult and what can be done to manage the food grain loss?

CS: In storage, insect pests are not facing any scarcity of food and shelter. Storage insects are very small in size and most of them are internal feeder so feeding stages are not visible. We can see them only when substantial loss already occurred. To control these insects, we cannot apply or mix any chemical as grains are edible commodity, also as stages of these insects are hidden inside the grain chemical will not reach there. Only through fumigation we can kill these insects. same time to check the cross infestation prophylactic treatment with insecticides is also important.

Before keeping grains in storage grains should be insect free and dry, moisture should be reduced. Cleanliness and hygienic conditions should be maintained.

BSN: How did you feel when you got Best teacher award??

CS: It was the happiest moment for me. As teaching and students were very close to my heart, I felt very happy receiving that award.

BSN: You are student's favourite teacher, there is no doubt in that, constantly every student in the IARI liked you the most, what is that one thing/things which made students to like you a lot according to you?

CS: All teachers are excellent in IARI, and students are also very studious. Whenever I use to chide my students, I always thought, how my children will feel in the same situation? Specially in M.Sc these students are leaving their home for the first time, they need affection, help and some strictness also during gaining knowledge. Hence, they have to be tackled intelligently and patiently. As I have already told you my students were close to my heart, I am very lucky to have them.

BSN: Your suggestions/views to Young entomologists magazine?

CS: It's very good, all the articles are very informative, youngsters are doing good job.

In the end, I would say that she possesses high level of initiative, strategic judgment and adaptability and resourceful person with a sustained record of achievement and innovation. She has par excellence interpersonal and communications skills. She had demonstrated competency in research or discussions; project management, including teaching and guidance.

Dr. S.N. Bhagyashree is working as Scientist at the Division of Entomology, ICAR- IARI, New Delhi. She is working on IPM of Vegetables and Biological control and also one of the Associate Editors of IE, managing Women In Entomology Section.

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Just Passing Through

Anurag Chugh and Divya Sharma

Introduction

I like to think that most fields of research have a central premise - a discovery/invention/realisation - that they hold sacred. In my mind's eye, I like to imagine each stage of progress in that field as branches and leaves growing outwards from that single kernel. For Civil Engineering and Architecture it was the invention of reinforced concrete - oh! what luck to find that concrete sticks to steel and their combination expands at the same rate avoiding thermal stresses due to the daily heating and cooling. For Molecular Biologists and Genetic Engineers it was the discovery of the Genetic Code - a single recipe for all life on Earth!. For Electronics and Computer Engineers like me it was the invention of the transistor and later on, the internet.

As I begin my amateur waddle into the vast ocean that is the study of insects and microbes, I suspect that the central premise here is the realization that the Earth actually belongs to these tiny creatures and us humans with all our ego and pride are just passerbys. Imagine a marathon where the cheering bystanders exchange Hi-5s with the runners running the marathon - only in our case, we are the bystanders while these tiny creatures who have been here for billions of years and would continue to be here long after we are gone pass us by with their short lives but unbeatable resilience.

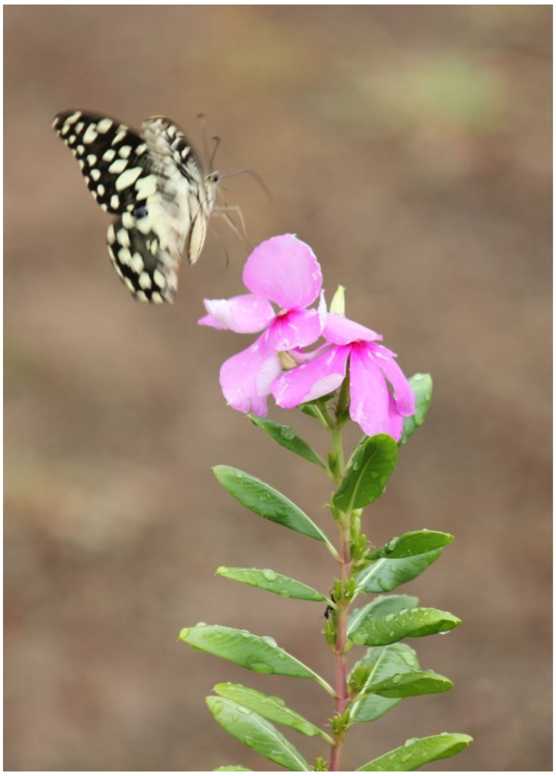
My first fascination with things this small, began in 2006. I had just finished graduating from my engineering college and was in Delhi for a project. I saw a bunch of Painted Grasshoppers basking in the Sun on weeds growing next to the footpath. I had just been relieved of the burden of studies and exams and was mentally free to pause and appreciate them. They looked like tiny plastic toys painted with bright colors.

Cameras become pervasive

A month later, I was back at my parent’s house in Mumbai. We had just bought a new house in an apartment building surrounded by gardens on three sides and not very far away from the mangroves. We would occasionally be given a visit by some scary centipede or moth with intriguing coloration or the usual praying mantises and dragonfly.

Digital cameras were pervasive by then, and I jumped on each chance to capture a photo of a new creature.

Cut to 2010. My father - a Naval Architect - was posted at the shipyard in Dahej, Gujarat overseeing the construction of a new vessel. The rest of the family (me, mom, brother and grandmother) were visiting him for a week. There were all sorts of bugs in the compound where we were put up. With lack of internet for entertainment and a brand new DSLR at my disposal, I ventured out to take photos of these insects. I was trying to understand and explore the nuances of photography - aperture, shutter speed, exposure, DOF - as well as learning to be patient - waiting for the right moment to take the shot as these insects moved about their business with great agility. My dad had been into photography since his college time and I thought I would make him proud by taking the prize shot of a butterfly at the moment when it barely lifts off after sucking the nectar from a flower - proboscis still extended! I came very close - I had spent 2 hours chasing the butterfly. To get a crisp photo, I had to play around with the aperture to maintain the DOF and compensate for the exposure by increasing or decreasing the shutter speed. By evening, the Sun was very close to setting and I could no longer maintain a fast enough shutter speed - The butterfly moves too fast to achieve this goal in anything less than full daylight! I did manage to get some other cool shots. It’s amazing how much patience you develop when photographing insects.



The Book Lice Episode

In 2011, I took up a job in Pune. I rented a 1BHK there and used to travel back to Mumbai every weekend to be with my family. During this time my fascination for insects turned to belligrance. I was being harassed by the two of their most pervasive species in two different cities - the book lice in Mumbai and ants in Pune. I could never have imagined that most of my waking hours would be spent worrying about these supposedly inconsequential creatures. During the week I would be researching and experimenting with ways to get rid of the ant infestation in my rented apartments in Pune and on weekends I would reach home in Mumbai to find booklice scurrying around among my painstakingly collected books. Let me talk about the book lice episode.

Over the 4 years of undergrad college and, I had amassed a huge collection of textbooks and for the next 6 years after that, having access to my own finances - I collected an even larger collection of fiction and non-fiction books. I was too attached to my

collection and worried about proper storage, so I designed a wooden bookcase that we got made especially for them. A salesperson dropped a flyer advertising a dehumidifier and my mom suggested that we get one for health reasons. I was all for it because I knew it would help me protect my books from the damaging humidity of Mumbai. And so we got one. I even placed it next to the bookcase. During days of high humidity, we would turn it on at night and shut the door to my room (me and my brother shared the room) for a zero sweat

good night's sleep. In the morning we would turn it off after we woke up.

A few weeks later I started observing small white insects moving around inside the bookcase, on and around the books. At first, I didn't think much of it, but as their numbers grew, I started to get worried. I caught a few of these bugs with cello tape and looked at them under a pocket microscope. They were 1 mm in length but looked scary under 100x magnification. I had photos of these bugs but I didn't know what species they belonged to, or most importantly, how to kill them! I emailed Meenakshi Venkataraman. I had recently purchased her book "A Concise Field Guide to Indian Insects and Arachnids" and thought that maybe she would be able to help me identify them and control them. She replied back informing me that these were "booklice". This was weird! I was using a dehumidifier, wasn't that supposed to deter the book lice?

In any case, I thought maybe the dehumidifier was not enough, so I went to work trying out other strategies - I tried placing neem leaves among the books, camphor, naphthalene and even baking powder + salt mixture to suck out the humidity inside the bookcase. I installed foam tape around the border inside the bookcase trying to make sure the book case sealed well and allowed the desiccants and chemicals that I placed inside to work their magic on the air inside the bookcase. That did not work. I thought that maybe the baking powder + salt mixture was not strong enough and that the air inside the case was still not dry enough to deter their growth. So I got a friend who was returning from the US to get me a pair of gel based mini dehumidifiers that I could place inside the bookcase. That did not work either.

Every weekend I would spend 2 hours taking out all the books, squishing all the booklice that I could see moving only to repeat the process again the next weekend when I was back in Mumbai. Remember the bookcase was in Mumbai and during the week I was in Pune. I even read that placing the book in a microwave and running it for 90 seconds would cause the water in the bodies of the booklice to boil and kill them. I tried that but some of the books with shiny covers had metallic particles in them which caused damage to the cover when I microwaved.

Then one day, it hit me. The very thing that I purchased to protect my books was responsible for killing them - the dehumidifier. The dehumidifier works on the same principle of refrigeration as a fridge or AC. It cools a surface and places it in the path of force blown air and causes the water vapour to condense out. Like the AC/fridge, the back side of the dehumidifier gave off heat. Throughout the night, it would suck out the humidity from the air inside the room at the cost of increasing the temperature by a few degrees. In the morning, when we turned off the dehumidifier and opened the window, the outside air - full of humidity would rush in and displace the dry air within a few minutes. But the furniture, walls, bookcase and the book had been absorbing heat all through the night and stayed warm for much longer! The warmth and the inrush of humidity created idle conditions for the booklice and other microbiota to flourish for a major part of the day as most objects in the room were bad conductors of electricity and cooled down very slowly. I soon found all kinds of mould growing on the underside of the planks of my box bed and also - of all places - on the ceiling. I would find booklice frolicking among the microbiota, perhaps feeding on it?

I discarded the dehumidifier and resigned myself to the fate of cleaning my books, the bed and the ceiling every 2 weeks until the relatively dry days of Mumbai winters. The life cycle of booklice is around 110 days with eggs hatching 2 weeks after laying. The strategy of squishing the booklice every 2 weeks was enough to eradicate them. But the mould and the booklice on the ceiling were more resilient. They got eradicated when we got the house repainted and the furniture polished. I realised that a dehumidifier is only good when used in sealed spaces, kept running for 24 hours and with its heat directed out away from the space it is serving.

The Ant Infestation Episode

While the situation with the booklice was developing in Mumbai, during the week, I had to contend with a new enemy at my rented apartment in Pune. Every night when I returned from work, I would find a line of ants carrying crumbs of food back to their holes. I became careful not to leave food around my house. At the beginning I considered them a minor nuisance, but one day I found thousands of ants migrating from some crack in the window in the living room and marching to some other point in the kitchen. I killed them all, but they were back the next morning. So, on a particular weekend when I didn't go back to Mumbai, I spent many hours looking for cracks between tiles and on the corners of the floor and sealed each one up with white cement. I was naive to think that that would solve the problem.

So I switched to another strategy. I would

leave Glucon-D around my house and wait for ants to come sniffing for it. Once they had begun transporting the particles back to their colony - which was some crack in the wall or between tiles that I had missed, I would spray some ant insecticide into the crack and seal it with white cement. I

repeated this activity around 20 times, but the ants just wouldn't leave me.

Finally, I discovered a lab in Ahmednagar, who sent me a formulation with ant pheromones mixed with Beauveria bassiana. When the bottle arrived, it was puffed, probably due to some gases released by the digestion process that the fungus was undergoing. I opened the bottle and the stuff oozed out from it. I placed it on the floor, the ants got attracted, came over and that was the last time I saw them for the next 1.5 years until I moved to my own flat in December 2012.

Balcony Garden

I got married in 2017. When my wife Divya moved to Pune, we teamed up to explore our shared love for gardening. We have two balconies in our house. We started getting flower pots and new plants every few days. Being a tech geek, I experimented with automating irrigation using a drip system and small pump but the nozzle kept getting clogged with Spirogyra or Algae so we gave that up and went back to watering using a bucket and a mug. We have many varieties of ornamental flowering plants and some vegetables and herbs.

Cursed Tomatoes

The first thing that we tried to grow was tomatoes. But around the same time that the plants matured to the flowering stage, they became infested with mealybugs. This was our first time growing a plant and on the very first try they got infested with bugs. By the time we realised what was happening, it was too late and we had to discard the plants.

We tried growing tomatoes again. But the second time they got infected with leaf miners and we had to discard them to prevent the miners from getting onto other plants. But that second time we did get some harvest out of them.

Tired of the leaf miners and mealybugs, we swore not to grow tomatoes again until we had a good handle on preventing inflictions of this plant.

For the past 2 years we have seen all kinds of infestations/infections on our plants. None of the remedies that we came across on the internet seemed to work effectively and sometimes would end up damaging the plant (neem oil, soapy water etc etc..). At one point, Divya and I thought of giving up this hobby. But we decided against giving up so easily and persisted. We have a local gardener who runs a small nursery nearby. We call him over once every three months. He prunes the plants and adds manure and other soil conditioners to each planter. The trimming helped get rid of diseased leaves. From then on, we have started inspecting each plant every 2 days for any signs of infestation and take proactive steps to get rid of them then and there. Our plants are now mostly pest free.

The Praying Mantis Episode

After so much talk of killing, extermination and devouring, let's switch to something different - let's leave it to the reader to decide for themselves if they find the story pleasant or not. Recently, Dviya and I have taken a keen interest in rearing the Common Mormon caterpillars into butterflies. We and two of our friends purchased a flat in the same apartment complex here in Pune back in 2012. All three of us have Curry Leaf Plants on our balcony. Every few months, we wake up on some morning to find the Common Mormon caterpillars on our curry leaf plant. These critters have voracious

diets. While our neighbours get rid of them immediately, we let the ones that appear on our plant to grow to maturity and turn into butterflies and leave. We also have a Kaffir Lime plant which is another favourite of these caterpillars. We in fact got a second “sacrificial” curry leaf plant so that we could let the future caterpillars take turns on alternately feeding on the 2 curry leaf plants and the one Kaffir Lime so that no one of the plant has to bear the brunt of their limitless diets.

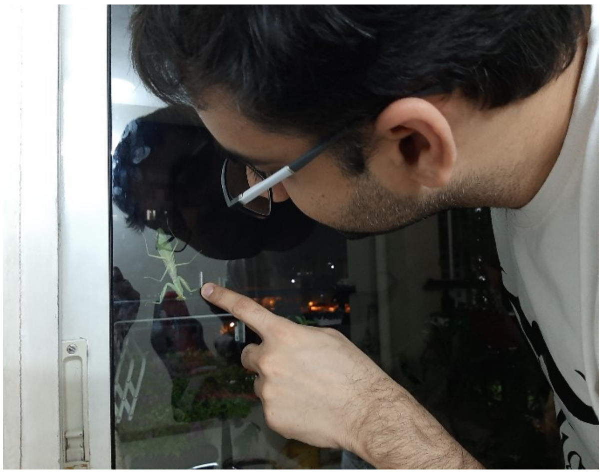
The first time these pretty caterpillars appeared on our plants, we placed them into bottles for two days and then placed them back on the plants so that they may build a cocoon and turn into butterflies. It was fun although we didn’t get to see them emerge from their cocoons. We decided that the next time they appeared, we would make a big deal out of it, look after them and take lots of pictures. The teacher in me awoke and I remembered the 2 years of my Teach For India Fellowship. I thought because the insects have a relatively short lifecycle, it would be practical for 7th and 8th-grade students to study and care for these insects as part of a project during an appropriate time of an academic year. And watching them turn into butterflies would be a reward in itself. So I thought why not try nurturing them ourselves first.

Recently on 1st April 2020, we woke up to find 4 caterpillars on our Kaffir Lime. This was our chance. Divya and I maintain a facebook page (https://www.facebook.com/DivyaAurAnurag) where we post comics depicting amusing moments from our daily domestic lives. We would take photos of these caterpillars everyday and post them online. We named the four of them after our favourite sci-fi characters and started tracking their daily antics. Little did we realise that our project was going to be short-lived. On the first day we also had another guest - a Praying Mantis who sat on the glass pane of the door to the balcony where we kept our Kaffir Lime plant. We were awestruck to have two different insects visit us on the same day. We didn’t give much thought to the praying mantis and Divya took a whimsical photo of me trying to communicate with the Praying Mantis. The next day the Praying Mantis had disappeared.

For the next 4 days, our first task after we woke up would be to take photos of the little caterpillars and post them online. On the 5th day, they were nowhere to be found. We frantically looked all around the Kaffir Lime plant but found no trace of them except for some residue which seemed like shriveled up caterpillars!!!!! My first thought was “Did the caterpillar die because of the intense Sun?” - didn’t seem plausible!, The Sun didn’t affect them for the first few days, why would it affect them now? Suddenly Divya made me aware of a movement in the leaves - it was the Praying Mantis! It was camouflaged among the leaves. It whipped out my phone to confirm the worst - the Praying Mantis do feed on caterpillars!. It had probably eaten all 4 of them in a single seating the night before and even pooped out their remains.

