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***Cover Page: *Dacus persicus* mating**
Photo by: Dr. Nagaraj, D.N Senior Scientist
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Insect Environment

(Quarterly journal to popularize insect study and conservation)

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The first issue of the Insect Environment was published in 1996. The sole objective of the Insect Environment is to popularize insect study through popular, semi-technical research notes and essays on all aspects of insects. The journal is published quarterly, in March, June, September, and December. The last issue was Volume 23 (December), 2020.

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

Author guidelines

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

This journal is unique in that it encourages articles from students to amateurs to professionals! It is hosted in CABI and ZooBank, ensuring global coverage.

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Editorial

Zooming is booming; in fact, blooming!

The new norm has indeed helped in countering social distancing via digital proximaling! Bandwidth has only served to narrow down bands of groups- be it students, professionals or families to cohesive platforms, and that is the order of the new norm. This is going to stay perhaps for a long time to come, at least the hybrid mode (physical and digital) as we have been witnessing in many recent seminars. There is a venue with physical attendees, while a large segment participates live on the screen, and integrating fairly well. There was a time when mainly Skype connected distances live, but today next door schools and colleges are networked from home; the new norm is NFH- network from home. In the almost last one year, I have attended over a score of conferences/symposia/seminars and given several talks in entomology alone. Add to this, several meetings. The knowledge discourses have also been booming including on-line distance learning.

Covid is evolving! From COVID 19 to 20, it has now become 21, with variants and strains. We as entomologists are comfortable with these 'mutations' as insects too have strains, biotypes, subspecies etc.,! A lot of daily vocabulary have become in vogue too: pandemic,

lockdown, social distancing, sanitizers, immunity-boosters, network buddies, bubbles etc., The latest is vax! Talking of immunity-boosters many have got into the fray; there are turmeric teas, herbal concoctions, fortified biscuits, herbal floor washes, green soaps, etc! Ah! There is this one- "bubble"- whatever that means! I only know our Indian cricketers travelled to Australia in a "bubble". On the field the "bubble" burst to send the Australians for a sixer over their own territory, and bring the trophy back to us. Cheers to our cricket team. Your name is from our class Insecta! And creepy crickets are indeed stridulating into a cacophony over your victory.

For those who survived the pandemic, touchwood we are in the majority. As to why the virus did not lay hold on to most, though it inflicted a 100% scare, set me thinking as how effective insect viruses will be within a population. Even if we pump high quality NPV, say against a pest like say *Helicoverpa armigera*, it fails to intra-penetrate fully across the population, unless integrated with *Bt*, entomopathogens, etc. A case of co-morbidity indeed!

Now, talking of *Helicoverpa,* I love the fellow for its sheer tenacity and ability to survive all odds. Come to think of it, there have been 100's of theses and many folds more of reputed papers on this poor fellow! Yet it survives. Now we have to wait and watch if its cousins the *Spodoptera*(s) would give it a wild displacement run. *Insect Environment* would love to capture such competitive upheavals.

We were the first to tell about *Spodoptera frugiperda* on banana in Kerala. In this issue we report its presence in potato by Dr. Jaipal Choudhary and team from Jharkand area of north India. In 2018 I have seen *S. frugiperda* on capsicum in a polyhouse on the outskirts of Bengaluru, in south India. They just devastated the plants, leading to abandoning the crop. Certainly, insects seem to have an intrepid audacity, to outdo hurdles, yet there is an alarm bell, that insect numbers are diminishing! Well, it could be true, for I have seen in the last ten years or so, *Apis dorsata*, the rock bee from which, much of our bottled honey in India comes, is becoming rare! This is at least true in urban areas. Huge trees are cut down for flyovers, apartment builders/dwellers scare or smoke them away, and forage plants are becoming fewer. So probably they emigrate to the peri-urban or beyond. In IE 22 (September) 2020, we had profiled Dr. G.T. Geetha and her research, wherein she found pollutant particles being

permanently piggy-backed on the thorax of these bees. This reduces their efficiency and survival. I invite notes for IE on this issue from observant field entomologist.

I am happy to note that entomologists of the ICAR-National Bureau of Agricultural Insects Resources are venturing into expeditions. Unless there is collection there is no growth for taxonomy and perhaps it is much the same for the entomologists of Zoological Survey of India, and National Pusa Collection, Museum of Indian Agricultural Research Institute, New Delhi. I appreciate the commitment of the insect taxonomists who have overcome the mid-Covid scare and are one with insects in the field.

On 29th January, 2021, Dr. Kolla Sreedevi and ICAR-NBAIR organized an excellent international webinar on the theme insect taxonomy titled: Insect systematics, importance, challenges and way forward. One important recommendation was to revive and refund the Network on Insect Biosystematics in India. I was associated with this programme as an administrator and knew how important this network was. I suggest that the network should encompass the whole Oriental region, as well, and be international in focus.

On the 5th February, another important webinar was organized on phytoplasma. Dr. V.V. Ramamurthy our editorial advisor, Dr. Rashmi, Dr. Devi Thangam and I from Insect Environment participated. The meet had important scientist like Dr. C.A. Viraktamath, Dr. N.K. Krishna Kumar and several people well-versed in the subject. Dr. Sundararaj of the Institute of Wood Science, Bangalore was the organizer.

IE has always been a record-chaser! Be it new insects, hosts or regions, they all find a place in our journal. That's the uniqueness of this quarterly. To name a few: A rare species of *Brachyrhynchu* from Orissa by Ashirwad Tripathy; teak defoliators *Hyblaea puera* on *Oroxylum* in Karnataka by Shankara Murthy *et al*; Buprestid leaf miner, *Trachys* sp on okra in Odisha by K.C. Sahoo; Cerambycid *Acalolepta nivosa* on Nerium from Coimbatore by Chitra and Shanmugam; Longhorn beetle, *Aristobia reticulator*on Aonla by MM Kumawat and L Wangchu, the mime, *Chilasa clytia* on *Cinnamomum* sp by Shivaji H Thube and T. P. Pandian, dung beetles in Davangere, Karnataka by G. Sreenivasa and B B Hosetti and many more are some of the insect vibes and records that have passed through pages of our journal as permanent documentation.

Keeping a pulse on invasive is yet another key objective of IE. Read an interesting article on *Frankliniella occidentalis* "the silent intruder", by R. R. Rachana and another short treatise on *Tuta absoluta* by A K Chakravarthy (former Editor of IE) and Nitin.

The entire editorial team congratulates all the authors for their scholastic contributions. As authors you become a part of Special Interest Insect Group. These also include students, teachers and insect-watchers. Our endeavour is to bring insect enthusiasts- professional and amateurs- onto one platform to accelerate the growth of insect science.

We have two international personalities who have joined our Editorial Advisory Board: We welcome Dr. Shoki Al-Dobai, Team Leader, Locust and Trans boundary Plant Pests and Diseases, FAO of the UN, Italy. His expertise in locusts, and other international insect pests, will be a great support for IE. We also welcome Dr. Hamadttu Abdel Farag El-Shafie a very senior entomologist with King Faisal University Saudi Arabia. We are thrilled he is a regular author as well with IE.

I hope all of you are now looking forward to the next issue of INSECT ENVIRONMENT 24(2) June, 2021. Our processing of articles is very professional and quick! All articles are freely downloadable from our website by all. We have no commercial interest. If you are not yet a subscriber, please send us your e-mail. Our subscription is **free**.

Insects are everywhere. Watch them and lens or pen them! Capture them on your cameras and mobiles, or write about them and mail it to IE. They too need our attention! We are in the fag end of Covid presumably, for the curve is dipping (hopefully?), but, a resurgence cannot be ruled out. So, do mask, sanitize, jab and take care!

Insect Environment appreciates the excellent Covid Management by the honourable Indian Prime Minister, Shri Narendra Modi and his help in terms of vaccine supply to the national and international communities.

Dr. Abraham Verghese

Editor-in Chief

Special Editorial

It is a pleasure to pen an editorial for the Insect Environment, a unique disseminating medium for the popularisation of Entomology. It has received a new look with great revival, thanks to the team and its hard work. In a retrospective and prospective view, I find the science of Entomology, like any other aspect of our life has also undergone its own problems /challenges, and extraordinary situations due to the Covid-19 pandemic. It is now a year in full that we are all experiencing this pandemic in all walks of our life. There is always a blessing in disguise. Covid 19 has taught a lot of lessons, unlike the previous such situations, as the world is now in an advanced stage and the humans too with their revolutionised human life in the present century. One aspect that has come to the fore is the critical and imminent need for enhancing our immunity and defense. Such an immunity and defense has its multivarious implications in all walks of life, wherever living organisms are involved and with the largest one, the organic world. This will become more apparent if we start imagining and deliberating the effect of Covid 19 and such pandemics on the organic world, and what kind of implications are likely.

Nevertheless, for example, if an entomologist experiences a pandemic like that of the desert locust *Schistocerca gregaria* Forskal, which inflicted the most of north-western India; or like that of the emerging coconut spiralling whitefly *Aleurodicus rugioperculatus* Martin, which inflicted most parts of southern India, the situation is going to be same as that of dealing with Covid 19. Naturally, this implies that the basic concept of development of immunity and defense is becoming critical in these situations too, where the main player is an insect or entomologist. With the entomologists learning by mistake in the past two centuries, such a kind of defense or immunity is going to be empirical to insect pest management too. Drawing an analogy with Covid 19 and such pandemics, it is explicit that anyone dealing with insects have to become responsive to the need for improving or developing immunity or defense, and no doubt, it is the most critical approach. This applies equally, whether it is an agricultural, horticultural, forest, household, structural or urban pest. In this respect, the conservation of insects and their associations/ relationships accrue more significance. It is important and the most judicious, as it

enables us to manipulate the innate immunity or defense enabled by nature through its multivarious and diverse organic world. It is time that we who deal with insects, become more sensitive to the fact that out of the more than a million insects, only a fraction of them is inimical to mankind. Plenty of them exists otherwise, with many of them contributing to the natural immunity and defense as required when dealing with pandemics similar to Covid 19, that happens with the insect world in relation to human beings.

These thoughts, I am sure will bring to the fore the importance of characterising and conserving the major components of insect biodiversity. The need for giving the required priority in dealing with insects as components of the organic world, in particular the fundamentals of insect science need not be overemphasized.

I will be glad if this editorial provokes an entomologist towards these thoughts and pave the way for redefining some aspects of entomological research in the near future.

Prof. V.V. Ramamurthy

Editorial Advisor

Research Articles

The date palm borers of the genus *Oryctes* (Coleoptera: Scarabaeidae): bionomics, economic impact and possible management measures

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Abstract

The genus *Oryctes* (Coleoptera: Scarabaeidae) comprises of several species that bore into fronds, roots, offshoots and trunk of date palm grown worldwide. Both larvae and adults of *Oryctes agamemnon* Burmeister and *O. elegans* Prell cause economic damage to date palm. This article summarizes the bionomics, biogeography and integrated management of the two major date palm rhinoceros beetles.