We vow to take care of our caterpillar better the next time. We read more about Praying Mantises. A website said that they serve as good pets. By the time we decided to let go of our grief and redirect our affections instead towards the Mantis, it was gone. Sigh! Perhaps there will be a next time!

Day 1: 1st April 2020 - New Babies!



Also on Day 1 : 1 April 2020

Day 3: Picard is done devouring half of its original leaf, moving on to the next one!

Day 5: 5th April 2020 Praying Mantis ate all 4 caterpillars in a single overnight sitting and pooped them out. Ah! Well! Circle of Life. ⚰️🐛

This might be the same Praying Mantis (or should I say PrEying Mantis) that appeared in our balcony on Day 1 when we discovered the new babies on our Kaffir Lime plant. It seems to us that it might have been tracking them, waiting for them to fatten up before devouring them. We didn't know that back then that Praying Mantises could feed on caterpillars.

Closing Thoughts

I and Divya have only just begun to appreciate the world of the tiny living things. There is a lot to learn and understand about them and their life cycle. We have developed fond affection for some of them and would gladly share our homes with them. With regards to others, we wouldn't mind dropping in on them in their natural habitat, but we definitely do not want them in our home. We do realise the naivety of that thought. Once they decide to pay you a visit, it's difficult to keep many of them out of your house. They have been on this plant for much longer than us and will continue to thrive even after we Humans are gone. It's high time we made peace with them and learnt to co-exist with them, because instead of them passing through our house, it's actually us passing through theirs.

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Mating of Flies

Susmita Ghosh

The lifespan of a common house fly is between 15-30 days. Once a male fly emerges from the pupa it takes no more than16 hours to mature sexually and for a female it is 24 hours. A female fly usually mates ones in a lifetime whereas the male fly is polygamous in nature.

Preferences of Ideal Partners

A very interesting fact about male flies is they opt to mate a virgin fly preferably larger and sexually mature enough for copulation. One common observation confirms that a male fly prefers female partners who are usually seven days old and also a virgin.

The other typical physical preference exhibited by male fly is, it prefers partner who is longer in size. Whereas a female fly chooses a heavier mating partner over a light one.

In case the strike occurs in the midair the pair immediately locates any surface and rests on it. However, the couple can fly off to another location if they are disturbed during copulation maintaining the same position.

Courtship

Courtship among flies is usually initiated by a male member that involves numerous stereotypical behavioural patterns. The male fly has to go through an elaborate ritual to finally convince and mate his desired partner.

The prime sensation that initiates or trigger the courtship behaviour in a male fly is vision. As soon as a male fly detects a partner it adopts typical orientation behaviours, to begin with it turns towards the female fly and starts chasing it. During this particular phase the male fly continues to flap and shake its wings and wag its body. These series of body languages are observed during the day time or presence of light when visibility is prominent.

Fig. 1. Copulating house flies

Absence of sufficient amount of light makes the above mentioned behaviours impossible. Therefore, a male fly has to adapt other behavioural pattern like olfaction. However, it works only at short distance. Therefore, during dark a male fly has to double its physical labour to detect a female fly for copulation.

Mating

Like every other living species, even in flies the touch sensation plays a crucial role in initiating the mating process. The first attempt that a male fly establishes is to touch the body of the partner with its foreleg. This is called tapping. Tapping is the first physical contact that helps the fly to not only attract its counterpart but at times also helps in determining the species and sex of the fly.

There is no definite direction from which a male fly makes his approach towards his chosen one. In fact, the attempt can be from any direction, i.e., from either side, head or rear end. The male fly usually "strike " (jump) upon a female one either in flight, during a resting position or while the counterpart is walking on a surface.

The mating of the common house flies begins with a male fly bumping into a female one called “striking". One single " strike" can last between 1-10 seconds which may occur either in midair or on any surface. However, if the female fly is not receptive the male fly flies away only after a few unsuccessful attempts of genital contact.

If the male fly is able to tap on a female and the gustatory organ on the foreleg can sense the female sex pheromones, the courtship is immediately taken to the next level, i.e., wing vibration. Vibration or flickering of the wings produces a species specific unique courting song. The quality of the "courting song" determines the possibility or chances of luring a desired mating partner.

Once the " strike" is successful and the male fly is able to gain the desired position between the wings of the female fly it then goes on to the next stage i.e., extending of its proboscis and licking of the female genitalia. The male fly then grabs the body of its partner with the forelegs and curl the tip of its abdomen. In case the female fly is receptive and approves of mating it spreads her wings thus allowing the male fly to mount. The final approval of the female fly confirms the initiation of the mating process. The female fly then pushes her ovipositor into the male genital opening thus initiating the mating process.

It takes several attempts from a male fly to finally convince a female fly to approve and accept the mounting. The couple continues to be in the mounting position between 10-20minutes during when the male fly ejaculates the seminal fluid in his partner. The female fly mates only once in its life time.

In contrary to male flies, the female flies mate once in a lifetime. The female fly lays egg on decaying matters like carrion, feces or food waste. The number of eggs laid can be around 100 per batch. She can continue to lay as many as 500 eggs in her lifetime.

AUTHOR

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Sustainable Pest management approach in organic farming

Yimjenjang Longkumer and Manoj Kumar

Abstract: Pest management in organic farming highly accentuates on preventive methods rather than utilization of deleterious inputs such as chemicals. Through these measures the environment and the natural enemies in the cropping system remain unaffected. With its efficient performance in controlling the target pest an incipient horizon is establish in plant protection. Their potential and compatibility with various components such as trap cropping, pheromone lures, botanicals etc creates a sound ecosystem and have eventually resulted as an alternative approach to synthetic chemicals. Thus, to counteract the menace caused by the pests through these methods cannot be ignored.

Key words: Pest management, trap cropping, pheromones, botanicals.

According to IFOAM which is the umbrella organization of organic movements defines organic farming as "a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic Agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved". Despite of the instant effect provided by the chemical pesticides it is imperative to know the other side of the story of conventional farming system. The chemical build up in the environment, intensive application of fertilizer's due to loss of valuable nutrients as a result of continuous monoculturing, loss of biodiversity etc. are the impact of conventional farming. However, these scenarios can be delineated by adopting organic farming. It involves the cultivation of crop without the involvement of any source of chemicals. In such farming system, the cultivated crops will be exposed to various pests during their life cycle. Their occurrence can be categorized as sporadic, endemic, epidemic etc. So proper intervention must be employed to overcome such activities to protect the crop damage. Such type of farming system totally relies on eco-friendly approaches in management perspective *viz.,* cultural control and biological control. Globally, Australia ranks first in area under organic cultivation while area under organic system in India is 1.18 million hectares (willer and lernoud, 2017). Madhya Pradesh ranks first among the highest area under organic farming followed by Himachal Pradesh and Rajasthan. The following components are the efficient tactics to counteract the activities of pest against the crop.

1. Trap crop

It refers to the cultivation of two or more crops in which the insect pest are towards the crop grown as a trap other than the main crop. This protects the main crop from the harmful activities of the pest. This method also the population of the natural enemies, preserves the biodiversity and sustains the environment since the use of chemicals are totally restricted. The list in table 1 depicted most efficient trap crop that protects the main crop against a particular pest. Aphids transmits more than 100 viral diseases of which *Myzus persicae* is known to transmit around 150 diseases such as papaya ringspot virus, potato leaf roll virus etc. with the utilization of trap crop for the aphid's activities, the damage can be avoided or maintained below ETL. The most efficient trap crop reported for different aphid species are presented in Table 2.

2. Pheromones

Pheromones are chemicals released by an organism which evoke an intraspecific communication in the population. Pheromones may be of aggregation, trail, epideictic, alarm and sex pheromone, but in insect pest management sex pheromones are well known. Due to their eco-friendly impact in nature they are emerging as an alternative to synthetic chemicals. Sex pheromones are exploited in three ways *viz.,* monitoring, mass trapping and mating disruption. Over 150 species of female insect pheromones have been isolated. The male and female sex pheromones differ in their property and action. The female sex pheromone acts at a longer range; the male sex pheromones on the other hand act at short range (Ganai *et al.,* 2017). Although, only few pheromones have been isolated, they play a vital role in controlling many key insect pests which are known to cause havoc in every cropping season. For example, *Scirpophaga incertulas* have been reported to cause yield loss of about 1-19% in early planted and 38-80% in late transplanted rice crops (Seni and Naik, 2017). In India, it has been reported that yield loss of around 52 % is caused by *Plutella xylostella* in cabbage (Devi and Tayde, 2017). The following pheromone lures (Table 3) are currently being developed by Pest Control India (PCI).

Fifty traps /ha was found effective in annihilation of males of *H. armigera* in pigeon pea (Shah *et al.,* 2015). Satpathi *et al*. (2017) also reported the highest yield of 53.98 q/ha in treatment comprising of mating disruption against 40.80 q/ha in control against rice stem borer. Pheromone trap resulted the lower infestation (4.20, 8.82, 9.31% DH and 9.41% WEH) caused by rice yellow stem borer than that of the untreated control (4.88, 23.75, 27.68% DH and 22.72% WEH) at 15, 30, 50 and 90 DAT.

3. Essential oils as Green pesticides

The term "Green pesticides" includes all natural materials that can reduce the pest population and increase food production. Consequently, EOs playing an vital role of pest control in organic food production globally (Abdel, 2016). Essential oils comprises of different chemical composition such as acetonic, aldahydedic, ester, etc that reacts differently and synergistically (Libs and Salim, 2017). Essential oils are known to have neurotoxic, cytotoxic, phototoxic and mutagenic action and the essential oils act at multiple levels in the insects due to which the possibility of developing resistance is low.

Conclusion

The above sustainable approaches have high active against insect, mite and nematodes. As such, they are considered as potential crop protectants crop protectants and for pest management in other situations (e.g. urban pest control). Current information indicates that they are safe to the user and the environment. Integration of all the methods as a viable component in IPM can result in satisfactory control of target pest without hazard to the crop and the environment in the long run.

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Applications of Simulation Modeling in Insect Pest Management

Arya, P. S., Subhash Chander and Prabhulinga, T.

Insect pest management can be described as a method to eliminate or reduce the population of undesirable insects. It deals with insect pests, its natural enemies and non-target species which are interrelated, subject to man-made production-intended interferences under varying weather conditions (Teng and Savary, 1992). Later, by the introduction of synthetic pesticides, the focus of pest management strategy shifted towards managing a particular insect pest with wide-spectrum insecticides, without considering other agro ecosystem components. This method was responsible for many problems related to pest management and the environment which resulted in the development of integrated pest management (IPM). The goal of IPM is to incorporate methodologies across all crop protection domains in a way that is consistent with crop production. In short, IPM can be called as applied ecology. Developing an IPM package demands detailed scrutiny of the system and in some cases, it may lead to the development of new management strategies by defining points of intervention (Pinnschmidt *et al.,* 1994).

With the advent of information technology, many tools were developed to resolve agricultural issues; crop growth simulation modelling is one among them. Simulation models are mechanistic models, which focus on quantitative knowledge of the underlying biological and chemical processes, crop physiological attributes, meteorological factors, pedological factors and incorporating the effects of pest, and their management factors on the crop growth and yield. These are knowledge-intensive tools and are universal, which can have limited as well as global applications (Chander *et al.,* 2007). Along with other system approach tools, they set up a shield for the incorporation of knowledge which can benefit several stakeholders (Aggarwal *et al.,* 2004). Crop growth simulation models like MACROS, CERES-RICE, CROPGRO, ORYZA, ALFAPRO2, SUCROS, WTGROS and INFOCROP were developed to look into the opportunities for increasing crop production. Advances in simulation modelling have also influenced integrated pest management (Chander *et al.,* 2007). Before 1960s, much of the research on pest management was done with empirical models. Some simulation models on population dynamics of single species were developed in 1970s and early 1980s. Later, population dynamics models comprising two trophic levels (pest species and natural enemies) were developed (Teng and Hofer, 1991). Later, decision support systems (DSS) started to advance with the incorporation of socio-economic and crop factors into pest models. A decision support tool in its simplest form is economic threshold level (ETL) and a computer system capable of integrating databases, algorithms and simulation model could be its advanced form (Teng *et al.,* 1998). Coupling of crop growth simulation models with pest effects at the physiological level has made great improvement in modelling crop – pest interactions, but a population dynamics part was missing in those coupled models. On the other hand, pest-crop models developed simultaneously, where crop and pest could influence one another dynamically (Pinnschmidt *et al.,* 1990). Further approaches have integrated the characteristics of the natural enemy component to pest–crop models. Research on pest management is essential to develop tools for enhancing pest management approaches. Such tools and decision models can be produced with the help of simulation models. In addition, simulation model development, analysis and evaluation are the common components of the system approach in pest management (Teng and Savary, 1992). Multifactor interactions in agro ecosystems can be analyzed with crop-pest models which relay on ecological processes and crop physiology and thus can have several other applications in pest management (Chander *et al.,* 2007). Some of the applications of simulation modelling in insect pest management are discussed below.

Determination of economic injury level (EIL)

Economic Injury Level (EIL) is defined as the minimum pest population density, which can lead to economic loss and Economic Threshold Level (ETL) is the level of pest population at which management measures needs to be taken, so as to prevent it from entering EIL. One would appreciate while learning how EIL is determined through simulation models. First of all, EIL is defined and then the ETL is set at a lower level than EIL, based on the pest multiplication rate. A desirable benefit-cost ratio could be attained by applying management measures at ETL. This means that, if we implement control measures at ETL, at least the cost of control is offset by the value of the crop spared from pest damage. It also leads to the judicious application of pesticides, which in turn reduces expenditure and pollution.

EIL can be determined with the use of crop-pest models. EIL is a dynamic entity that may vary with the growth stages of the plant or with geographical location or with the cost of control measures or with the market price of produce (Archer, 1994). The estimation of EIL by field experiments for various areas with different management measures and market conditions is a tedious job. However, EIL can be determined easily for many combinations of different variables, using a validated crop-pest model. For example, EILs of citrus rust mite (Allen, 1981), rice leaf folder (Satish *et al.,* 2007) and rice brown plant hopper (Sujithra et al., 2011) were determined with models. Similarly, simulation models can be used to determine EIL for multiple pests that infest the crop at the same time.

Rationalization of Pesticide Use

Coupled crop-pest models could be used for generating iso-loss curves. Iso-loss curves display different crop age and pest intensity combinations which result in the same amount of yield loss. For example, iso-loss curves were simulated in the case of rice stem borer (Reji *et al.,* 2008) and rice plant hoppers (Yadav and Chander, 2010). These curves can then be used in the pest monitoring programme. They also aid in the need-based implementation of management measures and prevent unwanted pesticide applications.

Risk analysis

Risk analysis is conducted to determine the probable damage by exotic pests if they are introduced into non-native regions. For example, in several countries, Hessian fly (*Mayetiola destructor)* is a very serious wheat pest but so far, it's not found in India. The entry of the pest into India by quarantine negligence may lead to havoc in the production of wheat. This can be measured using model simulation. It is not possible to intentionally carry the foreign pests under quarantine to other countries for testing its damage potential. In such cases, models can be very useful *i.e.* for assessing certain conditions where the exact fieldwork with pest might not be possible. SOYRUST, the soybean rust model predicts potential areas for soybean rust epidemics when operating with continental USA weather data (Yang et al., 1991). The losses incurred due to rust epidemics were calculated by linking model-produced disease estimates with the soybean crop model.

Pest Management Information System

Even though principles for developing information systems for pest management are well-founded, its adoption by farmers appears to be generally low. The farmers need an IPM system addressing multiple pests simultaneously because of the prevalence of several pests at a time in the field. There are only a few IPM programs that address different kinds of pests. Efforts have to be made to build a pest management programme which involves close participation of the farming community. Rather than using complex pest simulation models, the information system can include simpler simulation outputs such as EIL and iso-loss curves.

Ecological Pest Zoning

Pest zoning is a term especially applicable for the management of pests of large areas. The population dynamics model of pest can be used to find out the area of the same pest incidence potential in a region (Yuen and Teng, 1990). For example, it was possible to predict the regions of Haryana with a low, moderate, or high incidence of rice leaf folder (Chander *et al.,* 2006). Areas with the same potential for pest incidence need not be in continuity. The Pest Zonation protocol is as follows.

The pest population-weather model is developed based on long term pest incidence and weather data from a location. It then predicts the likelihood of pest outbreaks for the location. However, model results can be extrapolated to the whole region/state with the geographic information system (GIS) based on the historical weather data of different weather stations in the region/state. As a result, region/state is divided into zones of equal pest incidence potential based on the pest-weather relationship of a single location. Before the advent of GIS, such studies were not possible and pest-weather relations could be analyzed for individual locations only. Awareness of the occurrence of pests in different zones will aid in selecting suitable crop varieties (Chander *et al.,* 2007). This will also assist extension personnel in choosing suitable management solutions for various areas. Identification of pest hot spots will also be possible.

Climate Change Impacts on Crops and Insect Pests

It has been reported that global temperature and CO_2 are increasing since many decades.

This is likely to continue, which will affect the earth's climate. The increase in temperature and CO_2 will both influence crop growth and pests (Chander *et al.,* 2007). The effect of anticipated climate change on crops over successive decades can be simulated using crop-pest simulation models. Likewise, the effect of climate change on pests can be measured with the population dynamics model. The ultimate impact on agricultural production will rely on crop-pest interaction.

Pest forecasting

Pest populations can be anticipated using population dynamics models. In mathematical equations, these models represent various phases of pest growth such as egg, larval, pupal, and adult development. The size of the pest population in various stages can be predicted by running these models with weather data of a region. Hence, these models can play an important role in timely pest management.

Conclusion

Crop growth simulation models have contributed in improving the efficiency of field research by its wide range of applications in pest management. Earlier the applications of crop growth simulation models were limited, but later with the availability of data on the various attributes these models have got many applications. These simulation models have been applied in various areas of research *viz*., to study the impact of climate change on crop yield and pest occurrence, transgenic environmental impacts, pest forecasting, and sanitary and phytosanitary pest risk analysis. Even though the decision support system in pest management has developed from a simple decision tool to an optimization software with several criteria, for the convenience of users, a decision support system based on the simulation model needs to be developed.

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Architectonics of Stingless Bee Nest

Deeksha, M. G., Mahesh Jadhav, Niraj Guleria and Sandeep Kumar

Insect a ubiquitous critter has been encroached every corner of this tellurian. They are immensely diversified, thus making them to evolve more distinctly among themselves to survive by overcoming their stumbling block. There are some insects which are more advanced in their behaviour where they show socialism.

One among them is stingless bees, these are tropical and subtropical eusocial organism belongs to the subfamily Meliponinae, of the family Apidae. Worldwide there are more than 500 species of stingless bees taxonomically identified (Michener, 2007). This stingless bees have organised system on division of labours and work cordially in their nest. Their colony strength depending on species varies from several hundreds to lakh individuals (Wille, 1983). Commonly these bees are called stingless bees, as females have weak or vestigial stinger. In order to protect themselves from their anthropogenic foe they show belligerent nature by wreaking mild bite with mandibles, cause skin irritation by emanating caustic substance from mouth and crawl into nostril or ears of violator (Bhatta *et al.,* 2019; Roubik, 2006).

The nesting behaviour of stingless bee play cardinal role in visualising the stingless bees activity. The nest of stingless bee is a complexly organised and made from cerumen (a mixture of collected plant resins and wax produced by the bees on the dorsal side of their abdomen), other building materials like mud, vertebrate faeces, plant fibres and chewed leaf materials are also used for nest construction. The nesting design, both interior and exterior depends on the stingless bee species. Nest site preferred by stingless bees are hollow trees (Fig. 1a), on the ground, or occasionally in active colonies of social insects like termites, ants, wasps or other stingless bee colonies (Willie and Michener, 1973).

Archetypal design of nest has compartments like entrance, waste and resin dumps, batumen, brood cells, involucrum and store pots. Nest entrance act as a bridge between external environment and internal cavity of the nest and are built by the soil matter, dried plant materials and resin. In the nest entrance waste and resin substances are dumped (Fig. 1b) (Bhatta *et al.,* 2019). This resinous substance collected by bees from plants producing yellow coloured sticky materials, upon which nest wastes like excreta, dead bees or part of them, parts of brood, cocoons are deposited. The resins are also used to repair the nest if any cracks are found (Fig. 1c). The outermost covering, i.e., the interior wall of stingless bee nest is coated by batumen (Fig. 1d). It is made up of resin, mud and wax which has many roles like helping to size up the hive volume, temperature regulation and protection from rain (Divya *et al.,* 2016). The most executed part of nest is the brood cells, which occupy the heart point in nest and are divergent in

Fig. 1. (a) Dwelling of stingless bee on wooden log, (b) Nest entrance with waste and resin substances, (c & d) Resin and Batumen on interior wall of nest, (e & f) Brood cells and Involucrum, (g & h) Store pots, honey and pollen pack.

their shapes like spherical, ovoid and columnar depending on species (Fig. 1e) (Roubik, 2006). In this region worker bees as a skilled mason gives a strong foundation for brood cells by constructing wax pillars (Divya *et al.,* 2016). The brood region is surrounded by lamellar sheaths of involucrums which act as a passive thermoregulation system in nest (Fig. 1f) (Bhatta *et al.,* 2019). The number of layers and structure of involucrum varies according to the changes in external environment in order to maintain the internal brood temperature (Divya *et al.,* 2016). Outside the brood chamber, the food pots consisting honey and pollen collection are located. These food pots are comparatively many times larger than brood cells, where gazillions of pollens and millilitres of honey are packed and stockpiled (Fig. 1g&h) (Bhatta *et al.,* 2019).

Thus, by following this idiosyncratic way to build their nest according to the species requirement, stingless bees act as an artisan of their own perennial nest. This evince that this tiny creature has sensibility within them to prudent enough to own their well-being.

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BDR-10, a Newly Authorized Tropical Tasar Silkworm Race: Its Maintenance, Mass-Multiplication and Popularization in India

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Tropical tasar silkworm, *Antheraea mylitta* (D.) (Lepidoptera: Saturniidae) is an endemic wild silk fauna in India. It is distributed in the Chhota Nagpur Plateau, Central, South and Eastern parts of India. In addition to *A. mylitta*, other silk-producing species under the genus *Antheraea* are *A. assamensis* Helfer (muga silkworm), *A. compta* Rothschild, *A. frithi* Moore, *A. pernyi* Guerin-Meneville (Chinese oak silk moth), *A. roylei* Moore, *A. helferi* Moore, *A. knyvetti* Hampson, *A. andamana* Moore and Indian oak silk moth *A. proylei* (*A. roylei* × *A. pernyi*) are also recorded in India (Arora and Gupta, 1979; Jolly, 1980; Moore, 1877). Among them, *A. mylitta* and *A. assamensis* are economically most important wild-fauna in India, as they produce cocoon (silk) of commercial value during the larval stage of their life cycle. *A. mylitta* is holometabolous and polyphagous insect with the specific seasonal activities (Fig. 1). Its eggs are oval and creamy white to yellowish in colour similar to jowar grain size. The caterpillars are polymorphic (Chandrashekharaiah *et al*., 2020A) having green type as a dominant over yellow, blue and almond (Jolly *et al*., 1969). *A mylitta* behaves like a univoltine or bivoltine (BV) or trivoltine (TV), depending on the elevation and climatic conditions (Jolly *et al*., 1969). The final stage of caterpillar (pre-pupae) spins a silken cocoon around itself and transform into a pupa. Adults are with reduced mouthparts and digestive system. They are phenotypically highly variable with prominent sexual dimorphism (Chandrashekharaiah *et al*., 2020A).

A. mylitta is known to have many eco-races. Among them, the DABA eco-race is a semi-domesticated tasar silkworm, amenable for human handling and largescale commercial rearing. Since *A. mylitta* exhibit polyphagy, a striking color variation is evident at the larval and adult stages, which may relate to mimicry or cryptic nature against predators and to overcome various abiotic pressures (Endler, 1978; Forsman *et al*. 2015; Chandrashekharaiah *et al*., 2020A). The larval color polymorphism in *A. mylitta* is governed by dominant and recessive genes (YYbb-yellow, yyBB-blue, YYBB-green and yybb-almond) and follow the Mendelian theory of inheritance (Jolly *et al*., 1969). The larval body color of *A. mylitta* is determined by the dominant and

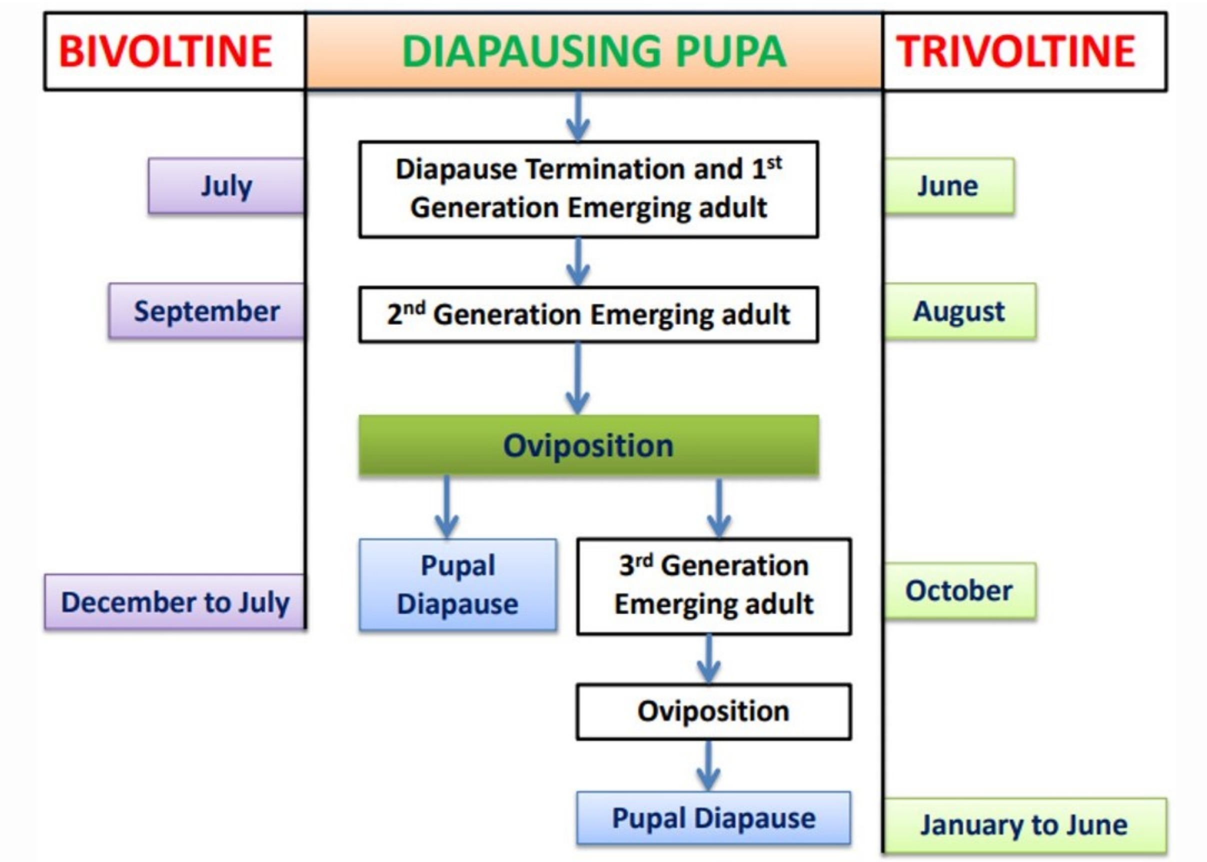

Fig. 1. Seasonal emergence pattern of *A. mylitta* in the DABA BV and TV

recessive genes. The green and almond larval types are genetically homozygous dominant and recessive in nature, respectively. The occurrences of green larval types are very prominent under natural conditions due to natural mimicry mechanism. On the other hand, almond larval types very rarely occur, due to strong predator pressure. The blue and yellow types are heterogeneous with variable resistance capacity against pathogens and environment variabilities. Relative allele frequencies do not change over a successive generation as per the Hardy-Weinberg equation. But, deviation in phenotypic ratio under natural conditions might be related to segregation, predation pressure, host-associated mimicry and environment (Mallet and Joron, 1999).

Development of BDR-10

In the year 1999, nearly 400 final instar yellow color larvae (Fig. 3A) were selected during the rearing of II crop DABA-BV (bivoltine) at Basic Seed Multiplication and Training Institute Boirdadar, Chhattisgarh. The selected larvae were reared separately and preserved for DFL (disease-free laying) preparation. Around 50 DFLs were prepared in the subsequent season from this stock. Further, these DFLs were reared and multiplied for 26 generations separately by following strict mass selection process at larval (color), pupal (weight) and moth (fecundity) stages. Finally, a new breed with phenotypically yellow body color larval type was developed and named as BDR-10.

Due to alfresco tending exercise of larvae, while rearing under outdoor conditions, the fitness may vary relatively in comparison to natural selection. The phenotypic variability also alters due to the

Fig. 2. BDR-10 adult moths (A&B) with different color polymorph and early-stage larvae (C). The sitting posture of the early emerged moths before wing expansion (A) and fully wing expanded adult moth (B).

quality of host plant and environmental factors. Strict selection imposed for economic characters at larval, cocoon and moth stages during rearing and seed production process might have led vicissitudes trait frequency over a period, which needs to be studied. Human interfered alteration of traits, through directional and random selection, alters fitness and eventually lost its wildness. The field observation on the phenotypic variation within the BDR-10 stock revealed that the majority of the worms with yellow body-color (96.75 %). In the remaining population, the phenotypic variation in the body color like the olive color (Fig 3B), apple-green (Fig. 3C) and green (Fig., 3D) types were recorded under outdoor rearing conditions. During early stage, almost all the larvae were yellow in color. Some larvae, after second instars, were turned into green types. However, such off-type larvae were further transformed into olive and apple-green color during fifth instars stage.

Economic characters of BDR-10

The BDR-10 cocoon, pupal and shell weight ranged from 9.59 g to 14.00 g, 9.60 g to 12.28 g and 1.50 g to 1.95 g, respectively. Correlation analysis also revealed that the cocoon weight, pupal weight, shell weight and silk ratio (%) were negatively influenced by the altitude (Chandrashekharaiah *et al.*, 2019). The clutch size in the BDR-10 varied from 215 to 230, cocoon usually grey color having 900-1100 m filament length, 50-60%

Fig. 3. Phenotypic segregation behavior in BDR-10 race (yellow larval type) under field conditions.

reelability and 60-65% silk recovery (Gupta VK *et al*., 2016). Further, observations indicated that the mortality of silkworm due to different pathogens was comparatively less in the BDR-10 compared to DABA-BV under outdoor rearing conditions (Chandrashekharaiah *et al*., 2020B). The coloration in insects linked to body temperature regulation and intraspecific communication (Brakefield, 1985). Since *A. mylitta* is distributed in the tropical parts of India, it will experience extreme high temperature, winter, predation pressure *etc*. In addition to these, food quality and management practices determine the stability and persistence of stock. Stability of parental stock is prerequisite in tropical tasar silkworm seed production, as its part of the life cycle exposes an outdoor condition while rearing. Greater phenotypic variability is also related to population fitness (Forsman *et al*., 2015). Therefore, the phenotypicvariability at larval and adult stages may help in overcoming effect of various abiotic pressures. But, ecological relevance of color types, the effect of predation pressure and climate change on its fitness are researchable issues for their conservation and economic welfare of rural populace in the tropical tasar sericulture practicing states.

The selection process has to follow for the elimination of off-types like larvae with other than yellow body color during reproductive and diapause seasons, early and late maturing individuals, poor feeding behavior, disease freeness, shell weight and fecundity as per the standard norms during each rearing. This selection process helps to preserve the seasonality, quality and commercial parameters within the stock. The minimum quality parameters observed in the BDR-10 like 1) Fecundity: ≥201; 2) Hatchability: ≥82 %; 3) Cocoon Yield/100 dfls (kg): >52; and 4) No. of cocoons/kg: ≥87.

BDR-10: An authorized race

The BDR-10 registration was published in the Gazette Notification: EXTRAORDINARY {PART II-SEC. 3(ii)} pp no. 4 published by Ministry of Textile, New Delhi, on Friday, June 8, 2018, and the same was authorized by Hybrid Authorization Committee (HAC) of Central Silk Board, on 25/11/2013. Rearing of BDR-10 recommended for the states like Jharkhand, Chhattisgarh, Odisha, West Bengal, Andhra Pradesh, Maharashtra, Madhya Pradesh, Bihar, Telangana and Uttar Pradesh. The crop schedule for brushing of dfls is around 15-20 July and 20-25 September for 1st and 2nd crop, respectively, which are similar to the brushing date followed in and around Raigarh, Chhattisgarh.

Mass multiplication and popularization of BDR-10

Mass multiplication and popularization of BDR-10 were initiated during 2017-18 at Central Tasar Silkworm Seed Station, Kargi Kota, Chhattisgarh through replenishment programme. A total of 9912 BDR-10 cocoons brought from the BSM&TC (Basic Seed Multiplication and Training Center), Boirdadar were processed under the grainage house and nearly 1100 dfls were produced during 1st grainage of 2017-18. Out of which, nearly 800 dfls were reared in the subsequent season. The strict selection was imposed while rearing for quality parameters as per the protocol and standard norms (Alok Sahay *et al.,* 2018) and about 59250 cocoons were produced. These cocoons were processed again during 2nd grainage and produced 22425 dfls. A total of 8950 dfls from this source were supplied to the BTSSO (Basic Tasar Silkworm Seed Organisation) units in Chhattisgarh, Jharkhand, Bihar, Odisha, Madhya Pradesh, Uttar Pradesh and Andhra Pradesh in the biannual replenishment programme for mass multiplication. In addition to these, the units in the states like Maharashtra and Telangana were also covered in the subsequent year. Nearly, 47940, 242524 and 454367 dfls were produced during 2017-18, 2018-19 and 2019-20, respectively (Fig. 4). The cocoon yield and other commercial characters in the BDR-10 have highly convincing compared to DBV in the areas like Kargi Kota, Deoghar, Dudhi, Madhupur, Baripada, Nabrangpur, Pali and Bhagalpur (Alok Sahay *et al*., 2018). Maximum dfls were supplied to the Chhattisgarh, Jharkhand and Odisha during 2017-18 to 2019-20 (Fig. 5). However, the performance of BDR-10 was quite promising in the states like Jharkhand, Odisha and West Bengal.