Keywords: Date palm, rhinoceros beetles, *Oryctes* spp., fruit stalk borer

Introduction

Date palm, *Phoenix dactylifera* L. is attacked by an array of insect pests including species of the genus *Oryctes* which are commonly called rhinoceros beetles. Beside date palms, rhinoceros beetles also attack other palms of economic importance including oil palm *Elaeis guineensis* Jacq. and coconut palm *Cocos nucifera* (L.) (Bedford *et al*., 2015). Several species of the genus *Oryctes* are reported to inflict serious economic damage on date palms grown worldwide either for commercial production or landscape ornamental (Al-Jassany and Al-Saedi, 2019; El-Shafie *et al*., 2020). This paper gives an overview of the bionomics, distribution, economic impact, and available management tactics of rhinoceros beetles on date palms.

Taxonomic status, biogeography, and dispersal

Rhinoceros beetles belong to the order Coleoptera, superfamily Scarabaeoidea, family Scarabaeidae, subfamily Dynastinae, and tribe Oryctini (Bedford *et al*., 2015). The genus

Oryctes is specific to the old world and includes about 40 species (Endrödi, 1985). De Mire (1960) presented an account of the taxonomic relations, association with date palms, and distribution of seven species of rhinoceros beetles. These are O. *boas* F., *O. elegans*, *O. monoceros* Olivier, *O. nasicornis prolixus* Woll., *O. rhinoceros*, *O. sahariensis* De Mire, and *O. sinaicus* Walk. (= *O. agamemnon*, Burm.). Out of the seven species, *Oryctes elegans* and *O. agamemnon* are considered important pests of date palm. The two species are found in the Gulf countries (Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates, Yemen, and Israel) (Krell and Král, 2017; Friedman and Dobrinin, 2020). The subspecies *O. agamemnon arabicus* was accidentally introduced in Tunisia for the first time at the end of 70's decade from United Arab Emirates as part of varietal exchange between both countries (Soltani, 2010). Thus, importation and transportation of infested palms and offshoots represent the main introduction pathway for *Oryctes* borers into new uninfested areas.

Biological and ecological aspects

Rhinoceros beetles undergo complete metamorphosis, passing through egg, larva, pupa, and adult stage (Figure 1). Female has a pre-oviposition period of 4-5 days and it lays its eggs at the base of fronds, in crevices and tunnels in the trunk as well as the roots of the date palm. The egg is tiny with a size of about 2-3.2 mm, resembling hen egg. The female lays approximately 100 eggs that hatch in approximately 2-3 weeks. Both species have three larval instars and the total larval period (258 days) represent more than 65% of the beetle life cycle (Al-Jassany and Al-Saedi, 2019). The pre-pupal stage takes 15 days and the pupal stage is completed in about 20 days. *Oryctes* beetles are univolting having one generation per year and the whole life cycle of the beetle is completed in about 391 days. The adult beetles are nocturnal and strongly attracted to artificial light (Al-Deeb, 2012). The male-produced aggregation pheromone of *O. elegans* is 4-methyloctanoic acid which attracts both sexes (Rochat *et al*., 2004).

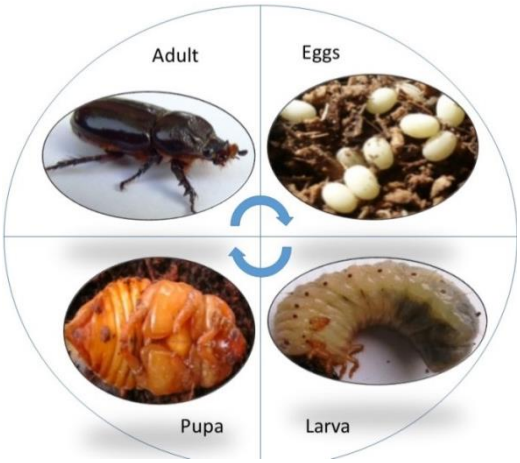

Fig. 1. The life cycle of the Arabian rhinoceros beetle *Oryctes agamemnon* (Photos: M. Z. Khalaf; design: H. A. F. El-Shafie)

Nature of damage and economic importance

Both larvae and adults of *O. elegans* and *O. agamemnon* cause injury to date palm which differ according to each species, the date palm cultivar and prevailing environmental conditions (Al-Jassany and Al-Saedi, 2019). The larvae bore into the base of frond below the palm crown or in the trunk (Figure 2) leading to breakage of fronds during windy weather. The adult beetles attack fruit stalks and the rachis of fronds or newly emerged unfolded fronds (Figure 3). Injury of fruit stalks lead to shriveling and premature drying of fruits which become unfit for human consumption. Palm mortality is high, particularly in young recently transplanted offshoots. Mature and old palms may also be infested with grubs, which results in yellowing of the fronds and reduction of yield. *Oryctes elegans* can also transmit the fungus *Fusarium proliferatum* Matsush that cause the leaf wilt disease of date palm (Al-Jassany and Al-Saedi, 2019; Ghaedi *et al*., 2020). The infestation percentages, by *Oryctes* species, in Iraq may reach 80-90% in some places leading to great economic losses. In many cases, the infestation by *Oryctes* borers is closely connected with that of the longhorn borer and termite damage (Al-Jassany and Al-Saedi, 2019).

Integrated management

Several components of integrated pest management (IPM) were recommended against *O. elegans* and *O. agamemnon* in the date palm ecosystem (Mohammed *et al*., 2018; Al-Jassany and

Al-Saedi, 2019). These include pruning of dead and old fronds, mass trapping of adult beetles using pheromone and light traps, entomopathogenic fungus *Metarhizium anisopliae*, use of selected insecticides, and adoption of strict quarantine measures on the movement of infested offshoots and old palms. Raising the farmers' awareness of the economic importance of rhinoceros beetle in date palm groves and encouragement of their participation in the control programs are also essential. In conclusion, the control measures used against red palm weevil and longhorn beetle, excluding the use of pheromone which is species specific, could also be used against rhinoceros beetles.

Fig. 2. Damage at the base of date palm frond (leaf) incurred by the larvae of *Oryctes agamemnon* (Photos: H. A. F. El-Shafie)

Fig. 3. Injury by adults of *Oryctes elegans* on the fruit bunch stalk (left) and on young unfolded leaves at the heart of the date palm (Photos: H. A. F. El-Shafie)

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Frankliniella occidentalis (Pergande) (Thripidae: Thysanoptera) – The silent intruder?

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The Western Flower thrips (WFT), *Frankliniella occidentalis* (Pergande) (Fig. 1 and 3) is highly polyphagous and a major pest of crops worldwide. It is the most destructive pest species in the order Thysanoptera (Mound, 2002) causing direct feeding damage to a wide variety of agricultural and horticultural crops. It is an important vector of tospoviruses causing great economic loss across the world (Rugman-Jones *et al.,* 2010).

Four females of *F. occidentalis* collected on tomato in November 2014 from Bengaluru formed the basis for the first definitive record of this invasive species from India (Tyagi and Kumar, 2015) as the earlier reports of this species from India (Kulkarni, 2010; Kanara and Acharya, 2014) are suspect (EPPO, 2013). Intensive surveys in Bengaluru, from where the first specimens were collected, failed to yield specimens of the WFT, probably because they were stray individuals and not part of a thriving viable population.

In February 2016 however, 9 females and one male of *F. occidentalis* were collected on leaves of *Erythrina indica* from Ooty in the Nilgiris, Western Ghats, South India (Rachana and Varatharajan, 2018). The record of a male, for the first time from India, is significant as it indicates the presence of a breeding population. Males are also known to be more effective vectors of tospoviruses than females.

This alien invasive species is often confused with the native species, *Frankliniella schultzei* (Trybom) (Fig. 2) but can be easily distinguished from the latter by the following character combinations: ocellar setae III on the tangent between the fore and hind ocelli (Fig.5) (ocellar setae III close together between hind ocelli in *schultzei*-Fig. 4), metanotum reticulate with paired campaniform sensilla (Fig. 6) (metanotum irregularly striate without campaniform sensilla in *schultzei*-Fig. 7), postocular setae IV the same length as ocellar setae III (Fig. 5) (postocular setae iv as longas the distance between hind ocelli and shorter than ocellar setae III in *schultzei*-Fig. 4).

The more favourable climatic conditions prevailing in Ooty as compared to that of Bangalore combined with the presence of males indicate that the WFT is likely to have established itself in Ooty. The Nilgiris could now serve as the springboard from where this species could disperse to other parts of the country.

Ornamentals and potato, grown extensively in and around Ooty, are transported to various parts of the country. The Groundnut Bud Necrosis Virus vectored by the WFT poses a threat to potato cultivation in the Nilgiris, and *Xerochrysum bracteatum* (Asteraceae), the common golden everlasting daisy, native to Australia and a host plant of the WFT, is often taken out of Ooty by tourists to other parts of the country. This along with other planting material carried by tourists and farmers could aid in the dispersal of *F. occidentalis* to the temperate regions of north and south India, where it is likely to thrive in the congenial climatic conditions prevalent there. Under these circumstances, it is imperative that the quarantine mechanisms within the country are activated and strengthened to prevent the spread of this notorious pest to the rest of India from the pockets of its occurrence in southern India – particularly the Nilgiris.