Considering the importance of BDR-10 over the DABA eco-race in terms of economic characters like higher cocoon yield, disease resistance and acceptance of the rearers in the states like Odisha, Jharkhand and Chhattisgarh. Therefore, it is the need of the hour to further intensify and popularize the BDR-10 among the stockholders in all the states to improve the cocoon productivity.

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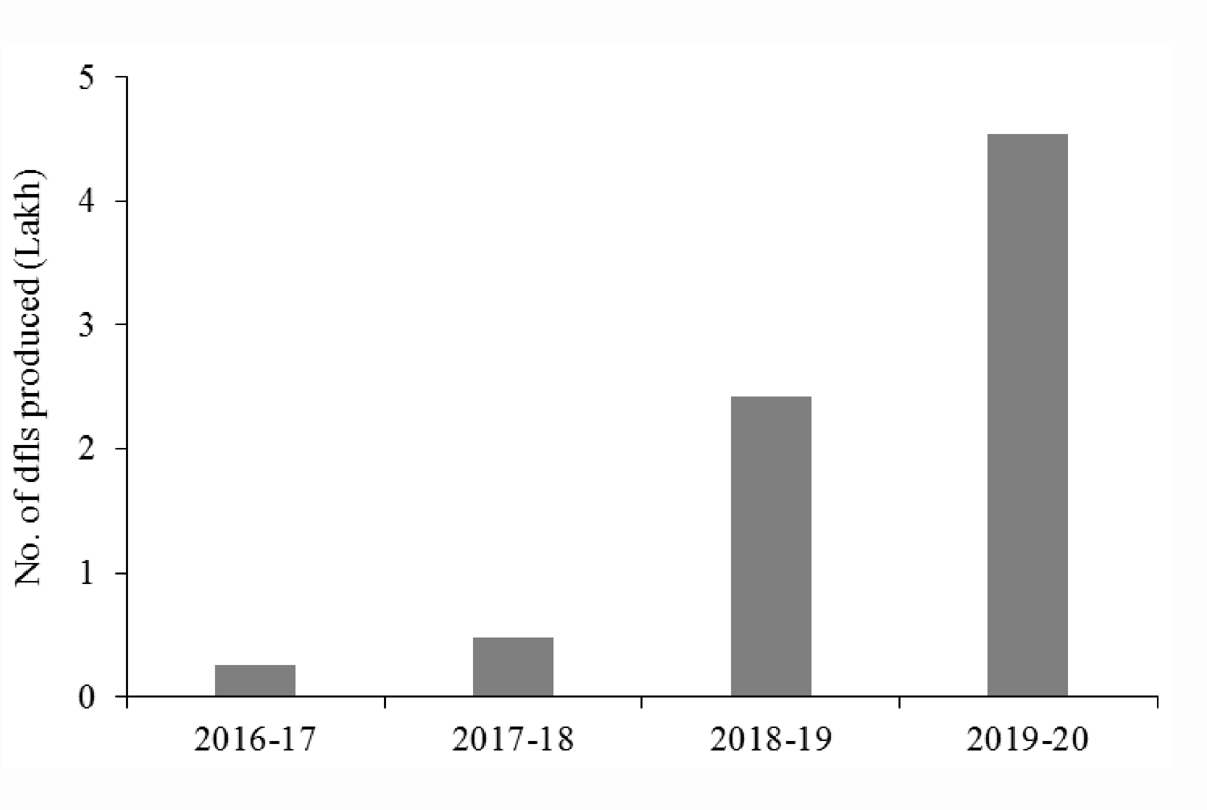

Fig. 4. BDR-10 DFLs produced under mass multiplication programme at BTSSO units during 2016-17 to 2019-20.

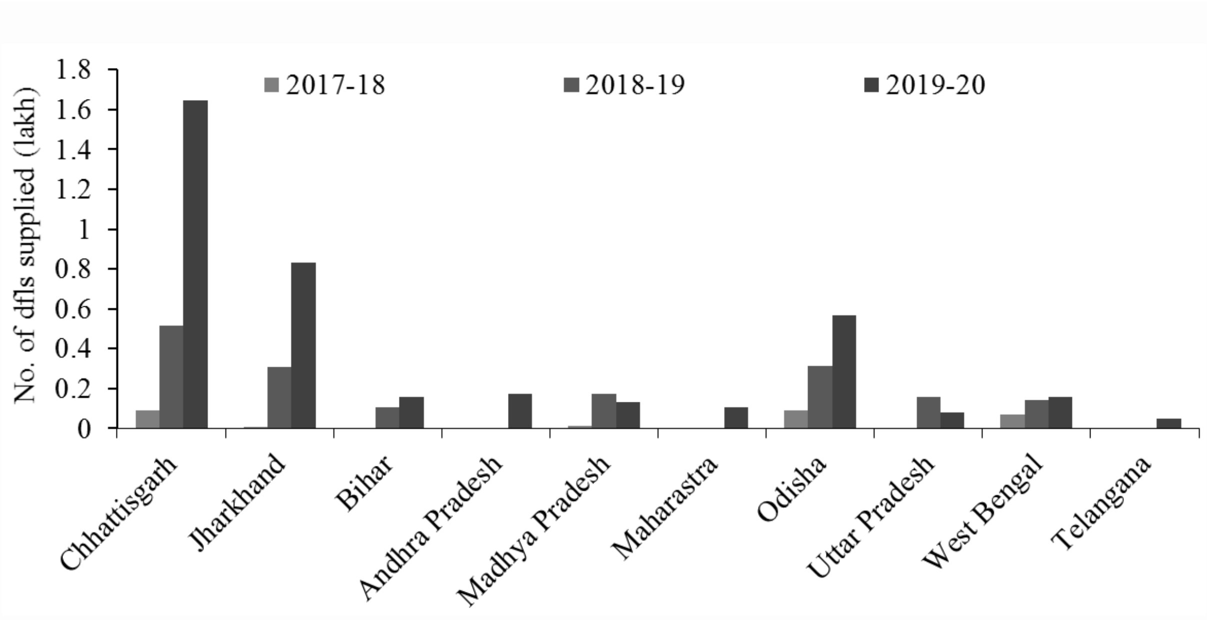

Fig. 5. BDR-10 DFLs supplied to different states during its popularization programme across tasar silk producing states

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Fascinating world of Singing Caterpillars

Harshita. A. P., Muddasar and G. S. Jamunarani

Abstract: Butterflies are one of the most beautiful as well as mesmerizing creatures on earth, comprising nearly 17,500 species around the world. They belong to the order Lepidoptera in the superorder Endopterygota. They undergo complete metamorphosis (Holometabola) consisting of egg, larval (caterpillar), pupal and adult stages. In the life cycle of butterfly, immature larva and pupa are the most vulnerable stages to natural enemies. They are eaten by various insects and non-arthropod predators. Therefore, different species of caterpillars have evolved with diversified defence strategies, such as hiding, camouflage, warning coloration, fleeing and deceiving to avoid predation. Interestingly, some of them have symbiotic association with ants to escape from their enemies. This phenomenon is more evident in singing caterpillars.

Key words: Symbiosis, association, singing caterpillar, Lycaenidae, Riodinidae.

What is symbiosis?

German botanist and biologist, A. B. Frank coined the term symbiosis in 1887. It comes from two Greek words that mean “with” and “living”. In 1879, a well known German mycologist Anton de Bary defined symbiosis as "the living together of unlike organisms". It is a kind of association between organisms of two or more different species which live in close organization, where one or both associated organisms are benefited. Each member in a symbiosis is termed as ‘symbiont’. If both the symbionts are benefited in an association, then it is called as ‘mutualism’. Some caterpillars belonging to Lycaenidae and Riodinidae families have evolved mutualistic relationship with many ant species.

Diversity of Lycaenidae and Riodinidae

Butterflies are grouped into six families namely, Papilionidae, Lycaenidae, Nymphalidae, Pieridae, Hesperiidae, and Riodinidae. Among them, Lycaenidae is the second largest family comprising nearly 6,000 species of butterflies including blues, coppers, hairstreaks and harvesters. Riodinidae constitutes nearly 1,500 species including metalmark butterflies. Majority of the species belonging to these two families are called ‘singing caterpillars’.

Why they are called singing caterpillars?

Caterpillars and pupae of some Lycaenidae and Riodinidae families produce substrate borne vibrations to call ants for their protection from predators and parasitoids. Caterpillars not only use chemical signals produced by myrmecophilous secretary organs such as pore cupola (present on skin of caterpillars), tentacles (present on the eighth abdominal segment of Lycaenidae and Rionididae), and dorsal nectary glands (located on the dorsum of the seventh abdominal segment of Lycaenidae) as mode of communication with ants, but also produce substrate vibrations through non secretary organs. These substrate vibrations resemble acoustic sound, which helps in attracting ants. Hence the name, "singing caterpillars." The term singing caterpillars was coined in 1997 by tropical biologist Philip James DeVries.

Fig. 1. *Oecophylla smaragdina* attending *Zesius chrysomallus* (Lycaenidae) caterpillar (Photo credit: Ashley Shaji)

Organs associated with sound production

Caterpillars of Lycaenidae start producing characteristic sound from the beginning of third instar. The organ of sound production within the family is poorly understood. They produce low amplitude, substrate borne sounds to call ants. In most of the cases, calls are similar to that of slow drumming sound. Pupae produce sound by stridulation of file and scraper found in inter segmental region of abdominal segments 4 - 5, 5 - 6 and 6 - 7.

In case of caterpillars of Riodinidae, a pair of specialized non secretary organs, vibratory papillae is present on the distal edge of prothorax. Throughout the length of these vibratory papillae distinct concentric grooves can be marked. Whenever caterpillar oscillates head, epicranial granulations present on head region slip across the concentric grooves, producing low amplitude sounds. Pupae produce calls by stridulation of two set of file and scraper, which are present between 4^{th} and 5^{th}, 5^{th} and 6^{th} abdominal segments.

Caterpillar- ant association

According to the studies, association of Riodinidae and Lycaenidae caterpillars with ants is very important for their successful completion of life journey without which the survival of caterpillars is very rare. Hence, it is crucial for caterpillars to maintain symbiotic relationship with ants as guards against their natural enemies. Caterpillars attract ants by offering amino acids and sugar secretions as food source. Ants attend these caterpillars to collect the secretions and their presence deters natural enemies from caterpillars. As a result, caterpillars of Lycaenidae and Riodinidae get protection. A list of a few singing caterpillars associated with ant species is enclosed in Table 1.

Conclusion

The association of singing caterpillars with ants has become a lifesaving strategy. The associated ants make the life of these caterpillars easier by protecting them from their natural enemies. While ants, in turn, get sugary honeydew secreted by singing caterpillars as a supplementary food source.

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Table 1. Examples of few singing caterpillars associated with ant species

Caterpillar	Associated ants	Reference
Riodinidae		
Eurybia elvina *Alesa amesis*	*Brachymyrmex musculus, Paratrechia sp., Pheidole gouldi, Solenopsis geminate*, *Wasmannia auropunctata*, *Crematogaster sumichrasti Camponotus femoratus*	Horvitz *et al*., 2016
Cupido minimu	*Myrmica schencki Lasius niger*, *Myrmica rubra*	Emmet and Heath, 1990
Lycaenidae		
Cigaritis zohra	*Crematogaster laestrygon*	Rojo, 1990
Cigaritis ardilla	*Crematogaster auberti C. antaris C. scutellaris*	
Cigaritis myrmecophila	*Crematogaster auberti*	Hinton, 1951
Lycaena dispar	*Myrmica rubra*	
Lampides boeticus	*Lasius niger*	
Thecla betulae	*Lasius niger*	Emmet and Heath, 1990
Quercusia quercus	*Lasius sp.*	Kitching and Luke, 1985
Tomares ballus	*Plagiolepis pygmaea*	Chapman and Buxton, 1919
Satyrium ilicis	*Camponotus aethiops*	Malicky, 1969
Satyrium esculi	*Camponotus cruentatus*	Martin and Gurrea, 1983

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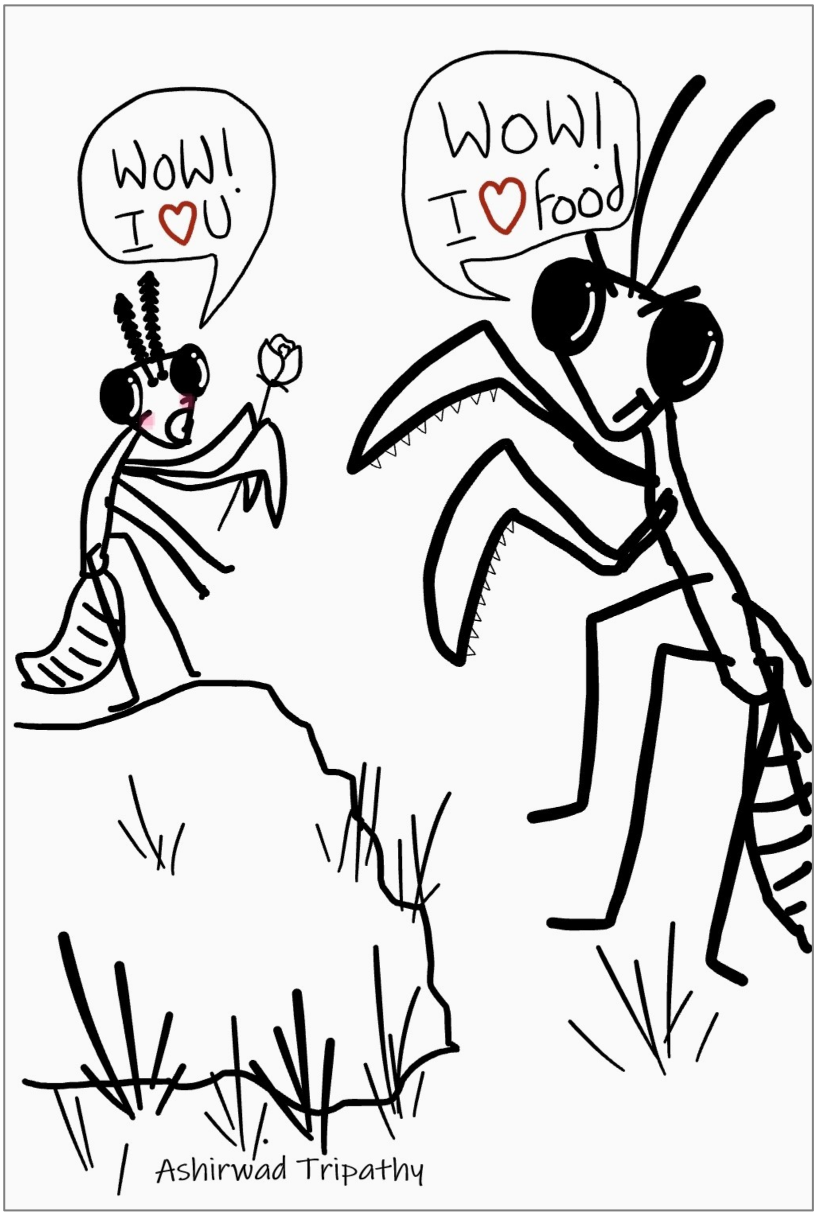

Notes on Displays of Violin Mantis

Ashirwad Tripathy

Praying Mantis (Insecta: Mantodea), holds a significant place in the ecosystem as predators. They mainly feed on grasshoppers, moths, butterflies, flies, beetles and are well adapted to their environment by camouflage and mimicry. They have attained their common popular name from the way they raise their two fore legs in a posture of prayer. They are often found waiting still for hours for their prey with their heads rotating 180°. They are diurnal and are attracted to lights at night. There are around 2300 species of mantids under 434 genera all over the world. From India 162 species of mantids under 68 genera belonging to six families were reported.

Almost all mantids, regardless of the family they belong to, show a cryptic colouring and behaviour that allows them to being unnoticed by other organisms both prey and predators. Some mimics flowers while some mimics dry leaves. Also, some have cryptic colouration on the body which scares the predator out. They have poor flying ability and are generally seen sitting on herbs, shrubs and trees. Therefore, they generally mimic plant structures or parts to camouflage in its environment. There are two families of plant mimicking mantis belonging to Empusidae and Hymenopodidae. The family Empusidae consists of two subfamily Blepharodinae and Empusinae of 10 genera and 30 species. Under the subfamily Empusinae, tribe Empusini four genera are present i.e., *Dilatempusa* Roy, *Empusa* Illiger, *Gongylus* Thunberg, *Hypsicorypha* Krauss. Among the genus Gongylus three species are present worldwide namely *G. gongylodes* L., *G. pauperatus* Fabricius, *G. trachelophyllus* Burmeister (http://mantodea.speciesfile.org).

Globally, *G. gongylodes* is distributed in India: Andhra Pradesh, Kerala, Maharashtra, Odisha, Tamil Nadu, Uttar Pradesh, West Bengal and Madhya Pradesh; Java; Malaysia; Myanmar; Nepal; Sri Lanka; Thailand. Out of three species present globally, two species of *Gongylus* is present in Odisha i.e., *G. gongylodes* and *G. trachelophyllus*. Here, description of defensive behaviour of *Gongylus gongylodes* L. (Empusidae: Empusinae) was made in R. Udayagiri Range (19°09’22.1’’N & 84°08’41.8’’E) of Parlakhemundi Forest Division, Gajapati District, Odisha, India.

Below the description of defensive behaviours recorded and reviewed in praying mantids were listed as follows. Frightening attitude in *Mantis religiosa*, *Stagmomantis* spp., Curious Behaviour of *Eremiaphila braueri*, Complex Combined Display (Curious posture, menacing movements, sounds, bright colours) in *Hestiasula sarawaka*, Simple Combined Display: A) Raised wings and Tegmina, foreleg spread and sway in *Deroplatys shelfordi*, *Gryllacris*, and *Theopropus*. B) Flattened coloured forelegs, but not the white mark under tegmina in *Deroplatys* *desiccata*. C) Plain foreleg and does not display at all in *Tenodera superstitiosa.* Adaptive Colouration in *Pseudocreobotra wahlbergi.* Floral Simulation in *Gongylus gongylodes* and *Idolum diabolicum.* Deimatic Reaction in *Stagmatoptera biocellata*.

Deimatic behaviour is designed to terrify predators and prevent them from attacking. It typically involves the display of some conspicuous colour or structure. It has also been called 'dymantic', 'frightening' or 'startle behaviour'. Deimatic displays cause attacking predators to hesitate, and perhaps withdraw, thereby giving the prey animal a chance to escape. It occur in both aposematic and cryptic animals so that they can be either a genuine warning of unpleasantness or a bluff.

Many large praying mantids and phasmids have dramatic deimatic displays. These insects are typically cryptic but, if disturbed, they expose previously hidden brightly coloured hind wings in a static display which is maintained for perhaps a minute or more. Large mantids also often expose bright colours on the inside of the forelegs and they may stridulate by rubbing the abdomen between the raised wings making a hissing noise.

The *Gongylus gongylodes* has fascinated entomologists for a long time. In fact, it was the first mantis described by Linnaeus in 1758. *Gongylus* prefers bushes and shrubs in hot areas of South-East Asia.

Gongylus Thunberg is considered to be a floral simulator and shows an impressive defensive behaviour. As in all Empusids, the anterior edges of the forewing are serrated. So, when disturbed, *Gongylus* rubs them against the femora of its hind legs, thus producing a hissing noise. Floral simulators mean that these mantids mimics a flower to confuse its prey. So, when a prey approach to sit or feed these virtual flowers the mantis grab and feed on it. Meanwhile, if *G. gongylodes* gets disturb it shows a dancing movement in which the mid leg and hind leg are fixed and the central axis of the body moves left and right with the raptorial legs folded and faced anteriorly. The prothorax resembles a stem and swaying sideways movements which mimics a flower moving in the wind (Fig:4). This movement is said to attract prey (insects, including butterflies).

Defensive posture shown to scare a predator or superior organism. The deimatic behaviour observed here as the raptorial legs crossed and enclosed towards the central axis of the body in a 'V' shape for 10-12 sec. Later it opens up this crossed position of raptorial legs upwards to form a 'W' shape formation which exposes a black spot on the ventral white surface of the thorax 8-10sec (Figs. 1-3). If that expression doesn't work it raise its raptorial legs upwards and waves from left to right and vice versa to scare the opposer. In this defensive behaviour the interesting thing to notice is that the mantid does not opens its tegmina or extend its forelegs to either side to increase the apparent size of the body. Rather it waves the raptorial legs in upward position from left to right and vice versa. Also, as earlier recorded that it rubs its tegmina with femora of its hindleg which produces hissing noise when disturbs, but here no hissing noise was observed. This kind of deimatic behaviour was not recorded in violin mantis earlier rather only floral simulation was recorded.

Figs. 1-3. represent the sequence of 'Deimatic behaviour' of female *Gongylus gongylodes*

Fig. 4. Swaying movement of *Gongylus gongylodes*

From the above study it can be concluded that there are still much more to discover in the defensive behaviour of the mantids. It is necessary to understand behaviour of an organism to understand its evolutionary linkages with other organisms.

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Fig. 5. Adult of Female *Gongylus gongylodes*

Fig. 6. Nymph of Female *Gongylus gongylodes*

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Pin Prick Method: An easy, viable and cost effective assay for screening hygienic stock of *Apis mellifera* Linnaeus

Bharathi Mohindru, Amit Chaudhary, Pardeep K. Chhuneja and Jaspal Singh

Beekeeping in India is an age-old practice; however, with the introduction of *Apis mellifera* Linnaeus, it has attained a status of commercial and industrial activity. Besides providing multitude of useful hive products, also contribute immensely vital ecological service i.e. pollination. Successful beekeeping and attaining high productivity depends upon the various bee husbandry practices. Among these, maintaining the health of a honey bee colony is a major aspect. Honey bees are highly social organism, headed by a queen bee whose prime function is to lay eggs. Hence, the qualities, especially, the behavioural traits like temperament, colony build-up, industriousness, resistance to pests and pathogens, tendency to swarm and abscond, etc. are passed onto progeny from the queen bee. Thus, the qualities inherited by a queen determine the performance of its colony.

Like other organisms, honey bees are also exposed to various pests and pathogens maladies. These cause the decline in colony growth performance and ultimately may lead to colony losses. One such example was the outbreak of the ectoparasitic mite, *Varroa destructor* Anderson and Trueman in North India in 2004-2006, which took a heavy toll on honey bee colonies.

To cope up pests and diseases, the beekeepers resorted to use of various chemical treatments, which though effective, are also problematic in the long term. Firstly, these chemicals offer only a short-term solution, and development of resistance in pests and diseases against chemicals over a period of use. Furthermore, pesticides can contaminate hive products (honey, bees wax), and some of them may potentially have side effects on the bees. Hence, one should look for an alternative safe and sustainable method to manage these biotic stresses. Breeding of a stock for traits such as natural disease resistance would be an ideal option. However, at present, beekeepers generally select the queens predominantly by their egg laying ability and body size and give only a meager weightage to other important behavioural traits. One such trait i.e. hygienic behaviour should also be utilized, which can benefit the beekeepers in terms of saving the money in managing the biological stresses and thereby help in maintaining stronger honey bee colonies, and ensuring higher quantity and quality of hive products. Unfortunately, this is not a common practice among bee breeders in their selection criteria.

Hygienic behaviour

It can be defined as the ability of bees to detect and remove diseased or parasitized or dead brood from the colony. It consists of two processes: uncapping and removal. Uncapping is the process in which the wax caps covering the brood cells are removed by some worker honey bees upon detecting dead or diseased larvae or pupae inside the brood cells. This is followed by the removal of the dead brood. Hygienic behaviour differs from the grooming behaviour which is the removal of foreign objects and parasites from oneself (auto-grooming) or removal of foreign objects and parasites from another worker honey bee in the nest (allo-grooming).

Significance of hygienic behaviour

Hygienic honey bees have the ability to detect, uncap, and remove diseased brood from their nest before the causative organism reaches the infectious stage. Because honey bees reuse brood cells, diseased brood must eventually be removed from the nest. As the bees eliminate the focal infection from the colony, hygienic behaviour has emerged as a general system of resistance to brood diseases. The colonies that express hygienic behaviour are economically important to beekeepers as this behaviour limits the multiplication and spread of infection within the colony.

Usefulness against *Varroa* mite infestation

Two important mite-resistant traits *viz*. hygienic and grooming behaviour are observed in honey bees. Hygienic behaviour can be used as one of the defense mechanism against *Varroa* mite as it has the potential to limit the mite multiplication. The bees remove the infested pupa from the cell and thus immature mites are left without food and die due to either shortage of food or ambient development conditions which were otherwise present in sealed cells. At times, the mite or its offspring are also removed along with the brood. Thus, the reduction in the average number of offspring per reproducing mite can be attained. Colonies with high levels of hygienic behaviour have a lower build-up of *Varroa* population. The grooming behaviour by the worker bees too leads to the mortality of the adult mites.

Assessment of hygienic behavior

In beekeeping, the traits of economic importance are the result of the behaviour of the whole colony. Therefore, the hygienic behaviour is assessed at the colony level. It is performed by middle aged in-house worker bees of 15 to 20 days old i.e. older than the typical nurse bees but younger than the typical foragers. Among various available assays for measuring this behavioural trait, the pin-killed brood method (Newton and Ostasiewski 1986) is simple, easy, not labour intensive and cost effective.

How to perform pin prick method?

First of all, select the sealed worker brood at pink eye pupal phase. Take out the sealed brood comb and pierce the sealed brood by using a number 1 size entomological pin (Gramacho and Spivak 2003) and mark the pricked area by coloured pins (Fig. 1). Care must be taken that the brood must be pierced by inserting the pin upto the midrib of a comb, thus deliberately killing the brood.

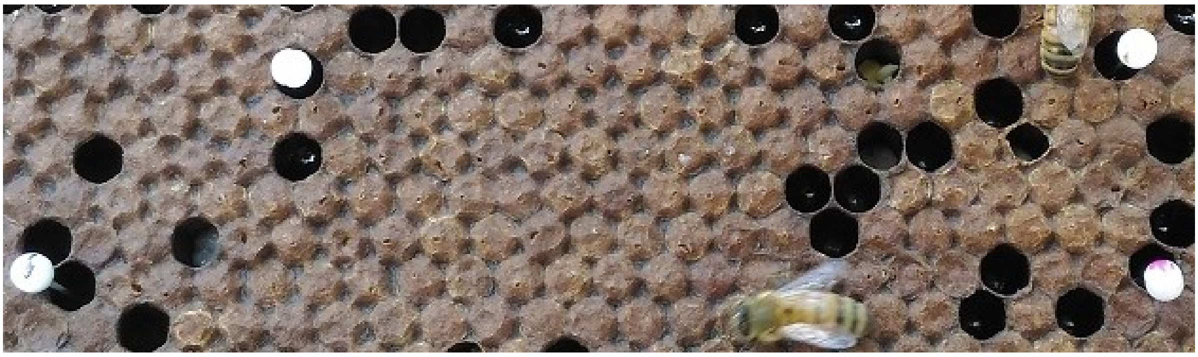

Fig. 1. Mark comb area having 100 sealed brood cells and pin prick the brood cells

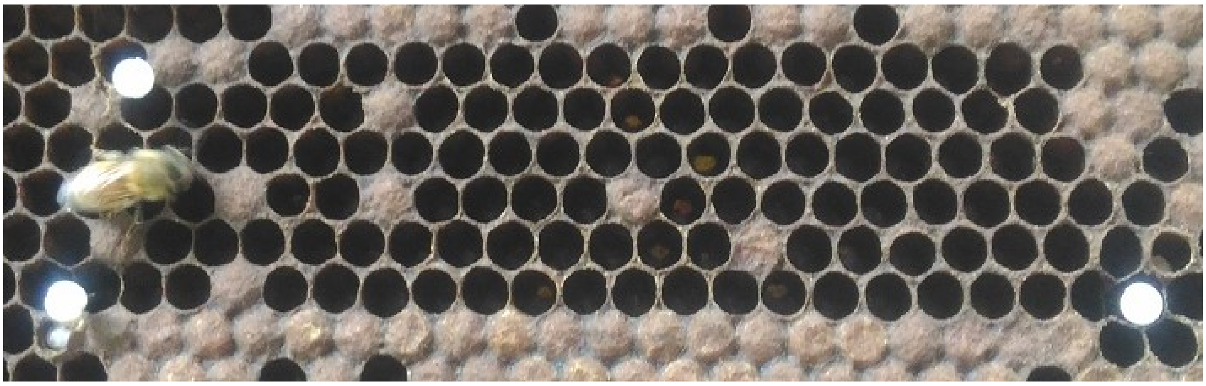

Fig. 2. After 24 h, record the number of cells uncapped and cleared

After pricking, put the comb back into original colony.

Recording the hygienic behavior

Record the percentage of brood removal (opening the cell and removal of pin pricked pupa from it) from each colony after 24 h (Fig. 2). The test in each colony will be performed thrice at 24 h interval to account for the variability in the existing intra-colony sub-families w.r.t. their hygienic behaviour.

Research work conducted at Dr A. S. Atwal Apicultural Laboratories, Punjab Agricultural University, Ludhiana revealed that 45 per cent of the colonies were hygienic (removal of dead brood > 80 per cent) 42 per cent were intermediary (removal of dead brood between 70 and 80 per cent) while 13 were non-hygienic (removal of dead brood < 70 per cent). The hygienic colonies also showed high percentage of removal of brood inoculated with *Varroa* mite (94.33%) as compared to the non-hygienic colonies (69.57%). Hence, the colonies showing mean scores i.e. removal of 80 per cent or more must be selected and marked as hygienic colonies.

Conclusion

Hygienic behavior in honey bees is a heritable trait. Thus, beekeepers can potentially concentrate this in apiary by screening colonies for hygienic behaviour. These colonies can be taken as parent stock for breeding queen bees that express high levels of hygienic behaviour. This can be obtained by performing stock selection ever for high hygienic behaviour in the successive generations. Queens from colonies exhibiting hygienic behaviour can be used as breeder colonies for the next generation of bees. New colonies are made from these daughter queens and again these colonies are screened for hygienic behaviour. Since the hygienic behaviour is a heritable trait, these daughter queens can further be used as breeder queens for the production of next generation queens. Consequently, by performing stock selection every year for this trait, hygienic behaviour can be fixed in the colonies over the time period. Hence, selection for hygienic behaviour should be a routine component of bee breeding.

Overall, hygienic behaviour of honey bees would benefit the beekeepers with no apparent negative characteristics that accompany the trait. Therefore, selection for hygienic behaviour of honey bees to control the brood diseases and devastating mite pests can be an effective alternative to use of antibiotics and pesticides in bee colonies to maintain the colony health and to check contamination of hive products.

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Strategies for conservation of wild bees

K. V. Nagarjuna Reddy and Veereshkumar

Importance of wild bees

When we say bees, most of us think only about the honey bees. A total of 20,507 species of bees have been recorded from the World (Ascher and Pickering, 2020) and nearly 75-80% of crops are pollinated by wild bees and remaining crops are pollinated by honeybees (Allen and Allen, 1990). Contributions of wild bees in pollination have always been underestimated due to our inadequate understanding of their nesting behaviour and more reliance on domesticated honey bees. Several wild bee pollinators are known to be found worldwide, that includes leaf cutter bees, carpenter bees, bumble bees, sweat bees and mining bees, etc. Only a few species of bees have been manipulated by humans to a limited extent for pollination activities (Pitts-Singer, 2008). These non- *Apis* bees are efficient pollinators than honey bees in many crops. Studies have shown that, only one-third of the pollination services are provided by honey bees while the rest is done by wild bees in the United Kingdom (Breeze *et al*., 2011). Garibaldi *et al.* (2013) surveyed 41 crop systems worldwide and found that fruit set increased significantly with flower visitation by honey bees in only 14% of the crop systems and an increase in wild bee visitation enhanced fruit set in the remaining 86% of the crop systems. Visitation by wild bees and honey bees enhanced fruit set independently in different crop systems, so pollination by managed honey bees supplemented, rather than substituted for, pollination by wild insects.

The challenges in utilisation of wild bees for pollination is a management tactics exist only for few species including leaf cutter bees and bumble bees. Leaf cutter bees (Megachilidae: Hymenoptera) have been used in large scale pollination of legume crops especially Alfalfa (Lucerne). The leaf cutting bee *Megachile rotundata* reformed the alfalfa seed industry by boosting its yields from 450 kg ha^{1} (when managed by honey bees) to an outstanding 1300 kg ha^{-1} (Thakur, 2012). This led to the exploration for utilization of other wild bees for their pollination services. In recent decades, there is a decline in the pollinator population due to fire, habitat fragmentation, destruction of natural habitats, and indiscriminate use of pesticides (Potts *et al*., 2010). In this context, the conservation of wild bees is very important to maintain diversified ecosystems.

Conservation efforts

Presence of bee populations with greater abundance and rich diversity is necessary for guaranteed pollination of domesticated crops and wild plants. Wild bees provide millions to the economy of agriculture and their contributions to forests, grasslands and wild flowers though impossible to measure, should not be overlooked (Thakur, 2012). Studies have shown that simple wild bee conservation efforts such as addition of native flower strips can provide additional income to the farmers (Delphia *et al*., 2019). Maintenance of pollination services in crops alone is not adequate to defend the wild bee conservation. The loss of interactions between the wild bees and plants could have inescapable effects accelerating species extinctions and negative impact on ecosystem functions (Biesmeijer, 2006 and Diaz *et al*., 2013). In order to prevent the collapse of ecosystem services, there is an urgent need for conservation of these wild bee pollinators.

Bee hotels: A new kind of hotel is opening around the world. Its guests are wild bees. These hotels don't offer maid service, but they do give bees a place to nest. The nest is provided with different-sized holes to facilitate nesting sites for different bee species.

Fig. 1. Reeds of *Ipomea cornea* developed for nesting of *Megachile* species

Though trap nesting in terms of bee hotels has been recommended to increase pollinator nesting sites but they are more prone to parasitization (Maclvor and Packer, 2015). Veereshkumar *et al.* (2015) developed a trap nest from reeds of *Ipomia cornea* and observed almost 85.55% parasitization by *Melittobia* species on *Megachile* species. It may be because the reeds used for trap nesting were placed in clusters and it was easy for the parasites to locate their hosts. Hence, it is recommended to distribute the trap nests in smaller clusters.