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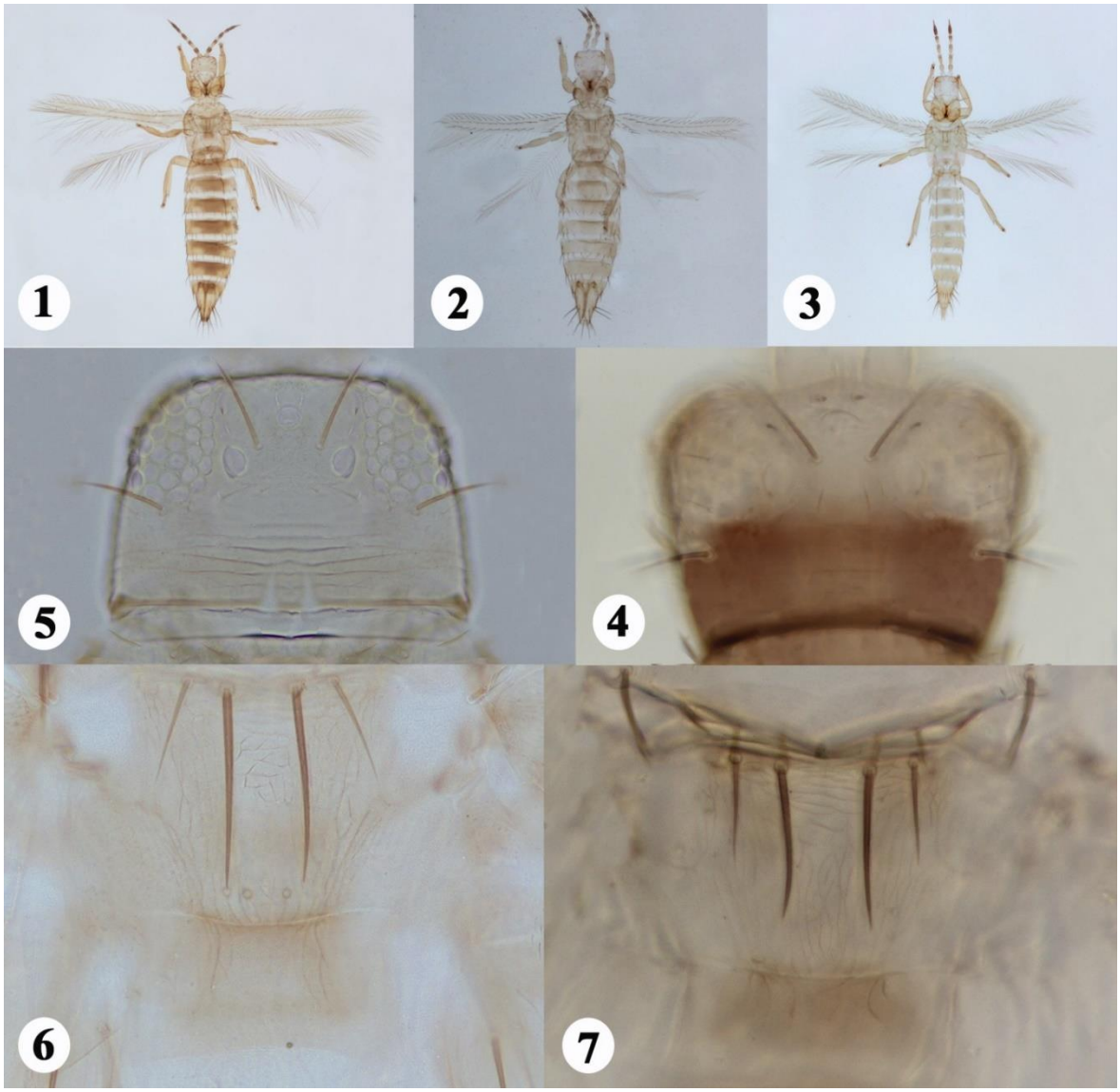

Figures 1–7: 1. Female *Frankliniella occidentalis*; 2. Female *Frankliniella schultzei*; 3. Male *F. occidentalis;* 4. Head of *F. schultzei*; 5. Head of *F. occidentalis;* 6. Metanotum of *F. occidentalis;* 7. Metanotum of *F. schultzei.*

Current status of the tomato pinworm, *Tuta absoluta* (Meyrick) in the Indian sub-continent: Challenges ahead

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The tomato pinworm, *Tuta absoluta* is an oligophagous pest, infesting economically important solanaceous crops (Sridhar *et al.*, 2014; Nitin *et al.*, 2019). In India, for the first time it was reported on tomato from the south Indian state, Karnataka (Sridhar *et al.*, 2014). Rapidly it invaded all the other south Indian states *viz*. Telangana (Kumari *et al.*, 2015), Tamil Nadu (Shanmugam *et al.*, 2016), Kerala (Sivakumar *et al.*, 2017), Andhra Pradesh (Rasheed *et al.* 2018) and North Indian states *viz*., Maharashtra (Shashank *et al.*, 2015), Gujarat (Chavan *et al.*, 2016), New Delhi (Shashank *et al.*, 2016), Madhya Pradesh (Swathi *et al.*, 2017), Punjab (Sandeep *et al.*, 2017), Meghalaya (Sankarganesh *et al.*, 2017), Himachal Pradesh (Sharma and Gavkare 2017), Uttarakhand (Singh and Panchbhaiya 2018), Chhattisgarh (Balaji *et al.*, 2018), Uttar Pradesh (Halder *et al.*, 2019), Bihar and Odisha (Sridhar and Srinivas 2019) (Fig. 1). This indicates that *T. absoluta* has now established itself in almost all parts of India in just about 5 years. This could be attributed to the un-regulated transportation of solanaceous fruits and plants especially tomatoes across the country. There are no reports of *T. absoluta* infestations from Rajasthan, Jammu and Kashmir. This may be because of upheaval climato-geographic conditions of these regions and solanaceous plants not being major crops there. In Jharkhand and other north eastern states extensive surveys could perhaps confirm *T. absoluta* infestation as these regions possesses favourable conditions during certain months of the year.

The tomato pinworm, *T. absoluta* has the potential to occur throughout the year in Indian agro-climatic conditions (Nitin *et al.*, 2017; Nayana *et al.*, 2018). Their activity and population increase with the increase in atmospheric temperature upto certain extent, (36^{o}c) (Nitin *et al.*, 2018), with significant damage to tomato production. Researchers have investigated COI gene sequences of *T. absoluta* and found that it is 100% homologous with the sequences deposited by researchers in NCBI database (Sankarganesh *et al.*, 2017; Shashank *et al.*, 2018), indicating

spread of *T. absoluta* from a single source. Genetic variations in *Tuta* populations are not yet detected.

Indian farmers are using pheromone traps for the early detection, monitoring and mass trapping of *T. absoluta* in their fields (Bhanu *et al.*, 2017). Along with the pheromone traps, solar traps also give promising results by trapping female *T. absoluta* (Sridhar *et al.*, 2019). Farmers are using synthetic insecticides as a primary control measure for *T. absoluta* management in spite of its drawbacks like environmental pollution, non-target effects and chance of developing insecticide resistance by the pest. Chemicals such as spinetoram, cyantraniliprole, flubendiamide and spinosad have given promising results in managing this pest both during vegetative and fruiting stages (Sridhar *et al.,* 2016). In some countries *T. absoluta* has developed resistance to diamide (Roditakis *et al.,* 2015), chlorantraniliprole (Silva *et al.,* 2016) and organophosphate and pyrethroid insecticides (Zibaee *et al.,* 2018), but in India *T. absoluta* showed reduced susceptibility to certain commonly used insecticide (Prasanna kumar *et al.,* 2020). *Tuta absoluta* management failure by chemical control is predicted to appear in future leading to adoption of an integrated pest management approach comprising eco-friendly methods. Integrated pest management approaches comprising of pheromones, microbials, natural enemies and eco-friendly molecules are more promising in controlling *T. absoluta* both environmentally and economically (Ballal *et al.,* 2016; Nitin *et al.,* 2018; Buragohain *et al.,* 2020). Along with these trials, researcher also found that the usage of yellow incandescent bulb traps to be very effective in attracting *T. absoluta* followed by blue light traps that captures both males and females (Sridhar *et al.,* 2019).

For the successful management of this noxious pest, Indian researchers should concentrate towards developing commercial genetically modified (GM) crop varieties that are resistant to *T. absoluta*, exploiting novel techniques such as RNA interference (RNAi) to silence the genes that result in impaired growth and/or development and even mortality of the pest. Sterile insect technique (SIT) can be employed for the management in a mass region as it is species-specific, environmentally friendly, and can be combined with other management options. Along with these interventions, legislations also play an important role in the management of invasive pests. Listing *T. absoluta* under quarantine species list, implementing cross-border quarantine facilities across the states, bringing public awareness through campaigns, conducting

farmers meets with the experts and sharing the knowledge among the stakeholders help in managing this invasive pest. Frequent exposure to insecticides, short lifecycle and generation period and higher rates of invasiveness are challenges to come in future.

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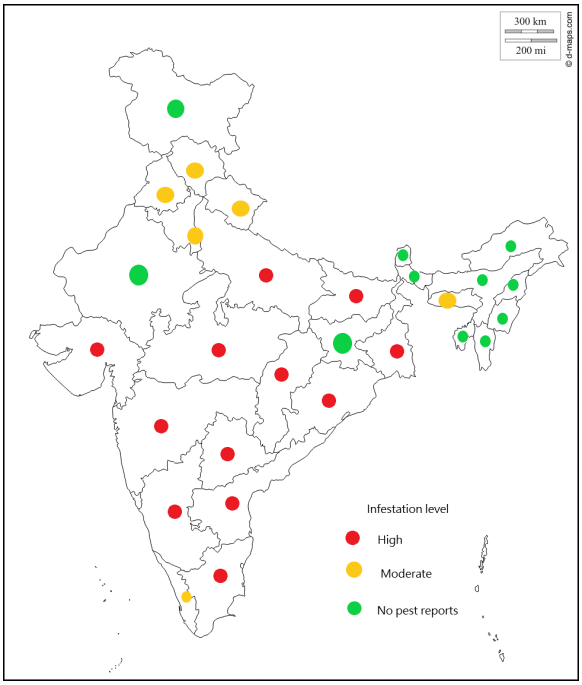

Fig 1. Indian states with *Tuta absoluta* infestation

Fig 2. Eggs of *Tuta absoluta*

Fig 3. *Tuta absoluta* infested eggplant

Fig. 4. *Tuta absoluta* infested tomato plant

Fig. 5. *Tuta absoluta* infested tomato fruit

Fig. 6. *Tuta absoluta* larval instars

Incidence of fall armyworm, *Spodoptera frugiperda* (J.E. Smith) on potato in maize-potato crop sequence

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Maize (*Zea mays*) is one of the most important crops grown for green cob in Ramgarh district of North Chota Nagpur region of Jharkhand, India. In this district, maize is usually grown round the year. The main cropping sequences followed by farmers in the district are maize-potato-cabbage, maize-cauliflower-potato-onion-cucurbits and maize-paddy-potato-cauliflower. Potato is the third major crop grown in the district after maize and paddy. Earlier on maize, stem borer, *Chilo partellus* was the major pest before the invasion of fall armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith) (Noctuidae: Lepidoptera) in the region. The FAW was reported in the beginning of year 2019 on early *kharif* season-sown maize crop from the Gola block of Ramgarh District.

The incidence was continuously monitored and observations were recorded on potato from farmer's field. For the survey, five farmers' fields in Gola block of Ramgarh district were selected for the study. In each field, ten plants at 5 random locations were selected and observations on the number of plants damaged by FAW were recorded. The damage symptoms on crop were noticed in collar region of stem and roots (Figure 1 and 2). The crop damaging larvae were identified as FAW, *S. frugiperda* based on morphological characteristics (Firake *et al.,* 2019). The level of infestation ranged from 2.0 to 5.0 percent in different farmer's field. The major damage was recorded after the first irrigation on 15-day old crop where plants were observed to fall down. It was also observed that high incidence of FAW on potato crop was recorded in fields where preceding crop was maize in the crop sequence. The possible reason behind high incidence in particular fields may be left over crop residues of previous maize crop. The farmers harvested only green cobs and remaining crop residues were ploughed in the same field before potato crop sown. So, initial predisposing factor of high incidence of FAW on potato crop may be from previous sown maize crop and their left over crop residues. In the high

incidence areas of FAW, crop sequence of potato after maize should be avoided to stop the multiplication of insects from previous residue population. Further detailed investigations are needed on its biology and adaptability in local environment.