Field of Dreams hypothesis: This hypothesis assumes that pollinators follow plant community restoration. "If you build it, they will come" (Palmer *et al*., 1997). Habitat losses are cited as the most frequent factor for declining wild bee populations. Habitat enhancements are considerably effective in coping with habitat losses. Restoration may involve the use of floral communities, which are preferred by the wild bees. Hence, sound knowledge of the preferred floral communities and their blooming period is an imperative aspect of restoration. Use of wild flowers as hedgerows around the field margins increase diversity and abundance by providing reliable foraging opportunities (Pywell *et al.,* 2012).

Ground-nesting "bee bank": More than 25,000 bee species nesting in the ground tunnels, in dried hollow stems, in dead woods and some desert bees even burrow into sandstone. Different species of bees nest in different soil types, but the soil should contain at least 35 percent sand.

Fig. 2. Ground nesting *Megachile lerma*

Stimulation of floral blooming by burning the grasslands increase the potential foraging sites, however burning activities may directly destroy the larvae in stem or twig nests. Hence, unnecessary mowing and burning should be avoided to prevent mortality. Disturbances to the habitat should be minimized to the practical extent during nesting season (Young *et al*., 2016).

Safe use of Pesticides: Many pesticides have lethal effects on bees. Many pesticides and herbicides can either kill the bees directly or severely weaken the health of a bee colony when they expose to the application or its residues. If possible, do not spray pesticides on flowers directly. If the bloom needs to be sprayed, apply the pesticides in the evening hours. Thus, bees will not be active in the field during evening hours. Systemic pesticides should be avoided during foraging season as they get sequestered in pollen and nectar. *Bt* based pesticides have been found to be non-toxic to wild bees (Mader *et al.* 2010). Organic farms support significantly more abundant wild bee populations compared to conventional farms due to reduced insecticidal and herbicidal usage, which ultimately leads to a greater diversity of floral communities (Holzschuh *et al.* 2008).

Implementation of bills: Introduction of farm bills/ Acts to fund habitat restoration on agricultural lands. In the United States, the Farm Bill is used to channel federal funding for habitat restoration and is governed by the Natural Resource Conservation Service and the Farm Service Agency. In the European Union, the government sponsors agricultural land conservation through Agri-Environment Schemes (AES). The Environmental Quality Incentives Program (EQIP) and the Wildlife Habitat Incentives Program (WHIP) had pollinators as a priority taxon (Vaughan and Skinner, 2008). Strict management policies regarding the introduction of managed bees into non-native regions should be implemented to prevent spill-over of pathogens such as chalkbrood infections to the native wild bees (Pitts-Singer and Cane, 2011). Such strict bills are much needed to conserve bees.

Future outlook

New practices for integrated management of both honey bees and wild bees assemblages will enhance global crop yields. Scientific research will continue to be an imperative component of wild bee conservation programmes. There is a need for intensive studies on floral and nesting habitats of lesser-known species, taxonomic identification of bees and location-specific studies. To monitor the population trends, a more reliable and direct standardized monitoring method should be developed. There is a need to evaluate the effectiveness and safety of trap nests from competitors and parasites.

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The Story behind desert locust outbreak in India

Snehasish Routray and Soumya Sthita Pragyan

Locusts are the swarming phase of short horned grasshopper (Acrididae: Orthoptera). They can breed rapidly in an exponential manner under suitable conditions and subsequently become gregarious and migratory. They can travel a great distance and damage the crop extensively on their way. The major locust species all around the world are Desert locust (*Schistocerca gregaria*), Migratory locust (*Locusta migratoria*), Bombay locust (*Nomadacris succincta*), Tree locust (*Anacridium rubrispinum*), Italian locust (*Calliptamus italicus*), Red locust (*Nomadacris septem-faciata*), Moroccan locust (*Dociostaurus moroccanus*), Brown locust (*Locustana pardalina*), American locust (*Schistocerca paranensis*) and Australian locust (*Chortoi-ceter terminifera*). Desert, Migratory, Bombay and Tree locusts are reported from India. Of these desert locust is most notorious one. A swarm of desert locust can be 1200 sq kilometer in size. Each locust can eat its weight in plants each day. So a swarm of such size would eat 192 million kilograms of plants every day. In 2019-20 there was an outbreak of desert locust in western and North-West Africa which further expanded to South-west Asia amid congenial environment. In India although there was no impact on rabi (winter) crops like wheat, pulses and oilseeds, but most of the late sown pulses and orange orchards were attacked severely by them. Due to changing weather conditions their outbreak increased and causing losses it can be visualized as a clear depiction of climate change.

Active breeding areas of desert locusts

The population outbreak of desert locust can be well understood after knowing its usual habitats. During recession period desert locusts inhabit and infest a broad belt of arid and semi-arid regions (between West Africa and North-west India) covering deserts of 25 countries. When favorable conditions boost the population they invade nearly 60 countries over 30 million sq km (WMO and FAO, 2016).

Within the recession area the movement of locusts is influenced by winds. The wind flows bring them into particular zones during the summer (Sahel and Indo-Pakistan desert) and during the winter/spring (North-West Africa, along the Red Sea, in Baluchistan (Pakistan) and the Islamic Republic of Iran) (Figure 1).

The locust affected countries grouped into three regions.

a. Western region: Western and North-West Africa (Algeria, Chad, Libya, Mali, Mauritania, Morocco, Niger, Senegal and Tunisia).
b. Central region: Along the Red sea, Djibouti, Egypt, Eritrea, Ethiopia,

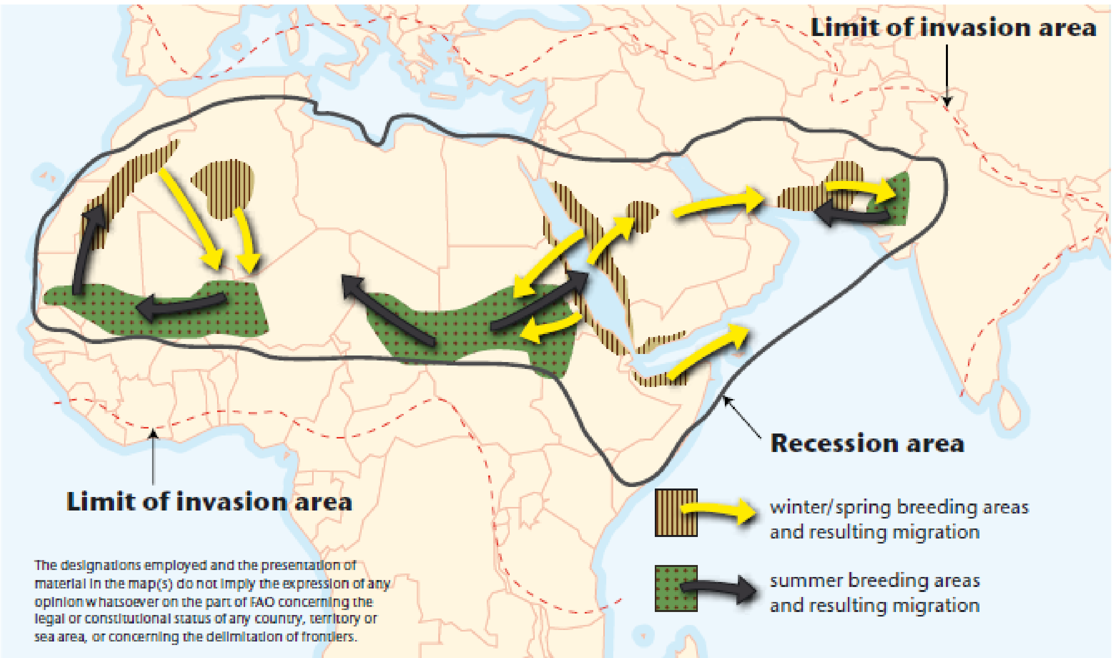

Fig. 1. Desert locust recession areas (Source: WMO and FAO, 2016; WMO-No. 1175)

Oman, Saudi Arabia, Somalia, Sudan, Yemen. During Plagues only Bahrain, Iraq, Israel, Jordan, Kenya, Kuwait, Qatar, Syria, Tanzania, Turkey, UAE and Uganda

a. Eastern region: South-west Asia- Afghanistan, India, Iran and Pakistan

Reasons for outbreak in 2019-20

As per the available literature, locust plagues were observed during the early 19th century to first half of 20th century. From 1973 to 1989 very few numbers of locust upsurges were observed (2 to 26). In 1993, 172 locust upsurge were observed (estimated loss was Rs. 7.18 lakh). In December 2019, the locusts destroyed over 25,000 hectares of crops in Gujarat. In 1998, 2002, 2005, 2007, 2010 very few swarming with small scale breeding was observed. But in 2019 the breeding sites were drastically increased to 1500) And in 2020, the locusts have already been reported to have destroyed crops in 18 districts of Rajasthan and 12 districts of Madhya Pradesh while crops in Uttar Pradesh, Punjab, Haryana, and Maharashtra were under threat of nearly 40 million locusts per square km.

During 2020-21, the locust incursions were reported in 10 States of Rajasthan, Madhya Pradesh, Punjab, Gujarat, Uttar Pradesh, Maharashtra, Chhattisgarh, Bihar, Haryana and Uttarakhand, where operations were undertaken in coordination with State Governments for locust control. State Governments of Gujarat, Chhattisgarh, Punjab and Bihar have reported no crop losses in their States. Initially during May-June 2020, Government of Rajasthan reported crop damage of 33% and more due to locust attack in 2235-hectare area in Bikaner, 140 hectare in Hanumangarh and 1027 hectare area in Sri Ganganagar; but now, as per revised report, it has been stated that earlier submitted data was related to initial stage of crop sown in Kharif season and this area of crop loss has been re-sown by farmers. State Governments of Haryana, Madhya Pradesh, Maharashtra, Uttar Pradesh and Uttarakhand have reported crop damage of less than 33% in 6520 ha, 4400 ha, 806 ha, 488 ha and 267 ha respectively due to locust attack this year (Ministry of Agriculture and farmers welfare, 2020).

a. Heavy rainfall over eastern Africa and the Arabian Peninsula: The Indian Ocean Dipole phenomenon

The outbreak of desert locust crisis can be traced back to May 2018. During this period cyclone *Mekunu* passed over an unpopulated desert on the southern Arabian Peninsula known as the Rub' al Khali. As a result, the sandy areas were filled with ephemeral lakes. This favoured the breeding of desert locust. The population growth of locusts was further amplified in October 2018 by Cyclone *Luban*. This was spawned in the central Arabian Sea, marched westward, and rained out over the same region near the border of Yemen and Oman. Usually, these areas get very rare cyclones. These unusual heavy rains were tied to fluctuations in the Indian Ocean Dipole. The main locust breeding areas in the Horn of Africa, Yemen, Oman, Southern Iran and Pakistan's Baluchistan and Khyber Pakhtunkhwa provinces recorded widespread rains in March-April. Experts says a prolonged bout of exceptionally wet weather, including several rare cyclones that struck eastern Africa and the Arabian Peninsula over the last 18 months, is the primary culprit.

East Africa experienced unusually widespread and intense autumn rains, which were capped in December by a rare late season cyclonic storm 'Pawan' that made landfall in Somalia. These events triggered yet another reproductive spasm. Quasi uniform trade winds, seasonal displacement of ITCZ (Inter Tropical Convergence Zone) and extra tropical depressions also contributed in aggravating the locust plague.

In late 2019 (Oct-Nov), unusual warm waters in the western Indian Ocean lead to heavy rainfall in Eastern Africa and The Arabic Peninsula. These warm waters were caused by the amplified Indian Ocean Dipole (IOD). Because of this dipole the western Indian Ocean remained warm as compared to the eastern part. The intensity of IOD is positively correlated with the rainfall in the East African region between October and December (Hirons and Turner, 2018). The Eastern Africa received its wettest rainfall season in over four decades during October to November, 2019. Heavy rainfall triggered the growth of vegetation in arid areas which ultimately favoured the desert locust population outbreak. In the beginning of 2020, main locust breeding areas of Horn of Africa, Yemen, Oman, Southern Iran and Pakistan's Baluchistan and Khyber Pakhtunkhwa provinces received heavy rains and that further triggered the population build up

b. Western disturbances and irregular heavy rains

The increased pre-monsoon rains have in turn been caused by the increased frequency of western disturbances (WD which are low pressure systems that originate in the Mediterranean Sea or mid-west Atlantic Ocean, move eastwards and are the cause of most of North western India's pre monsoon rain. Scientists have also said that the increased WD activity could have a polar connection and be linked to the polar vortex – a low pressure system of extremely cold swirling air in the north and south poles. Every year during December to March, an average of 4–6 western disturbances (WD) per month reaches to India. This year there was larger than usual number of WDs active over India. So, this might have partially contributed to the excess pre-monsoon rains and rapid triggering of the locust outbreak in India.

c. Unusual rainfall over Rajasthan and other Indian regions

During March 2020, India received rainfall a total surplus of 47 %. Central India received excess rainfall (surplus rain of 219 %,) followed by Northwest India which has received 75% excess rain. The excess rainfall over North West and Central India can be attributed to a large number of Western disturbances. All-together 7 western disturbances have approached Western Himalayas during March. The month of March recorded widespread rains over Punjab, Haryana, Rajasthan, Uttar Pradesh, Bihar, Madhya Pradesh, and Maharashtra. Gujarat also experienced unseasonal rains on a few occasions. Also, South-east Iran and south-west Pakistan (Iran-Pakistan region) received too much rain in January 2020 which attracted the swarming. The desert locust swarms started arriving in Rajasthan during the first fortnight of April Locust Warning Organisation observed "low-density I and II instar gregarious/transient hoppers" at Jaisalmer and Suratgarh in Rajasthan and Fazilka in Punjab adjoining the Indo-Pakistan border. Subsequently, there has been the arrival of swarms from the main spring-breeding areas. The unprecedented rainfall lead to lush vegetation and favoured locust population build up.

d. Possible impact of Cyclone Amphan

Having arrived in India through Iran and Pakistan, the locusts have not just registered their presence in the border states of Rajasthan and Gujarat, but in the interiors of Maharashtra, Uttar Pradesh and Madhya Pradesh as well. The FAO mentioned, much of these movements were associated with strong westerly winds from Cyclone Amphan in the Bay of Bengal. While the rabi crops, recently harvested, survived the onslaught, the locusts can take a heavy toll on India's kharif produce if not controlled by the time the harvest season arrives. Due to the heavy pre-monsoon showers(March-May) owing to the extremely positive IOD, the swarms were attracted to the North and Central India due to the availability of green pastures as well as barren lands to lay eggs in the arid and semi-arid regions.

e. Lack of proper control measures to stop the plague by Iran and Yemen

Experts believed that the current locust invasion was part of the residue population that survived after February 17, 2020 in the deserts of Pakistan and Iran. After 1993, for the first time in May 22, 2019, large swarms of locusts invaded bordering areas of Pakistan.

Control operations were less successful in Iran and Yemen. On February 17, 2020 the Iran and Yemen plant protectionists could either have controlled all the locusts or forced them to go across the border in Pakistan and Iran. They stopped the locust control measures and expected that Pakistan would take similar measures to eliminate them, but, the residue population continued breeding (FAO, 2019).

Conclusion

Being a highly polyphagous pest, desert locust feed any greenery on their way. Last one and half a year the unusual rain and wind patterns through various cyclones favoured the locust population *via* greening many deserted areas. These weather factors are the direct impact of global swarming. Secondly, cyclones altered wind pattern temporarily. The swarms of locusts, unable to stay in the deserts moved southward to Yemen and entered Africa creating a famine-like situation. They have impacted almost the entire eastern Africa and parts of North Africa. Intensive research regarding their bionomics, host ecological interrelationship and forewarning system can mitigate possible losses by them. Experts says since from the past 20 years less attention has been paid towards locust research in India. In this regard there is an urgent need to conduct basic and applied research on host-ecological inter-relationship and development of forewarning system to mitigate locust menace timely in near future

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Ants and Plants: Some friendship tales

Kishore Chandra Sahoo and Mahendra K R

Ants (Formicidae: Hymenoptera), one of the most numerous groups of animals on our planet, interact with plants in various ways. In some instances, the interaction may be negative, affecting the associated plant (like in the case of leaf cutter ants and seed harvester ants), and in the other case it may be positive with a mutual benefit. Flowering plants are thought to have facilitated ant diversification by providing novel sources of food and habitat, and ants to have facilitated plant diversification by providing defense and dispersal (Nelsen *et al.,* 2018). Here, in this article, we have tried to summarize some of the extraordinary and spectacular friendly relationships of plants with ants.

Myrmecophily: Friendship for Pollination

A wide range of flying insects (Bees, butterflies, moths, flies, etc.) are well known to pollinate various plants while visiting the flowers. But some plant species have also managed to orient ants to help them in pollination (myrmecophily) by providing the ants with reward (nectar) in return. Can pollination be achieved by flightless insects like ants?

Yes, ants can help in pollination in those plants which need to transfer pollen from male flower to female flowers of the same plant. The first record was in worker ants belonging to the species complex *Iridomyrmex gracilis* as effective pollinators of orchid, *Microtis parviflora* (Peakall and Beattie (1989). This orchid is self-compatible but not autogamous (Autogamy is the kind of pollination in which pollens are transferred from the anther to the stigma of the same flower). Flightless workers of *Iridomyrmex gracilis* ants forage the orchid persistently, visiting individual flowers and inflorescences repeatedly. They actually do this to take nectar from the flowers. But while doing so, the pollinia (mass of pollen grains) from one flower sticks to head of the ants and get transported to the stigma of another flower of the same plant. Another such example of pollination is also observed in orchid, *Dactylorhiza viridis* by the ant *Formica exsecta* in Alps, Italy (Claessens and Sheifert, 2017) (Fig.1).

Myrmecochory: Friendship for Seed Dispersal

Seed harvester ants carry away the seeds of some plant species to their nests for consumption. Few plants have managed to manipulate this relationship to fool the ants and get some benefits from them. Some plants take the help of ants for dispersal of their seeds (myrmecochorous plants) and this phenomenon is called myrmecochory. These plants have special seeds with lipid rich portion, called elaiosome which stimulate ants to carry these seeds back to the nest. The elaiosome is removed and the seeds are then discarded in an abandoned

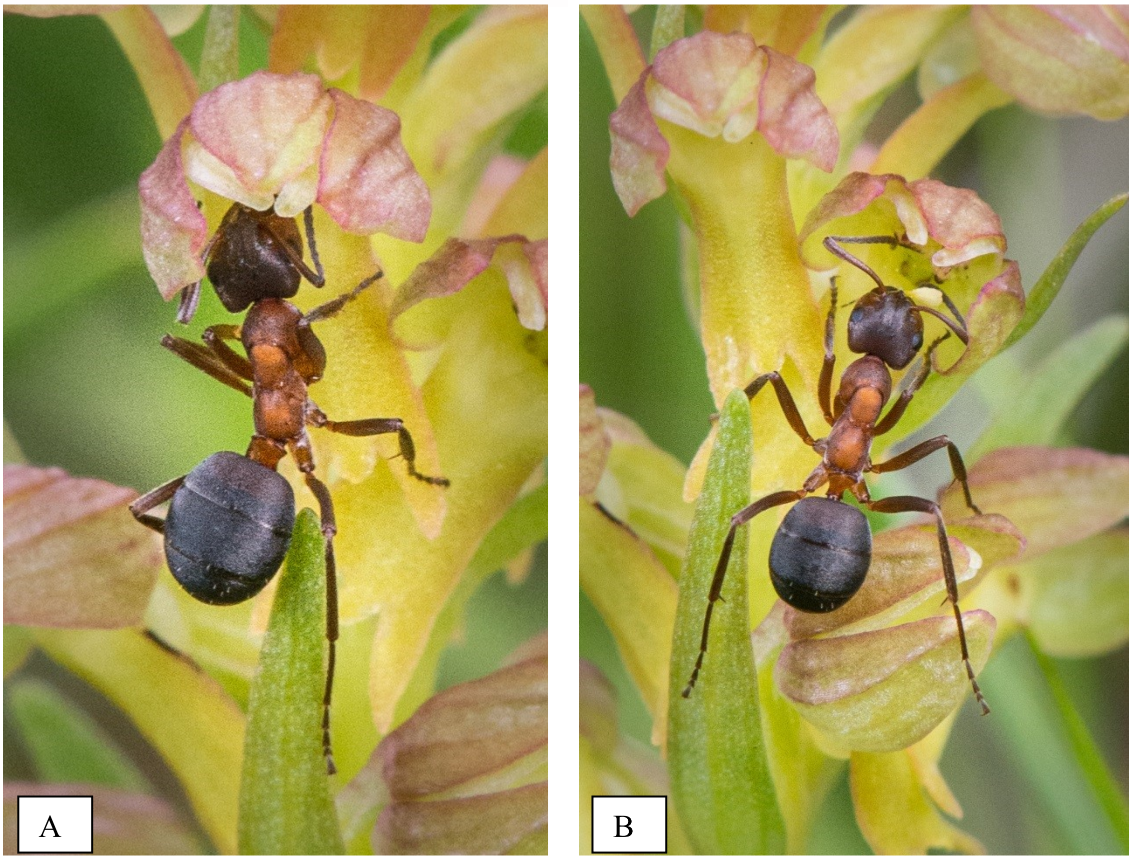

Fig. 1. A) *Formica* (*Coptoformica*) *exsecta* inspecting a flower of *Dactylorhiza viridis*, B) *F. exsecta* visiting a flower of *D. viridis* with a pollinarium attached to its head. Photo Credit: Jean Claessens (Reproduced with permission)

gallery of the ant nest. This is exactly what the plant wanted, a safe and suitable place for germination of its seeds. Brainy plant!!

Myrmecochory can be called a mutualism, but the relationship is not specific between a single plant and an ant species. There is no evidence that any myrmecochorous plant relies on a single ant species to collect its seeds (Gullan and Cranston, 2010). For example, five ant species (*Camponotus piceus*, *Lasius alienus*, *Lasius bombycina*, *Lasius fuliginosus* and *Tapinoma erraticum*) were observed to disperse the elaiosome bearing seeds of *Sternbergia colchiciflora* (Amaryllidaceae) (Fig. 2). Ant workers remove the seeds from the rifts of ripening fruits and carry them one by one (Molnar *et al.,* 2018).

Myrmecophytes: Friendship for Defense

Plants suffer the load of a variety of herbivores starting from early stages of their growth to maturity. How can these herbivores be deterred? Some plants have developed appreciable strategies to do so by the help of ant-partners. Certain plants remain closely associated with ants, called as myrmecophytes or ant-plants, where both the partners get benefit from each other. Ants either get a nesting site on the plant and/or nectar & nutrients from the plant. And they in return act as soldiers by defending herbivores attacking the plant.

One such classical example is the *Pseudomyrmex-Acacia* association, in which the *Acacia* plant offers three types of

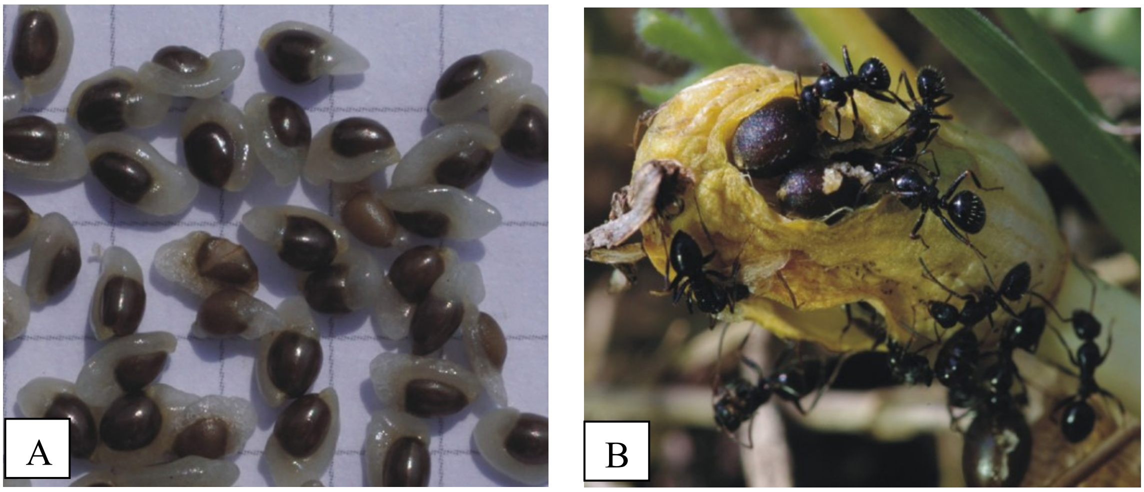

Fig. 2. A) Elaiosome bearing seeds of *S. colchiciflora;* B) Workers of *Camponotus piceus* carrying the seeds from ripened fruits of *S. colchiciflora* (Reproduced from Molnar *et al.,* 2018 with permission)

resources to the partner-ants (i.e., 1. Extrafloral nectar, 2. Beltian food bodies and 3. Domatia in hollow thorns) in exchange for defense from herbivores and encroaching vines. Extrafloral nectaries located at the petiole provide solution of water, sugars, and amino acids. Beltian bodies produced by the plant at the leaf tips provide protein and lipids to the ants. Whereas, the greatly enlarged hollowed thorns provide the nesting site (Domatia) to the ants. The whole ant colony is distributed among the numerous hollow thorns of a tree. Worker ants patrol the tree 24 hours a day, both guarding the colony against predators and searching for food. Since the tree contains their nest, obligate acacia ants (*Pseudomyrmex*) react strongly to any disturbance of the tree. If alarmed, ants will pour out of the thorns to attack, defending the acacia by both biting and inflicting a painful sting on any animal in contact with the tree. The ants keep the plant free not only of insect and vertebrate herbivores, but of fungi and other plants as well.

Like the Beltian bodies of *Acacia,* several other plants are also known to produce food bodies. For example: Mullerian bodies of *Cecropia* (Cecropiaceae) contain glycogen and lipids, Beccarian bodies of *Macaranga* (Euphorbiaceae) are especially rich in lipids and Pearl bodies of *Ochroma* (Bombacaceae) are rich in sterols. All these food bodies produced by different plants are meant for attracting ants and consequently deriving defense benefits from them (Rico-Gray and Oliveira, 2007).

Many myrmecophytes, however, do not offer any direct food reward for their ant inhabitants and provide only the domatia space where the ant colony develops. They rather harbor honeydew-producing homopterans inside the domatia and their honeydew constitutes the main energy source for ant inhabitants. Such myrmecophytes, though have to invest some energy for feeding its sap to the homopterans, but ultimately the reward it gets from the ants is much more compensatory. One such phenomenon is the association between *Macaranga* trees, *Crematogaster* (subgenus *Decacrema*) ants and *Coccus* scale insects in tropical forests of Southeast Asia. The plants are protected against vines and herbivores by the ants that, in turn, gain residence in domatia created by hollow stems and nutrients from the plants indirectly via the exudates of *Coccus* scale insects.

Myrmecotrophy: Friendship for Nutrition

There are certain insectivorous plants which derive their nutrients from insects trapped in specialized structures (pitchers, sticky mass, etc.). What if the plant can get its nutrients from the animal partner in a mutually beneficial manner?

It's a tedious job for the ants to construct their nests. If someone can provide a ready-made nest it will be easier. Some species of plants came forward to offer rooms for the ants to establish their colony. But the plants don't do that for free. The debris deposited in the ant colony is rich in organic matter and nutrients which is absorbed by the host plant.

This seems particularly important for epiphytes that often face severe nutritional constraints. A diversity of epiphytes is known to house ants. One such example is *Dischidia major* (Asclepiadaceae) which is an epiphyte on the trunk of *Dipterocarpus* tree. *D. major* possess pouched leaves with a hollow space inside, called 'pitchers' and adventitious roots that grow at the leaf joints to attach the stem to the host plant. But one root grows into the pitcher cavity through an opening at the base. This root proliferates inside pitchers that are inhabited by ants, usually *Philidris sp.* (subfamily Dolichoderinae). *Philidris* build partitions by using the internal roots as framework and shape their nest for brood rearing. They bring debris from outside and use it as a construction material to build walls, which causes extensive root growth and branching, and in turn more roots may encourage the ants to continue building. Roots are used as a frame for the partitions, thus creating intimate contact appropriate for absorption. The epiphyte is now ready to absorb the ant-deposited debris, in addition to faeces and discarded food, as a nitrogen source. Moreover, stomata located inside the pitchers can also absorb ant-respired carbon dioxide (Peeters and Wiwatwitaya, 2014).

The driving force behind these associations is the necessity to fulfill their own lacunas by sharing, what they can, with their partners. These stories of mutualism explain how two species can live happily in nature by helping each other. Nature is full of wonders and surprises. Especially these spectacular products of evolution are always making mankind to explore and reveal the secrets of nature. There exists thousands of such fascinating tales in nature. Some are already been told and many are yet to be…..

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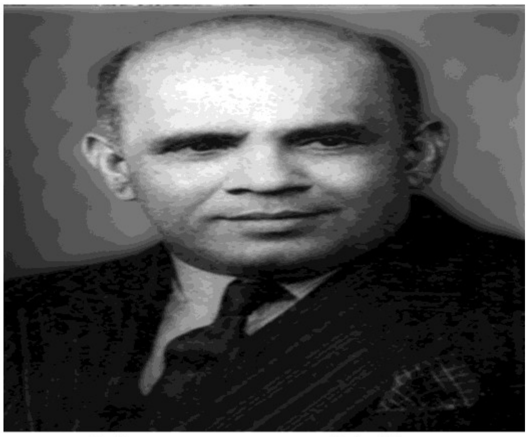
Dr. E. S. Narayanan Contributions in the Field of Entomology

Sujatha, G. S., Sagar, D. and Sachin S. Suroshe

Dr. Ennapada Sundaram Ayyaar Narayanan was one of the eminent scientist who worked on a wide base of subjects in the field of entomology. His major contributions are in the field of biological control with specialization in Hymenoptera. He was very fond of saying "If entomology is the basis for earning one's bread, sanskrit literature and scriptures are food for the brain and soul".



Narayanan, E.S.

Glimpses Towards his Journey

Dr. E. S. Narayanan was born on 15th February 1904. He was educated from Government Victoria College, Palghat (Kerala) and Presidency College, Madras, acquiring M. A. degree with Zoology as major subject. He joined the Imperial Agricultural Research Institute, Pusa in 1930 and was privileged to work under Thomas Bainbrigge Fletcher. After few years of service at Pusa, Dr. E.S. Narayanan travelled to England and joined the Imperial College of Science, Technology and obtained Doctor of Philosophy from University of London. He also underwent postgraduate training in Biological control of insect pests and noxious weeds under professor W. R. Thompson (F.R.S) during the summer vacation. During his Ph. D., he spent three months in a bee farm in Kent to acquaint himself with the realistic elements of the technology and exercise of bee keeping especially the breeding of queen bees; additionally, he surpassed all the exams of the British Bee-keepers Association.

Professional Career

After his return back to India, he joined Imperial Agricultural Research Institute, New Delhi. After independence he was appointed as imperial entomologist. Later, he was embellished as Head, Division of Entomology and he held this position for 15 years, the longest ever by any Englishman or Indian. In 1955, Dr. Narayanan visited the United States of America including Hawaii and Canada to study the progress of work in the biological control of insects and noxious weeds. On his return, he was appointed as Principal, Central College of Agriculture, Delhi as an additional assignment, later, he was appointed as Dean, School of Agriculture and Forestry in November 1955.

On his retirement from Indian Agricultural Research Institute in June 1962, Dr Narayanan was appointed as Director in Sericulture Research Institute, Mysore. He was entrusted with the task of planning new research laboratories, recruitment of necessary staff and initiation of research programmes. He retired from the directorship in 1967. In his 5 years of stay at the sericulture research institute, he carried out a number of experiments in genetics and manipulation of genes culminating in the evolution of several new races of silkworms with superior commercial characters.

Dr. Narayanan was a senior fellow of Indian National Science Academy and the Indian Academy of Sciences. He was a founder member of the Entomological Society of India and was president for 4 terms from 1953-1960. He was elected president of the Agricultural Sciences section of the Indian Science Congress Association held at Calcutta in 1957. Dr. Narayanan has published more than 150 papers that include memories, bulletins, books etc.

Areas of Research

Dr. Narayanan contributions are in the field of insect taxonomy (mites), genetic study (silkworm races), biology and anatomy of insects and majorly on biological control with specialization in Hymenoptera. His first work was on mass multiplication of *Stenobracon deesae* (Cam.) which is major parasitoid of sugarcane and maize stem borer (Narayanan and Venkatraman, 1952). He described different Tribes namely Gliptini, Lissonottni, Banchini of sub family Banchinae, family Ichneumonidae based on morphological characters (Narayanan and Lal, 1954). He identified parasitoid complex of *Bracon hebetor-brevicornis* and *Hymenia recurvalis* (Narayanan *et al*., 1957 and 1958) and studied the biology of pea leaf miner, *Phytomyza atricornis* (Meigan) parasitoids (Narayanan *et al*., 1956). He has also contributed in the field of acarology which led to the identification of new species of mites majorly predatory mites. He recorded and identified the incidence of mango bud mite, *Aceria mangiferae* Sayad along with Swaraj Ghai for the first time. Even identified a new predatory species, *Typhlodromus roshanlali* and described three other predatory mites as predators on mango bud mite (Narayanan and Ghai, 1961). Also, identified some new records and a new species of mite associated with mango malformation. Apart from this he has identified a new species of *Melichares* (Blattisocius) (Aceosejidae) associated with the fig insects and did experiment on superparasitism in *Trichogramma evanescens minutum* riley, which is the efficient parasitoid of stem borers. He conducted superparasitism experiments in *Trichogramma* field colonisation and results showed that progenies from the superparasitism will not be effective, as parental parasitoids leads to defective, ill developed wings, and remains inactive due to poor nutrition in host (Narayanan and Chacko, 1957). He worked on host selection and oviposition response in *Apanteles angaleti* Muesebeck (Braconidae: Hymenoptera) and did work on *Aholcus euproctiscidis* Mani (Scelionidae: Hymenoptera), an egg parasitoid of *Euproctis lunata* Walker. In addition to field of biocontrol and acarology he also worked on morphology, biology and genetics of insects. He described the univoltine new races of silkworm suitable for Deharadun and Kashmir based on hatchability, hibernating egg, percentage of silk, content of shell and filament length (Narayanan and Tikoo, 1969). After 1940, many taxonomists contributed to National Pusa Collection (NPC) and E S Narayanan is one of them for Hymenopteran collections. He has published research papers in reputed journals *viz*., Oriental science, Indian Journal of Entomology, Indian Journal of Plant Protection, Bulletin of Entomology, Proceedings of the Indian Science Congress, Current Science, Proceedings of the Indian Academy of Sciences etc.