Figure 1. Damaged potato plant from collar region

Figure 2. Larva of *S. frugiperda* damaging potato plant

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Jamun seed and fruit borer complex at University of Horticultural Sciences Campus, GKVK, Bengaluru

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Jamun (*Syzygium cumini* (L.) Skeels) (Myrtales: Myrtaceae) is one among the many under explored tropical fruits which are popular for medicinal and traditional value. The commercial cultivation of jamun has been given more importance recently, although it still lacks the documentation of area, production and productivity in Karnataka or any other state of India for that matter. There is very minimal or objective information available on the insects associated with jamun. The first record of an insect pest invading Jamun in India is of helmet caterpillar, *Carea angulata* (Fabricius) (*Carea subtilis* (Walker)) from south India dates in 1913 at Coimbatore, Tamil Nadu (Iyer, 1919). Butani and Jotwani (1975) compiled for the first time and later in 2010, Rajesh Kumar *et al*., made a compilation of pest spectrum invading jamun from the scattered information available.

Regional Horticulture Research and Extension Centre, University of Horticultural Sciences Campus, GKVK, Bengaluru located at 930 meters above mean sea level at 13° 05′ North latitude and 77° 33′ East longitude in the Eastern dry zone (Zone-5) of Karnataka. Fifteen identified varieties/ selections of Jamun, have been planted in an orchard system including Bahadoli and Dhupdal, the most popular varieties of jamun in peninsular India. Twelve promising and performing selections from farm universities of Karnataka; one from Tamil Nadu and a seedless variety obtained from a farmer in Kolar, Karnataka (originally from Rajasthan) were planted during 2012 (13 varieties) and 2013 (Dhupdal and seedless).

Jamun trees were observed from 2017 to 2019, on the insect pest's activity, nature of damage, density on different varieties, *etc*. Insect specimens were collected, immature were reared and adults were processed, preserved and few were got identified from Dr. C. A. Virakthamath, Emeritus Professor and Dr. H. M. Yeshwanth, Post-Doctoral Research Fellow, Department of Entomology, UAS, Bengaluru.

Among the 25 insect pest species devouring on leaves/twigs, fruits/seeds and bark/stem of jamun tree only 12 could be identified up to species level and six up to generic level. The pests invading either jamun seed or fruit appeared to be of economic importance while the one on seedless variety causing leaf gall needs studies to understand the impact on growth and yield (Pooja *et al*, 2019).

Among the fruit and seed borers, only four pests *viz.*, *Conogethes punctiferalis* Guenée **(**Lepidoptera: Crambidae) boring fruits (Plate 1); *Curculio c-album* (Fabricius) (Coleoptera: Curculionidae) and Eulophid wasp, *Anselmella kerrichi* (Narayanan, Subba Rao and Patel) (Hymenoptera: Eulopidae) feeding on seed and *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae) damaging the pulp were identified. Pest status of *Zeugodacus cucurbitae* (Coquillett)(Diptera: Tephritidae) adult captured during the fruiting season needs to be confirmed for its pest status on Jamun. *Anselmella kerrichi*was recorded on the unseasonal fruits of GKVK-1 variety. This variety bloomed early by the end of October and bear fruits during November–December 2018 deviating the normal season. Seed weevil, *C.c-album* appeared to be number one pest of economic importance from the studies as up to 100 percent fruit damage in few varieties was documented from two harvests during 2018 and 2019. Still the identity of four -lepidopteran fruit and seed borers needs to be confirmed.

Thirteen varieties which yielded economically during 2019 season excluding GKVK-1 and seedless varieties were analysed for fruit and seed borer complex. Based on the fruit damage symptoms the major jamun fruit and seed pests recorded were *C. c-album* (72%), followed by *C. punctiferalis* (8%) (Plate 1) and unidentified lepidopterans (20%), irrespective of the jamun varieties.

There is an urgent need for delineating the unidentified lepiodpteran species complex along with the cryptic species of *C. punctiferalis* infesting jamun (Shahsank *et al.*, 2014). The present record of *C. punctiferalis* is the first report on Jamun which has been noticed to bore young twigs besides fruits (Pooja *et al.*, 2019).These studies clearly stresses the need for evolving sound database on the bioecology, pest potential and pesticide free management tools for managing *C. c-album, C. punctiferalis, A. kerrichi* and unidentified lepidopteran complex as the crop acreage is growing day by day due to its nutraceutical values of fruits, seeds, leaves and bark besides drought tolerance.

			
Infested fruit	**Larva**	**Pupa**	**Adult**

Plate 1: Fruit borer, *Conogethes punctiferalis* Guenée

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First record of teak defoliator, *Hyblaea puera* Cramer (Lepidoptera: Hyblaeidae) on *Oroxylum indicum* (Lamiales: Bignoniaceae) from south India

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Hyblaea puera Cramer (Lepidoptera: Hyblaeidae) commonly-known as teak defoliator and is widely distributed throughout southern Asia. It is a polyphagous pest, recorded on 45 plant species across the world (www.plantwise.org). In India, this species was reported for the first time on *Oroxylum indicum* (Bignoniaceae) in Assam (Nath and Barman, 2002). *O. indicum* is a medium-sized deciduous tree, growing 8-12m tall. The roots, stem, and leaves of *O. indicum* arebeingused in traditional medicine for thousands of years to cure various diseases like allergies, urticaria, jaundice, asthma, sore throat, laryngitis, hoarseness, gastralgia, diarrhoea, dysentery, infantile, erythema and measles cough (Dev *et al.,* 2010).

During our periodical visit to Green graduation plot at College of Agriculture, Bheemarayanagudi, Karnataka, we noticed the incidence of *H. puera* on *O. indicum.* The neonate larva webbed the tender terminal leaves and fed within by scrapping the green tissues leading to the drying of leaves (Plate 1E-F). Later, larva webs the leaf margin and feed within (Plate 1G). As the larvae grew, they fed on entire leaves and caused defoliation of the plant. It caused about 50 percent defoliation of the plant (Plate 1H). After feeding, it pupated on the leaf in a thin silken cocoon (Plate 1C). To confirm the identity of the pest, larvae, and pupae were collected from infested plants and reared on *O. indicum* in the laboratory. Pupae were maintained in wooden cages. After emergence, adults were mounted and identified as *H. puera* (Plate 1D) using literature. In the previous report, Nath and Barman (2002) provided the biology of *H. puera* on *O. indicum* without life stage images. In the current paper, we provided images of life stages and damage symptoms (Plate 1). To our knowledge, this is the first record of this species on *O. indicum* from south India.

Plate 1: Life stages and damaging symptoms of *H. puera* Cramer on *O. indicum*

A) Egg; B) Grown-up larva; C) Pupa; D) Adult; E-H) damage symptoms

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A rare species of *Brachyrhynchus triangulus* Bergroth, 1889 (Hemiptera: Aradidae): A new record from Odisha and Mainland India

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Aradidae is commonly known as flat bugs due to their extremely fattened body. Insects of this family are cryptic and their economic importance is not much known. Some of them are mycophagous (fungus feeding) and some are attracted to bark beetle pheromones (Chandra and Kushwaha, 2015).

The genus *Brachyrhynchus* Laporte, 1832 belongs to the subfamily Mezirinae which is characterized by granulated body, sulcation on sternum, short rostrum and a well-developed metathoracic scent gland. Mezirinae is the largest subfamily of Aradidae (Schuh and Slater, 1995). *Brachyrhynchus triangulus* Bergroth was previously reported from Myanmar, Sri Lanka and Malaysia (Distant, 1902). In India, only four species are known i.e., *Brachyrhynchus feanus* Bergroth 1889, *Brachyrhynchus membranaceus* (Fabricius, 1803), *Brachyrhynchus undulatus*, Bergroth 1892 (Distant, 1902) and *Brachyrhynchus triangulus* Bergoth, 1889 (Chandra and Kushwaha, 2015).

Material examined: R. Udayagiri, Parlakhemundi Division, Gajapati Dist., Odisha (19°09’16.7’’N 84°08’43,8’’E) (Fig.1), 8.IX.2018 (1ex.) male, coll. Ashirwad Tripathy.

Diagnostic character: Body above piceous, granulate, abdomen brown and piceous, antenna 1st, 2nd and 3rd joint sub equal in length and piceous; fourth joint shortest and conical shape; pronotum very narrow and anterior portion with 4 large tubercles; anterior lateral margin sinuate, scutellum triangular and granulated, corium longer than scutellum, lateral margin of 6th abdominal segment sinuate and excavated.

Distribution: India (Andaman and Nicobar Islands, Odisha), Myanmar, Sri Lanka, Australia, Vietnam and China.

As *Brachyrhynchus triangulus* was discovered recently in Andaman and Nicobar Islands, India (Chandra and Kushwaha, 2015), this becomes a new record from mainland India (Odisha State).

Fig. 1: Showing collection site and *Brachyrhynchus triangulus* Bergoth, 1889

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Metagenomics of the melon fly, *Zeugodacus cucurbitae*: Variation in bacterial communities across different developmental stages

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The melon fly, *Zeugodacus cucurbitae* (Coquillett, 1899) (Diptera: Tephritidae), is a serious insect pest of cucurbitaceous and other related agriculturally important crops distributed in different parts of the world. The major incidence of *Z. cucurbitae is* reported from Asia, some of the African countries, the South Pacific islands of South America and islands of Oceania and Hawaii (Drew and Hancock, 2000). The bacterial communities in insects including fruit flies mostly reside in the gut, hemocoel, mycetomes and within the cells. These associated bacteria play a very important role in the host's nutrition, development, reproduction, resistance to pathogens, and semio-chemicals production (Douglas, 2015). Extensive knowledge of an insect's microbiota is an essential step toward understanding the biology and physiology of insects and may also be an initial step in the development of novel pest-management strategies.

The development and availability of recent high-throughput DNA sequencing technology have enabled the entire metagenomics profiling of insects including fruit flies across different stages (Naaz *et al.* 2020; Choudhary *et al.*, 2021). The complete knowledge of metagenomic profiling of bacterial communities of different stages of high economical importance *Z. cucurbitae* is required for the development of novel pest-management strategies. Earlier very few studies on *Z. cucurbitae* microbiota have been done and was restricted with culture-dependent techniques or low resolution molecular approaches or trap-caught adult male flies collected from different geographic regions as well as wild and mass-reared mature and newly emerged adults using high throughput sequencing (Yong *et al.*,2019; Hadapad *et al.*,2019). Keeping these facts in mind, the study was done on high-throughput Next-Generation Sequencing (NGS) on the Illumina HiSeq platform to examine the variation in bacterial communities at different developmental stage (1st instar, 3rd instar, pupa and adult female) of *Z. cucurbitae* life cycle, targeting V3-V4 region of the bacterial 16S rRNA (Choudhary *et al.*, 2021). The 16S rRNA gene

has been universally used for taxonomic studies of prokaryotic species and meta barcoding has proven to be a valuable tool and widely used for characterizing the microbial diversity.