E. S. Narayanan as A Mentor

Dr. Narayanan was born with a golden tongue and a silver pen; he was a great speaker and writer. His lectures were simply brilliant and up to date with many anecdotes. A voracious reader with a capacity to remember anything he read, he could fluently quote the writings of some early great entomologists. He took charge of the imperial entomologist to the Govt. of India at a very crucial period when partition of the country was taking place and only economic entomology was considered necessary and other fundamental studies and research including systemic entomology was looked up as a luxury. In spite of some hard looks and pessimistic view of administrators, he did his utmost to convince bureaucrats that systemic entomology is the basis of any economic entomology and encouraged the young entomologists of the division to take up taxonomic studies important group of insects like Ichneumonidae (Hymenoptera) and neglected group like Acarina. As one of the long reigning head of the division, Dr. Narayanan was responsible for implementing five-year plan projects during his tenure. Though, he eventually believed in the biological control of insect pests and weeds, nonetheless he encouraged and supported many other sections of entomology without any reservation. He was extremely helpful to students and he always kept in touch with them.

Honours

Dr. Narayanan was bestowed with many awards and honours for his significant research contributions; he was Fellow Academy of Science, Fellow of Entomological Society of India, Fellow of Nautical Institute, Fellow of Royal Entomological Society. He made two endowments in the entomological society of India for the award of two medals for the most outstanding research paper published in the Bulletin of Entomology and the Indian Journal of Entomology, respectively, to perpetuate the memory of his beloved mother and his dear wife Late Srimati Sita Narayanan. This is the first time in the annals of the society that such an endowment has been made by a member for the advancement of research in pure and applied entomology in India.

Dr. Narayanan came from a family of Sanskrit scholars and naturally he turned his attention to Sanskrit scriptures and literatures. He was highly respected educationalist and philanthropist, he left for heavenly abode on 23rd January 1991.

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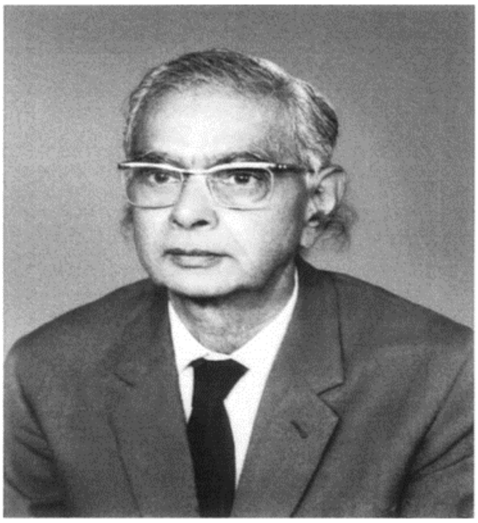
Contributions of Dr. M.S. Mani to the Field of Entomology

Jabez Raju B and Karthik S

Mahadeva Subramania Mani (M.S. Mani) is a distinguished Indian Biologist, Ecologist and contributed greatly to the field of Entomology in India. He not only inspired many through his work in Insect Taxonomy and High altitude entomology but also through his personality. Because of his notable work, Gordon Edwards from the University of Colorado called him as "The Dean of High Altitude Entomology". M.S Mani from his humble beginnings had a challenging life and inspired his students and his fellow scientists.

Early Life of Dr. M.S Mani

He was born on 2nd March 1908 in Thanjavur (Tamil Nadu, India). He completed his secondary schooling in K.S High School from Thanjavur. He attended Government Arts College, Coimbatore and passed the Intermediate examination. He then joined Madras Medical College to study medicine and had to leave the college due to his father's sudden demise and financial limitations. Later he moved to Calcutta and worked as a part-time tutor in Physics in Bangabasi College. He later worked as a gallery assistant in the Zoological Survey of India, during which he studied gall inducing arthropods (Especially Cecidomyiidae: Diptera) and the galls encouraged by them. He got M.A degree from the Madras University in 1937 based on his research on chalcids under the



supervision of Baini Prasad, the then director of Zoological Survey of India (ZSI) (Calcutta) and was the first person to be awarded Master's based on research thesis and scientific papers by the university (Ananthakrishnan, 2007). He has mastered over 20 languages including French, Russian, German, etc. For a brief period, he earned money working as an interpreter and German language translator in the censor unit of Army (Cherian, 2003), New Delhi. He joined St. John's College, Agra where he established the School of Entomology in 1950. He was awarded with a Doctor of Science (D.Sc) by the University of Agra in 1947 for his work on gall forming insects (Raman and Gupta, 2007).

His Professional Career

Dr. M.S. Mani got interest in studying insect induced galls while he studied at Government Arts College, Coimbatore. He collaborated with Sir C.V Raman on insect coloration while working at Bangabasi College, Calcutta. He joined as a research assistant to the then Imperial Entomologist H.S Pruthi at the Imperial (now Indian) Agricultural Research Institute, Delhi in 1937. He started teaching at St. John's College, Agra in 1945 and in 1956 he left to work as Deputy Director of Zoological Survey of India and continued to teach in the college until 1984. He then moved to Madras and taught in Presidency College as an Emeritus Professor in the Department of Botany till his death. He was the pioneer of Cecidology in India.

M.S Mani led the Indian delegation of Zoologists to U.S.S.R in 1963. He represented India in the Man and Biosphere (MAB) programme committee on Alpine and Arctic Ecology (Little hammer, Norway) in 1972. He was a visiting Professor of Entomology at Tribhuvan University (Kathmandu, Nepal) in 1975.

Dr. M.S Mani as a Mentor

Dr. Mani was an inspiring teacher. He was quite approachable and helpful to his students. He would test his students to evaluate their seriousness (Gupta V, 2003). He trained his students on various groups of parasitic hymenopterans particularly the Chalcidoidea, Proctotrupoidea, Braconidae, Ichneumonidae, Bethylidae, and Evaniidae. He took his students along with him in his expeditions to the Himalayas. His students like Virendra Gupta and Ananthanarayan Raman promoted his work. Several students obtained Ph.D working on Himalayan insect fauna and their ecology under his guidance.

Major Research Accomplishments

His research work on gall forming arthropods lead to evolution of a new discipline, Cecidology in India. Professor M.S Mani has over 35 books to his credit besides over 250 research papers and monographs. His book "Introduction to High Altitude Entomology" greatly influenced many in India and abroad. He published a book called Invertebrate Zoology in the mid 1950's. He published a series of papers in "Agra University Journal of Research". He was the first person to report maternal solicitude in Thysanopteran in a species *Giganothrips elegans* (Mani & Rao, 1950). "The ecology of plant galls" (Mani, 1964) and "Plant galls of India" (Mani, 1973; 2000) were his outstanding books acknowledged by cecidologists globally. Other important books written by him were General Entomology (1982), Butterflies of the Himalaya (1986), Ecology and Biogeography in India (2012), Ecology and Biogeography of High Altitude Insects (1968), Ecology and phytogeography of high altitude plants of the Northwest Himalaya (1978). Modern Classification of Insects (1974), Pollination ecology and evoluion in Compositae (1999), The Fauna of India & the adjacent countries (1989), Indian Insects (1989), Introduction to Zoology (1950), Beetles of the Himalaya (1967), Insects (1971, 1977) etc.

Other Notable Contributions

He contributed the English version of the German technology, for manufacturing hydrogenated oil (Vanaspati) in India to the creator of the manufacturing plant at Modinagar. He has held various positions during his life time i.e., Honorary Research Worker, Zoological Survey of India (1933-37), Research Assistant, IARI (1937-45), Professor of Zoology & Entomology St. Johns College, Agra (1945-56), Director, Zoological Survey of India (1956-68), Professor Emeritus, Presidency

College, Madras (1991-2003). The Ministry of Environment and Forests (Government of India) recognized him with the coveted E. K. Janaki Ammal award for his contributions to insect taxonomy in 2002 (Gupta, 2003). His book “Your face from Fish to Man” can be entertaining to the readers with a tinge of humour (Cherian, 2003).

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When counting tigers, include me not!

Pretexts, contexts, so many texts,
None as relevant as us insects.
We are aplenty, village or city,
Today, I'm the one for your curiousity!

Simply a colorful nymph,
It is in teak forests that I triumph.
They call me Degonetus serratus,
Oh, what a fancy status!

I damn wish I could fly,
Like other critters in the sky.
But, my clan's glad I can crawl,
Year-round, together we prowl!

Yes, I carry an angry beast's visage,
On my little back as a message.
Yet, when counting tigers,
Include me not, nor ligers!

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THIRD INDIAN ENTOMOLOGIST PHOTO CONTEST

The Indian entomologist photo contest aims to encourage insect photography among photographers, professionals, amateur entomologist and the layman. The theme of the third episode of the photo contest was 'Insects and aspects related to insect life'.

With these objective entries were invited during December 2020. Each participant was to submit one good photograph which met a few prescribed standards along with the filled in application form in which the participant had to furnish his/her details, caption, description, specifications of the photograph and also a declaration on the ingenuity of the photograph. We received a total of 40 entries which were screened first for the prescribed standards and overall quality of the image. Final evaluation was done by a committee of three independent members under the oversight of editorial board members and also by an invited expert, based on the following criteria: quality (clarity, lighting, depth of field, composition), relevance of the subject matter (theme, rareness of subjects), creativity and originality. To ensure a blind review the details of the photographer was hidden and the evaluators were only presented with the photograph, caption, description and technical specifications.

The first place was won by Saiteja Katta (Department of Entomology, University of Agricultural Sciences, GKVK, Bengaluru, E-mail id: kssteja118@gmail.com); who captured a mating pair of Syrphid (*Allobaccha* sp.) hovering in air, from Bengaluru.

The second place was won by Sanath R M, (Sajangadde House, Hosala Village, Barkur, Udupi, Karnataka, E-mail id: Sanath.rm89@gmail.com); who captured a Lappet moth (*Gastropacha* sp.), which mimics a dry leaf with a stalk, from Uudupi, Karnataka.

The third place was won by Laxmisha K M, (No-93, Hemant Hostel, Indian Agricultural Research Institute, Pusa Campus, New Delhi, E-mail id: lakshmieshakm@gmail.com); for his photograph of Angled Pierrot butterfly (*Caleta decidia*) captured from Satpura Tiger Reserve, Madhya Pradesh.

BUG STUDIO ASSOCIATE EDITORS

Mr. S. S. Anooj

Mrs. S. Rajna

1st Place: *Love in Air*. A mating pair of Syrphid (*Allobaccha* sp.) hovering in air, Bengaluru, 08.10.2020 (Canon EOS 700D with Canon 100 mm f/2.8 Macro USM lens, ISO 100, F/11, 1/100). By Saiteja Katta, University of Agricultural Sciences, Bengaluru.

2nd Place: *Master of disguise.* A Lappet moth (*Gastropacha* sp.), which mimics a dry leaf. Ududpi, 06.12.2020 (Canon 80D with Canon 100 mm f/2.8 Macro USM lens, ISO 100, F/8, 1/250). By Sanath R M, Hosala Village, Barkur, Udupi, Karnataka.

3rd Place: *The Sitting Pierrot.* K Angled Pierrot butterfly (*Caleta decidia*) Satpura Tiger Reserve, 08.09.2017 (Canon EOS 1200D with Canon EF-S 55-250mm F/4-5.6 lens, IS0 1000, F/5.6, 1/250). By Laxmisha K M, Indian Agricultural Research Institute, Pusa Campus, New Delhi.

ANKIREDDY JAWAHAR REDDY

DEPARTMENT OF ENTOMOLOGY, ACHARYA N. G. RANGA AGRICULTURAL UNIVERSITY, ANDHRA PRADESH, INDIA

Jawahar Reddy is a Ph.D. research scholar working on bioassay studies of seven native *Bacillus thuringiensis* isolates which were earlier proved as lepidopteran specific and their efficacy studies against the okra shoot and fruit borer, *Earias vittella* Fab. (Lepidoptera: Nolidae) under both laboratory and field conditions.

He is also working on the screening of selected okra genotypes, obtained from ICAR-IIHR, Bengaluru against fruit and shoot borer under field conditions and characterization of tolerant varieties for biophysical and biochemical factors like phenols, tannins and chlorophyll against *E. Vittella.* In future, he is planning to extend his research work on genetic diversity studies of *E. Vittella* from populations of different regions of Andhra Pradesh using molecular tools.

MANISH CHANDRA MEHTA

DEPARTMENT OF ENTOMOLOGY AND AGRICULTUAL ZOOLOGY, IAS, BHU, VARANASI, UTTARPRADESH, INDIA

Manish Chandra Mehta is pursuing his Ph.D. from Department of Entomology and Agricultural Zoology, Institute of Agricultural Sciences, Banaras Hindu University under the guidance of Dr. M. Raghuraman (Professor, Department of Entomology and Agricultural Zoology, BHU) and Dr. M. Mohan (Principal Scientist, ICAR-NBAIR, Bangalore). He is working on the estimation of genetic diversity of the Indian population of rice yellow stem borer, *Scirpophaga incertulas* (Lepidoptera: Crambidae) using SSR markers. The aim of the investigation is to identify intraspecific variation among the population of YSB collected from Northern, Central, Eastern and Southern states of India along with phylogenetic analysis and tree construction.

The molecular work is being conducted at ICAR-NBAIR, Bangalore and the field work for testing bio-efficacy of various synthetic, bio-pesticides and organic pesticides against YSB of Varanasi region, is being conducted at the Agricultural Farm of BHU. In future he is interested to work on the aspects of chronobiology and manipulation of the clock genes for pest management.

B. RAGHAVENDER

DEPARTMENT OF ENTOMOLOGY, PROFESSOR JAYASHANKAR TELANGANA STATE AGRICULTURE UNIVERSITY, HYDERABAD, INDIA

B. Raghavender is pursuing his Ph.D. in Department of Entomology, PJTSAU, working on survey and mapping of brown planthopper (*Nilaparvata lugens*) incidence in southern Telangana zone and phenotypic, genotypic evaluation of elite rice genotypes for BPH resistance, under the **s**upervision of Dr. P. Rajanikanth. He is working on host plant resistance which is one of the cornerstones of environmentally benign pest management systems. In this context, he conducted polyhouse screening of sixty-two rice genotypes against rice BPH among which 10 genotypes showed resistance against BPH were taken for biochemical analysis and molecular characterization using SSR markers. In addition to that he is working on digital mapping of BPH endemic areas in south Telangana zone in correlation with weather parameters and composite map will be generated using ArcGIS.

MOGILI RAMAIAH

DIVISION OF ENTOMOLOGY, ICAR-INDIAN AGRICULTURAL RESEARCH INSTITUTE, NEW DELHI, INDIA

Mr. Mogili Ramaiah, Ph.D. scholar at Division of Entomology, ICAR-IARI, working on the "Biosystematics studies on leafhopper (Hemiptera; Cicadellidae) species associated with bamboo from India", under the guidance of Dr. Naresh M. Meshram (Senior Scientist). His research work comprises of collection leafhopper specimens from different locations of India by both light traps and net sweeping, followed by its processing (sorting, card mounting and labelling) and identification. He intends to prepare the detailed description, diagnostic keys and photographic illustration of characters for ready identification of the bamboo leafhoppers up to genus and species level. Further, DNA barcodes reference library will be generated for easy identification of the species. Knowledge about bamboo leafhoppers is very scanty in India. His study will be able to provide a holistic view of host distribution of bamboo leafhopper and the combined molecular data.

Ms. Arya P. S., Mr. Priyankar Mondal, Ms. Aparna S, Student Associate Editors of IE compiled the information for this section.

ABOUT THE MAGAZINE

Indian Entomologist is a biannual magazine that publishes articles and information of general, scientific and popular interest. The magazine publishes letters to the editor, columns, feature articles, research, reviews, student opinions and obituaries. The magazine accepts articles on all aspects of insects and terrestrial arthropods from India and worldwide. Short field notes and observations are also welcome. This magazine is intended to provide a broad view of topics that appeal to entomologists, other researchers interested in insect science, and insect enthusiasts of all stripes.

Notes for Contributors

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

About articles

IE is intended to publish following categories of articles

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

Reviews – two types of reviews will be published a. invited review (editorial team will contact eminent entomologists to contribute) and b. peer reviewed review (any author/s can submit a comprehensive reviews on modern entomological developments).

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

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

Field notes - on unusual observations entomologists encounter during fieldwork (Invasive insects, outbreaks, behaviour etc.). Submissions should be no more than 2,000 words in length.

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

Student corner- students working on interesting topics of entomology to share their views and opinions about their research work. Can submit with personal photograph; it should not be more than 1,000 words in length.

We encourage entomologists to contact us if you have any interesting story to share about insects.

Contributions to be sent to the Managing Editor, in digital format (MS Word) as an e-mail attachment to indianentomologist@gmail.com