The study revealed that overall bacterial community in the different developmental stages of *Z. cucurbitae* consisted of 23 phyla, 32 classes, 69 orders, 99 families and 130 genera. The phyla, Proteobacteria, Firmicutes, Actinobacteria and Tenericuteswere dominant and only shared among all the different developmental stages. Proteobacteria was the most predominant phylum in the larval and adult stages (mean ranged from 88.12 to 99.68% of total) whereas Tenericutes was the dominant in the pupal stage (mean 87.53% of total). Among the core phyla, Proteobacteria was represented by two classes (Gammaproteobacteria (87.85-98.42% in larva and adult) and Alphaproteobacteria), Firmicutes by two classes (Bacilli and Erysipelotrichia), Actinobacteria by a single class (Actinobacteria) and Tenericutes by single class (Mollicutes: 87.53% in pupal stage). The bacterial orders were represented by five core members (Enterobacteriales, Betaproteobacteriales, Pseudomonadales, Mycoplasmatales and Bacillales). Enterobacteriaceae was the most abundant bacterial family (56.43-98.16%) across all developmental stages except in pupal stage, family Mycoplasmataceae was most abundant (87.53%). However, the most dominant genus was *Providencia* and *Klebsiella* in larval stages (48.25-76.37%) and adult female stage (63.58%), respectively. Whereas in pupal stage, *Candidatus*-Bacilloplasma lineage was most dominant (87.05 %). Thedominance of the members of *Enterobacteriaceae* during larval and adult stage may have their role in sugar metabolism. The results suggest that the process of digestion may differ with the developmental stage, resulting in variation in the bacterial communities during its life cycle.

The variation among different developmental stages of *Z. cucurbitae* may be due to requirement of digestion process, type of food on which they feed and transmission pattern of bacterial species from one stage to another stage. Bacterial community transmissions during ontogenesis have been reported on other fruit fly species (Naaz *et al.*, 2020).

Distinct bacterial community association with specific developmental stages of *Z. cucurbitae* might suggest a specific role of microbial community to fulfill the developmental needs of associated stage in the fly. Results of study also supplement information to the available literature and provide a better understanding of the microbiota associated with *Z. cucurbitae* and

other tephritids. The bacterial community can also be used for managing fruit fly species through various ways, including attracting as odors, enhancing the success of sterile insect technique, declining the pesticide resistance, mass rearing of parasitoids etc.

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Report on infestation of bruchid beetle, *Acanthoscelides* sp. (Coleoptera: Bruchidae) on seeds of *Leucaena leucocephala* in industrial area of Himachal Pradesh

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The studies were conducted in Baddi, Barotiwala and Nalagarh (BBN) industrial area of Himachal Pradesh situated at an altitude of 422-448 m above mean sea level and between 30º55' to 31º02' N latitude and 76º42' to 76º49' E longitude to find out the insect infestation on seeds of tree species *viz*., *Leucaena leucocephala*, *Toona ciliata* and *Dalbergia sissoo* growing along road side. Seeds/pods of these tree species were collected from four selected sites, a. National Highway 21-A in Baddi industrial area, b. Baddi-Barotiwala Link Road c. Kalka-Charnia Link Road and d. 200m away from road in Kalka-Charnia Link Road which was taken as control. The collected seeds were observed for insect pest infestations and after observation, the seeds were put in the plastic containers (7.0 cm diameter) covered with muslin cloth and kept on the laboratory table for further emergence of the insect pests, if any. Five plastic jars were maintained per location. In total sixty jars containing seeds of three tree species collected from four sites were kept on the laboratory table. The data on per cent infestation of damaged seeds were recorded at weekly interval. The emerged insect species were recorded and identified. The per cent insect pest infestation was calculated by the below given formula:

$$\textbf{Insect pest Infestation (\%)} = \frac{\text{Number of infested seeds}}{\text{Total number of seeds}} \times 100$$

The seeds of *L. leucocephala* collected from National Highway 21-A in Baddi industrial area were found infested with bruchid beetle which was identified as *Acanthoscelides* sp. (Coleoptera: Bruchidae) (Fig. 1).The infested seeds did not germinate as these were completely damaged by the beetle (Fig. 1). The beetles were dark brown in colour with marginal shading on elytra (Fig. 2). The light yellowish coloured eggs of the beetle were observed on *Leucaena* seeds (Fig. 1). The larvae developed inside the seeds and adult beetles emerged from the seeds. At the time of collection of seeds/ pods, per cent seed infestation was recorded as 12.8 per cent which increased with the storage interval. After 12 weeks of storage, 54.8 per cent per cent of the seeds

were found infested with the beetle. No insect infestation of seeds/ pods of *L. leucocephala* collected from other sites were recorded. Similarly, no insect pest infestation on seeds of other tree species was observed.

Table 1: Infestation of bruchid beetle, *Acanthoscelides* sp. on seeds of *Leucaena leucocephala* collected from National Highway in BBN industrial area of Himachal Pradesh

Date of observation	Per cent insect infestation
3-4-2015	12.8*
10-4-2015	13.6
17-4-2015	16.4
24-4-2015	20.0
1-5-2015	21.6
8-5-2015	24.4
15-5-2015	27.2
22-5-2015	28.0
29-5-2015	32.8
5-6-2015	41.2
12-6-2015	48.0
19-6-2015	54.8

*Average of five replications

We found infestation of *Acanthoscelides* sp. in seeds of *L. leucocephala* collected only from National Highway 21-A (Baddi) which is most polluted area and under high pollution plants grow under stress and are liable to be attacked by insect pests and diseases. In germination test, lower germination of *L. leucocephala* seeds collected from this site has been recorded (Sharma *et al*., 2018) as compared to other sites. The insect predation might have contributed to reductions in seed germination. The impact of insect predation on seed germination has also been reported by previous workers (Janzen, 1971). The severe predation of *Leucaena* seeds by *A. macropthalmus* has been reported by Rodrigues *et al.,* (2012). The seed germination was

drastically affected by the insect predation. They observed no germination of *Leucaena* seeds which were attacked by *A. macropthalmus* against 59 per cent germination of unattacked seeds.

Leucaena leucocephala is an important fodder tree species of low and mid hills of Himachal Pradesh and insect predation by *Acanthoscelides* sp. will affect its natural regeneration.

Acknowledgement:

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Figure 1. Seeds of *Leucaena leucocephala* infested with bruchid beetle *Acanthoscelides* sp.

Figure 2. Adults of *Acanthoscelides* sp.

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Species diversity and relative abundance of scarab beetles in Jorhat district of Assam, India

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Scarab beetles (white grubs) have become increasingly difficult pests in Assam with their intensifying damage every year as evidenced by the several outbreaks that occurred over large areas during the recent past. Abrupt emergence of white grubs as a major threat to numerous economically important crops of this region may be due to intensive cultivation, improvements in irrigation facilities, conversion of fallow lands, deforestation as well as overall changes in the climatic scenario. Of late, scarab beetles have been gaining major pest status in various economically important crops of North-East India. Some of the species showed endemism to a particular habitat and few species are spreading to regions where they had not been recorded in the past (Bhattacharyya *et al.*, 2017). On the contrary, some ecologically beneficial scarab beetle species are known to play important role in burrowing and burying of dung, regulating enteric parasites and dung breeding dipterans pests, soil aeration, nutrient cycling, secondary seed dispersal etc. (Borenmissza, 1970; Fincher, 1981; Estrada and Coates-Estrada, 1991; Mittal, 1993; Chandra *et al.*, 2012). Keeping this in view, the present documentation was undertaken for the species diversity and relative abundance of scarab beetle fauna in Jorhat district of Assam.

For the collection of beetles, a light trap designed by ICAR-NCIPM (National Centre for Integrated Pest Management), New Delhi was set up at the Horticultural Experimental Farm, Assam Agricultural University, Jorhat (26.7227° N, 94.1957° E) from March to September, 2019. The light trap catches of scarab beetles were collected daily and counted. Subsequently, species-wise sorting was carried out in the Soil Arthropod Pests Laboratory, Department of Entomology, Assam Agricultural University. Further, total numbers of scarab beetles (month-wise) trapped in the light trap during the course of study were correlated with the weather parameters.

The emergence of the beetles was observed from March and reached the peak (603 numbers) during May, 2019 (Table 1). However, from the month of June onwards, the light trap

catches of the beetles showed a decreasing trend and reached the lowest individual numbers during September (37). Correlation study between monthly beetle numbers and different meteorological parameters *viz.*, temperature (maximum and minimum), relative humidity (morning and evening), total rainfall, number of rainy days, bright sunshine hours (BSSH) and wind speed showed a non-significant correlation during the study period (Table 2).

The study on relative abundance of light trapped catches of scarab beetles indicated that *Apogonia* sp. was the most predominant species and contributed 19.79 per cent out of the total number of beetles trapped during the period of investigation. The second most abundant species was *Sophrops irridipennis* Brenske (17.62%) followed by *Adoretus* sp. (13.49%) and *Anomala chlorosoma* Arrow (7.56%) (Fig.1). The scarab beetles which were found in lowest numbers were *Anomala chloropus* Arrow, *Heteronychus* sp., *Holotrichia serrata* Fabricius, *Brahmina coriacea* Hope, *Adoretus bicolor* Brenske etc.

Table 1. Light trap catches of scarab beetles along with the meteorological parameters during March-September, 2019

Months	Beetles collected (Number)	Temperature (°C)		Relative humidity (%)		Total Rainfall (mm)	Rainy days	Total BSSH (hr.)	Wind Speed (Km/h)
		Max	Min	Morn	Even				
March	123	27.0	15.7	91	61	77.2	12	120.0	2.3
April	589	28.9	19.8	92	70	184.6	7	123.2	2.2
May	603	27.8	21.7	95	80	327.6	19	62.0	2.6
June	143	32.6	25.2	90	73	328.6	13	111.4	2.3
July	81	31.9	25.9	92	80	403.5	8	191.0	2.6
August	64	33.8	26.2	91	72	194.4	8	191.0	2.3
Sept.	37	31.8	24.5	96	76	370.1	17	126.4	1.6

Table 2. Correlation of scarab beetle population with different meteorological parameters during 2019

Meteorological parameters	Correlation coefficient (r)
Maximum temperature (°C)	-0.612 NS
Minimum temperature (°C)	-0.393 NS
Morning relative humidity (%)	0.234 NS
Evening relative humidity (%)	0.137 NS
Total rainfall (mm)	-0.113 NS
Rainy days	0.145 NS
Total bright sunshine hour (hr.)	-0.638 NS
Wind speed (km/hr)	0.333 NS

NS - Non Significant

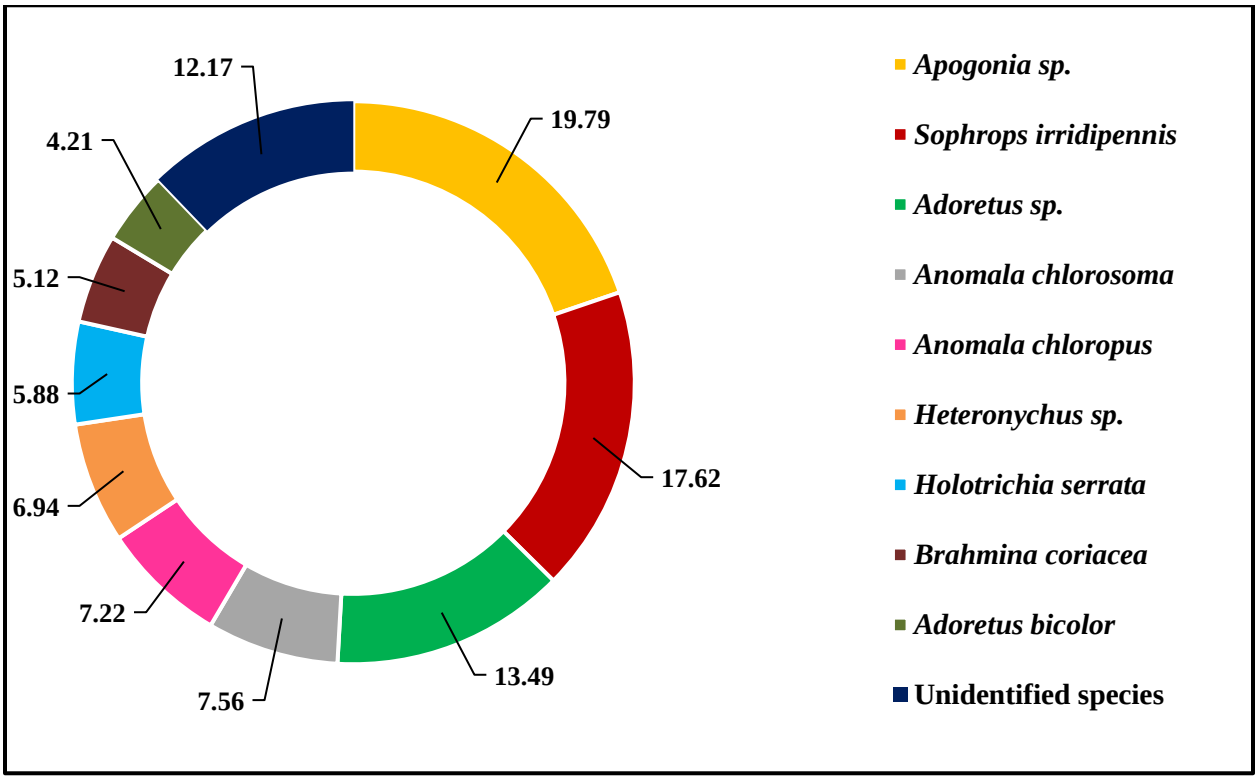

Figure 1: Species profiling of scarab beetles during 2019

Conclusion: Year-wise computation of species diversity and relative abundance of scarab beetles and its interactions with weather parameters will help to understand the recent emergence pattern of several scarab species in Assam. Moreover, this type of modelling can further be used to predict the potential pest species that might emerge or are already in the process of emerging as major pests of economy concern in the region.

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First report of leek moth, *Acrolepiopsis assectella* (Zeller), their nature of damage on garlic crop at Raipur, Chhattisgarh

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Garlic botanically known as *Allium sativum* and belongs to Alliaceae family (Iciek *et al*., 2009; Lanzotti, 2006). Garlic is native of Central Asia. It is mostly used for salads, soups; pickles for seasoning foods in culinary purpose and also to add smell and flavour to salted meat and fish. It is rich in organosulfur compound known as allicin (allyl 2-propen ethio sulfinate or di allyl thio sulfinate). The world's major garlic growing countries are China, India, Republic of Korea, Russia, Egypt etc. The main garlic producing states in India are Rajasthan, Madhya Pradesh, Gujarat, Uttar Pradesh, Maharashtra, Himachal Pradesh, Karnataka, Tamil Nadu and Chhattisgarh.

Leek moth is an invasive species, native to Europe. It favours plants in the allium family, especially onions, leeks, garlic, shallots and causing damage to young leaves, flowers and cloves. The adult moth is brown and white and is nocturnal, making it difficult to detect. The adults lay eggs on the host plant, and then, a week or so later, small, yellow larvae hatch and begin feeding. The first generation of larvae eats the leaves. Feeding by larvae damages plants and is particularly devastating on early *Allium* spp. plants. Most plant damage occurs at the perimeter of a cropped field (Nyrop *et al.,* 1989). Generations that emerge later in the summer find their way inside the plant, working their way down into the bulb. The invasion usually causes the bulb to rot, either in the ground or after being harvested and stored.

The study on nature of damage of Leek moth, *Acrolepiopsis assectella* (Zeller) on garlic crop was carried out at Horticulture farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during *Kharif* season, 2020-2021on garlic variety GG-4. Symptoms were recorded by destructive sampling at periodic intervals. The larvae were found to cause damage on vegetative stage.

The larvae soon after hatching feed on leaf surface and mine galleries 2-5 mm long in the epidermis of the leaves. Later they fold and bore the leaves towards the centre of the plant,

causing symptoms like hole on inner leaves and grooves in the mature plant. They prefer to feed on the young leaves but they can also feed on more than two months old leaves. After about five days, the larvae move toward the centre part of the plant, eventually boring through the folded inner leaves. Larvae may feed on the insides of hollow leaves, creating translucent “windows” or bands on the leaf tissue. Feeding on the leaf tissue by the caterpillars causes a reduction in plant growth. If larvae are numerous, weakening or withering of the plant can occur. On old leaves, open galleries can be seen which decrease the economic value of the plant. Occasionally, larvae attack the cloves. Larvae are probably stimulated to feed by sulphur components of the host and by other general plant compounds.

Fig. 1.1. *Acrolepiopsis assectella* larva

Fig. 1.2. Damage caused by larva on leaves

Fig. 1.3. *Acrolepiopsis assectella* adult

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Diversity of natural enemies of insect pests of cucumber (*Cucumis sativus)* in mid hills of Meghalaya

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Introduction

The day by-day growth in the awareness of vegetable's profound nutritive value has persuaded us to include more vegetables in our daily diet. Cucumber belongs to the cucurbitaceous gourd family with its origin from India. It is widely cultivated all over the world for its exquisite taste, ready to eat edible fruit and for making pickles. Major constraints for successful production of cucumber are damage caused by insect pests throughout the growing period. The extent of yield loss by insect pests ranges from 30 to 100%, depending upon the cucurbit species and the season in different parts of the world (Dhillon *et al*., 2005). Besides insect pests, several natural enemies also harbour in cucumber crop ecosystem which builds up their population by consuming their prey/hosts (pests) and regulate them. They are also known as biological control agents and provide outstanding regulation in reducing the level of pest populations below economic injury level (Chambers and Adams, 1986). Limited information is available on biodiversity of natural enemies in cucumber crop ecosystem and hence efforts were made to establish the correct identity of individual natural enemies present in cucumber crop ecosystem.

Study area and methodology

The research was carried out in year 2017-2018 in different experimental farms of ICAR Research Complex for North Eastern Hills (NEH) Region and College of Post Graduate Studies (CPGS), Umiam, Meghalaya ($25^0$41' N latitude, $91^0$55' E longitude). The natural enemies of insect pests were collected with various collection methods like hand picking, net sweeping and aspirator. The parasitoids were either collected directly or parasitized insect pests were collected from the field and later, on emergence these parasitoids were collected and subsequently used for identification.

The preliminary identification of the collected species was done based on established taxonomic key and also by matching characters with identified species in Insect Museum of Entomology Section of Crop Protection Division, ICAR Research Complex for North Eastern Hill (NEH) Region, Umiam, Meghalaya. The species which could not be identified were sent to ICAR-Indian Agricultural Research Institute (IARI), New Delhi; University of Agricultural Sciences (UAS), Bengaluru; ICAR-National Research Center for Banana (NRCB), Tiruchirappalli, Tamil Nadu for identification by expert taxonomists.

The insect specimens which were collected and identified were either dry preserved by spreading and pinning in insect box with labelled information about the species or by preserving it in 100% ethanol in vials with proper labelling. Photographs were also taken for all the specimens and voucher specimens were maintained at Insect Museum of Entomology Section of Crop Protection Division, ICAR Research Complex for North Eastern Hills (NEH) Region, Umiam, Meghalaya.

Results and Discussion

A total of 10 natural enemies (predator and parasitoid) were collected, identified and documented during 2017-2018 from cucumber crop ecosystem in mid hills of Meghalaya. The collection details are presented in Table 1.1.

Among the natural enemies collected in cucumber crop ecosystem, six species were predators and remaining four were parasitoids. The predators consisted of five coccinellids and one predatory spider. The coccinellids collected were *Oenopia sexareata, Micrapis* sp., *Oenopia kirbyi, Coccinellidae* sp. and *Coccinella septempunctata.* The notable ladybird beetles were *Oenopia kirbyi, Coccinella septempunctata* and *Micrapis* sp., these predators were found throughout the season feeding on aphids and soft bodied insects. The parasitoids recorded were larval parasitoid viz., *Hyposoter* sp., *Apanteles* sp., *Diadegma* sp., and *Diachasmimorpha* sp.

The natural enemies observed were self-documented wherever possible and are presented in Fig. 1 to Fig. 8.

Table 1.1. Biodiversity of natural enemies in cucumber crop ecosystem in mid hills of Meghalaya.

Sl. No.	Common name	Scientific name	Status
1	Ladybird beetle	*Oenopia kirbyi*	Predator
2	Ladybird beetle	*Micraspis* sp.	Predator
3	Ladybird beetle	*Coccinellidae* sp.	Predator
4	Ladybird beetle	*Coccinella septempunctata*	Predator
5	Ladybird beetle	*Oenopia sexareata*	Predator
6	Predatory spider	*Oxyopes* sp.	Predator
7	Ichneumon wasp	*Diadegma* sp.	Parasitoid
8	Braconid wasp	*Apanteles* sp.	Parasitoid
9	Parasitoid wasp	*Hyposoter* sp.	Parasitoid
10	Opine parasitoid	*Diachasmimorpha* sp.	Parasitoid

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Fig. 1 – *Oenopia kirbyi*

Fig. 2 - *Micraspis* sp

Fig. 3 - *Coccinellidae* sp.

a) Grub

b) Pupa

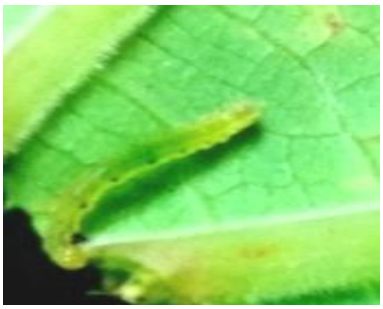
c) Adult

Fig. 4 – *Coccinella septempunctata*

Fig. 5 - *Oenopia sexareata*

Fig. 6 – *Oxyopes* sp.

Fig 7 – *Diadegma* sp.



a) Larva of cucumber moth

b) Parasitized larva

c) Adult parasitoid

Fig 8- *Apanteles* sp.

a) Larva of *Euproctis* moth

b) Parasitised larva

c) Adult

Fig 9 – *Hyposoter* sp.

Fig 10 – *Diachasmimorpha* sp.

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New distributional record of *Daphnis hypothous crameri* Eitschberger & Melichar, (Sphingidae: Lepidoptera) from Odisha, India

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The Indian subcontinent is well known for its high biodiversity, varied environment and habitats, and interesting geological history. However, much work remains to document and catalogue the species of India and their geographic distribution, especially for invertebrate groups, in which Odisha still remain unexplored as per insect diversity is concerned.

Moths and butterflies contribute to essential ecosystem processes such as herbivory, pollination and decomposition in many terrestrial biomes. They are strongly associated with vegetation structure and composition, which make them a suitable indicator taxon for various ecological studies (Lomov *et al*., 2006). As they are highly sensitive to environmental changes and proved to be powerful indicator of forest disturbance moth communities are receiving increasing conservation interest (Luff and Woiwod, 1995, Summerville *et al*., 2004, Scalericio *et al*., 2009). Documenting the faunal diversity of moth can get evolutionary insights and a first step in developing conservation goals for the Lepidoptera (Gadhikar *et al*., 2015). Species level inventories will provide baseline data on the geographic distribution of species which is a prerequisite for management and preservation of natural habitats whereas local level inventories provide information for economic and educational activities (Arandhara *et al.*, 2017).

There are around 1,42,000 moth species in the world. In India, over 12,000 moth species have been recorded, yet this number is far from being correct as major work is needed to prepare a comprehensive list (https://indianexpress.com, 2018). There are about 2000 species of Sphingidae under 200 genera globally (Kitching, 2021). The last well documented moth fauna of Odisha was studied by Mandal and Maulik, 1991 in which they mentioned about the Sphingidae of Odisha. Later, Jena *et al*., 2018 studied the diversity of moth in Gupteswar Proposed Reserve Forest of the Eastern Ghat Hill, Koraput, Odisha.

Moths of genus *Daphnis* Hubner belong to tribe Macroglossini under family Sphingidae (Lepidoptera) and are known by nine species from different part of the globe (Amritpal *et al.*, 2015). There are only four species of this genus known from India i.e., *Daphnis nerii* (Linnaeus, 1758), *Daphnis hypothous* (Cramer, 1780), *Daphnis placida* (Walker, 1856) and *Daphnis minima* (Butler, 1876) (Sondhi *et al*., 2021; Sankararaman and Manickavasagam, 2018). *Daphnis hypothous* is distributed in India, Borneo, China, Indonesia, Nepal, Malaysia, Myanmar, Sri Lanka, Taiwan and Thailand (Amritpal *et al*., 2015, Iyer and Kitching, 2019). Among the Indian states, there are records of this species from Assam, Tamil Nadu, Arunachal Pradesh, Tripura, Karnataka and Meghalaya (Amritpal *et al.*, 2015 and Sondhi *et al*., 2021). Eitschberger and Melichar (2010) discovered a new subspecies of it by evaluating the genetic differences of the specimens. The specimens found from south east Asia were described as *Daphnis hypothous crameri* Eitschberger and Melichar, 2010. Here, the photographic evidence of it was gathered from different regions of Bhubaneswar (20.285019, 85.792854 on 29.12.2018; 20.284544, 85.793262 on 15.11.2019), Odisha.

Amritpal *et al.,* (2015) provided a key to distinguish the two closely related species: *D. nerii* and *D. hypothous:*

Forewing with ground colour bright green, M1 arising from upper angle of cell, R5 and R4 stalked; hind wing with veins M1 and Rs shortly stalked; male genitalia with aedeagus having a well sclerotized short spur and a sclerotized plate with short bicuspid spur; valva with narrow friction scales; female genitalia with corpus bursae companulate .....nerii (Linnaeus)

Forewing with ground colour dark brown; M1 (R5, R4) stalked from upper angle of cell; hind wing with veins M1 and Rs from upper angle, but not stalked; male genitalia with aedeagus having two long well sclerotized spurs; valva with foliate friction scales; female genitalia with corpus bursae oblong.....hypothous (Cramer)

This observation marks a new distributional record *Daphnis hypothous crameri* Eitschberger and Melichar, 2010 from Odisha. As earlier documentations are from North-eastern and Southern parts of India this is a new record from eastern India.

Fig. 1: *Daphnis hypothous* (Left) and *Daphnis nerii* (right)

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Response of pupal weight of stalk borer, *Chilo auricilius* Dudgeon (Crambidae: Lepidoptera) on biology of *Tetrastichus howardi* (Olliff) (Hymenoptera: Eulophidae)

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Abstract

The biological attributes of *Tetrastichus howardi* (Olliff) (Eulophidae: Hymenoptera) were studied at 26 ± 2°C and 65 ± 5% relative humidity in the laboratory on different weighed pupae of sugarcane stalk borer, *Chilo auricilius* Dudgeon (Crambidae: Lepidoptera). The lowest value for the mean number of progeny per pupa was recorded as 41.17 progenies/pupa and increased with increase in weight of pupa. The maximum progeny (82.83 progenies/pupa) was obtained from pupal weight of more than 0.091g. The number of female also increased per pupa (37.67 to 77.50) as pupal weight increased. The female biased sex ratio (>90%) was observed in all ranges of weighed pupa. It can be inferred that higher numbers of adults in short period of time, a strong preponderance of females on more weighed pupae and gregarious development makes it possible to multiply *T. howardi* on sugarcane stalk borer pupae in the laboratory.

Key words: Sugarcane, *Chilo auricilius*, pupa, weight, *Tetrastichus howardi*

Introduction

The success of biological control programmes depends on the mass rearing of parasitoids (Pastori *et al*., 2008 ; Pereira *et al*., 2009) and the specific hosts that are used for rearing, making it mandatory to study their biological interaction (Nakajima *et al*., 2012;Kumar *et al*., 2016). The development of mass-rearing methods depends on the knowledge of biological attributes i.e. sex ratio, reproductive potential, length of the life cycle (egg to adult), exposure periods of parasitoids to host and parasitoid sensitivity to abiotic factors, i.e. temperature, light, and humidity (Favero *et al*., 2013).

Tetrastichus howardi (Olliff) (Eulophidae: Hymenoptera) is a gregarious and polyphagous endopupal parasitoid of sugarcane borers, show great potential as an effective bio-

agent (Baitha and Sinha, 2005; La Salle and Polaszek, 2007; Kumar, 2020). It parasitizes sugarcane borer pupae (Cherian and Subramaniam, 1940; Puttarudriah and Sastry, 1958; Vargas *et al*., 2011; Sankar and Rao 2016) in their galleries in sugarcane.

The knowledge of biological attributes particularly on host size, weight, quality, etc. is of vital importance in the mass rearing of *T. howardi* on alternate hosts and developing strategies for their subsequent release in the field (Pereira *et al*., 2015; Kumar *et al*., 2018). Its polyphagous nature, high fecundity and ability to attack a wide range of hosts are considered as valuable for the biological control of sugarcane borers. Providing host pupa in a proper manner to have potential production with the desirable biological attributes requires knowledge about the various interactions between the host and parasitoids. The knowledge on host – parasitoid interaction, gives us a platform upon which the right choices of host to mass multiply the parasitoids.

Sugarcane stalk borer, *Chilo auricilius* Dudgeon (Crambidae: Lepidoptera) is a specialized borer of sugarcane. In sugarcane, it extensively damages the mature cane stalk (Mazumder, 2020) and it is also known as "Tarai borer" due to its prevalence in the *Tarai* region (moist as well as cold area in the subtropical belt). The study was undertaken to rear *T. howardi* in the laboratory by using different weights of pupa of *C. auricilius* as well as to generate opportunities for studying the potential of this parasitoid in controlling *C. auricilius* on sugarcane crop.

Materials and Methods

The host pupa of stalk borer, *Chilo auricilius* was collected from sugarcane fields at Research Farm, IISR, Lucknow. Freshly formed pupa is thin, slender and yellowish –white or creamy yellow in colour and as it matures the colour changes to light brown.

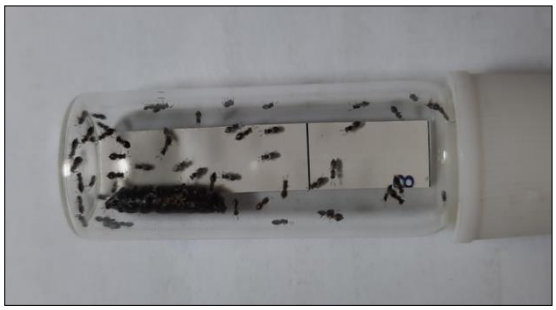
The pupal parasitoid, *Tetrastichus howardi* was maintained on pupae of sugarcane stalk borer, *C. auricilius* (Fig.1). Newly emerged mated females of *T. howardi* were kept singly in glass vials (15 x 2.5 cm). The weight of each stalk borer pupa was recorded on electric balance. Each individual female parasitoid was provided with a pupa of stalk borer. Fine streaks of honey-water solutions (1:1 v/v) were provided as adult food and the glass vials were plugged with cotton wool. The individual females were allowed for 24h parasitisation and then removed. The

experiment was conducted at 26 ± 2°C and 65 ± 5% relative humidity with five replications. The observations were taken after the emergence of parasitoid on the developmental period (from egg to adult), the number of progeny emerged per pupa, female emergence and sex-ratio (M: F).

Stalk borer pupae

Parasitised pupa by *T. howardi*

Emergence of *T. howardi*



Emergence of *T. howardi*

Figure 1. Fresh pupa of *C. auricilius*, parasitised pupa and emergence of *T. howardi*

The sex of adult parasitoids was determined by assessing the morphological characteristics of their antennae and abdomen (LaSalle, 1994). The data (except sex ratio) were subjected to analysis of variance (ANOVA) at 5% probability.

Results and Discussion

On stalk borer pupa, developmental period varied from 17.33 to 17.83 days and it was not influenced by weighed pupae. The period of development of this parasitoid on different hosts is variable, but generally, the cycle lasts from 14 to 20 days (Puttarudriah and Sastry 1958, Favero *et al*., 2013). The lowest variation on duration of the cycle (egg-adult) of T. howardi on *C.*

auricilius indicates that host pupae are suitable for the development. The production of progeny per pupa was recorded lowest as 41.17 and increased with increase weight of pupa (Table 1).

The maximum progeny (82.83 /pupa) was obtained from pupal weight with more than 0.091g. It may be associated with nutritional availability and size of the host. The weight of host pupa was correlated with the number of adults emerged (Nadarajan and Jayaraj, 1975). The smaller host pupa gave rise to less number of parasitoids whereas larger ones supported more parasitoids (Puttarudriah and Sastry 1958; Kfir *et al*., 1993; Baitha and Maurya, 2012). The limitation of space and deficiency of food materials in smaller pupa resulted in either low fecundity of females or greater mortality among immature stages or both. Parasitoids in general, determine the quality of host by its size and believed to contain more resources than small host (Godfray,1994; Islam and Copland 1997).

Table 1. Response of host weight of stalk borer pupa on biological attributes of *T. howardi*

Weight of stalk borer pupa (gm.)	Development period (days)	No. of progeny/ pupa	No. of Female	Female (%)	Sex Ratio (M:F)
< 0.050	17.7[a]	41.17 [a]	37.67 [a]	91.07 [a]	1:10.9
0.051 - 0.070	17.8 [a]	47.50 [a]	43.50 [a]	91.72 [a]	1:11.6
0.071 - 0.090	17.5 [a]	71.31[b]	66.30 [b]	92.95 [a]	1:14.1
>0.091	17.3 [a]	82.83 [b]	77.50 [b]	93.53 [a]	1:14.9

Means followed by different letters in the same column are significantly different (P<0.05)

The number of female increased per pupa (37.67 to 77.50) as weight of pupa increased. The female biased sex ratio (>90%) was observed in all ranges of weighed pupa (Table 1). Uematsu (1981) observed that parasitoids may have the ability to modify sex ratio of the progeny according to host size. As weights of pupa increased, the sex ratio (M: F) also increased from 1:10.9 to 1:14.9. The large is more beneficial to the fitness of daughters than sons and selection would then favor wasps to lay daughter on large hosts and more sons in small hosts (Assem, 1971; Kobayashi and Shimada 2000; Harvey *et al*., 2004).

It can be inferred that higher numbers of adults in short periods of time, a strong preponderance of females on more weighed pupae and gregarious development make it possible to multiply *T. howardi* on field-collected sugarcane stalk borer pupae in the laboratory.

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Understanding within-field distribution of stages is the key to design management strategies against areca white grubs, *Leucopholis lepidophora* Blanchard (Coleoptera: Scarabaeidae)

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Many species of white grubs are well known pests of a number of cultivated crops in India. They belong to four sub families of Scarabaeidae *viz.*, Dynastinae, Cetoniinae, Rutelinae and Melolonthinae, which include all the phytophagous species. Among them, the areca nut white grubs belong to the subfamily Melolonthinae and genus *Leucopholis.* This genus consists of three important species *viz*., *Leucopholisconeophora*, *Leucopholis lepidophora* and *L. burmeisteri. Leucopholis lepidophora* and *L. burmeisteri* take two years for completion of life cycle, whereas *L. coneophora* takes one year for completion of life cycle. Among these three species, *L. lepidophora* is the major pest in the Malnad region (Karnataka, India) (Kalleshwaraswamy *et al*., 2015). Field survey conducted by Rakesh (2007) revealed that field population in Uttar Kannada and Shimoga districts (in Karnataka) in young paddy field converted into arecanut gardens showed higher grub load and more striking damage symptoms than old and traditional gardens. The variation in the availability of different stages depends on soil moisture content of the garden (Kumar, 1999). Understanding the spatial distribution of different stages of *L. lepidophora* in soiland their seasonality is basic to design management strategy. With this background, experiments were conducted for 2 years to study the spatial distribution of different larval instars.

For studying spatial distribution, two types of gardens were selected. First type was old traditional gardens *i.e.*, gardens which are approximately > 50 years of age. Second type of garden selected were new gardens *i.e.*, gardens which are converted from the paddy fields and < 25 years of age. The old traditional gardens were selected in Kesare village (N13º52.145'; E075º14.506'), Thirthahalli taluk and Bheemanakone (N14º07.355'; E075º03.280') Sagara taluk. New gardens selected in Kesare village (N13º52.145'; E075º14.506'), Thirthahalli taluk and Kabbinamane village (N14º06.464'; E074º58.581'), Sagara taluk. The gardens of Bheemanakone and Kabbinamane, selected for the experiment were of 50 year (old garden) and 17 year (new

garden) old with an incidence of zero per cent and about 40 per cent, respectively. In Kesare, gardens were around 50 years old (old traditional garden) and 15 year (newer garden) age with an incidence of about zero per cent and 35 per cent, respectively. Number of trees showing symptoms out of total trees was used for calculating per cent incidence. The soil samples were collected and analyzed as per the standard procedures. The plant spacing followed was 8 x 8 ft or 9 x 9 ft with drainage in the alternate rows in all the gardens selected which is a common practice in the Malnad region.

An acre area of the selected gardens was mapped and divided into five grids of 800 m^2 size. A total of 3 samples (herein considered as sampling sites) were taken in each sampling site, first, 1foot radius around the palm (30 cm away from base of the palm), second, 2-3 ft away from the base of the palm, third, 3-4 ft away from the base of the palm. The first sample was taken in circular manner around the base of the palm whereas second and third samples were taken in 1 square ft. Five such samples were taken from each grid (25 samples per acre). Number and stages of larvae collected at 2 different depths *viz.*, 0-30, 30-60cm in each sampling sites were recorded. Observations were recorded at monthly interval (2^{nd} week of each month). Different immature stages (eggs, larvae and pupae) were collected along with loose wet soil in small plastic box with perforated holes on the lid and counted. Larval instars (I, II and III instars) were differentiated based on the head capsule width during the study period by using ocular micrometry for the measurement as reported by Channakeshava (2006). The head capsule width reported by Channakeshava (2006) was 2.90 -3.60 mm, 7.32-7.90 mm and 19.00-22.00 mm for I, II and III instars respectively. Based on the stages and depth at which the stages collected from both gardens and with 2 years data, schematic plates/figures representing different stages in soil were generated.

Results and discussion:

Spatial distributions of white grubs were examined around the palm and between the palms in both new and old traditional gardens.

In old traditional garden, only first instar grubs were found between July and September in all the 3 sampling sites of garden. However, grubs were not observed in the remaining study period (November onwards to June).

In new garden

The first instar grub population was found only between July to October. The grubs were found in all the 3 sampling sites during July to September. First instar grub population was absent from November onwards to June.

Sampling round the palm indicated, presence of second instar white grubs from August to November and very low grub load in December. No second instar population observed in January to June in between the palm.

Third instar population was observed all around the year, owing to its long duration and as a result insect is known to have 2 year life cycle (Kumar, 1999). In between the palms of new garden, third instar white grub grub populations were not observed. However, they were found throughout the year at around the palm. It appears from the Table 1 and 2, the grub population is very less. However, considering the random distribution of grubs as reported in Japaneese beetle (Villani and Wright, 1988), there is need of standardization of sampling technique for this major pest of arecanut. The grubs which are located in the root zone could not be sampled owing to damage caused to the palm by destruction of roots during sampling.

Pupa were found only between April to June and were found maximum at 30-60 cm depth than 0-30 cm. However, adults were found during June to October. Adults were found both around the palm, as well as in between the palms at a distance of 2-3 ft and 3-4 ft away from the palm. This indicated the adult emergence was restricted between June and October months (Kalleshwaraswamy *et al*., 2015). The presence of the adults at 2-3 ft and 3-4 ft away from the base of the palm indicated that these are previously emerged, mated and entered into soil for egg laying. Adult emergence was restricted to July to October months (Kalleshwaraswamy *et al*., 2016) which could be collected by using female baited traps.

Based on the observed pattern of grub distribution in new and old gardens, a schematic representative figure was generated for easy understanding of spatial distribution of *L.lepdophora* stages in soil (Figure 1 and 2). The understanding of within field distribution was key to design the experiments and to target different instars and also to decide the spray schedule. Our study conclusively demonstrated that soil drenching of insecticides twice targeting

both early instars and later instars was effective than the traditional practice of single time application or untimely application. The study showed that the timing is crucial in reducing the grub population. In a new garden (paddy field recently converted to areca garden), between July to September, presence of all the instars was evident Figure 1) with I and II instars found in top soil. This emphasises the need of spraying insecticide to entire field. First application should be taken up during July/August by spraying throughout the garden per hectare basis and second treatment by drenching the insecticide around the root zone (per tree basis) during September/October (Adarsha *et al*., 2015). This idea was effectively implemented in large scale demonstration and proved efficient in reducing the grub population and recovery of infested palms. However, in old traditional areca gardens (Figure 2), few eggs and early instar grubs were observed in July-September but in the later months they were not found thriving, indicating soil parameters play a crucial role in supporting the grub population.

Any insecticidal management taken up other than this period (July to October) will be futile expenditure. The reason being (i) only third instar population will be present in the soil (ii) third instars will be present deep in the soil, say > 30 cm to 90 cm depth) (iii) they are less susceptible to insecticides/bio agents and (iv) In dry seasons, moisture content of soil gets reduced and larvae move to deeper layers (<60cm) in search of moisture (Villani and Wright, 1988).

Owing to these problems, an additional strategy was developed. In order to take up any management strategies, larvae have to be brought to top layer without affecting the root functioning. Hence, increasing the soil moisture by filling water to drainages by plugging ends and flooding helped to bring the white grub larvae to top layer. Our studies clearly indicated that combined effect of insecticidal spray and water filling to drainages by plugging two ends + flooding completely for eight days was effective in bringing the larva to the top layer of 15 cm depth, which leads to mortality of grubs. As insecticide could not reach the depth of 60 cm during dry season (November to May), upward movement of grubs by increasing the moisture in field through flooding increases the chance of exposure of grubs to the insecticide (Adarsha, 2017).

Particle size analysis revealed that the textural classes of the soil under study area *i.e.*, new gardens are sandy loam and old traditional gardens varied from silt loam to silt clay loam. The results indicated that incidence is more in soils rich with sand content. Whereas clay content negatively influenced population of white grubs. The old traditional gardens were generally forest lands converted into gardens many years back and were rich in clay content and do not support the grub movement and eventually lead to reduction in population. The study of within-field distribution and soil analysis paved the way for successful design of management strategy against this major pest of areca nut.

Acknowledgement

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Table 1: Within field distribution of different stages of areca nut white grubs at 0 - 30 cm depth in a new garden

	Eggs			I instar			II instar			III instar			Pupa			Adult		
	I*	II**	III***	I*	II**	III***	I*	II**	III***	I*	II**	III***	I*	II**	III***	I*	II**	III***
July	1.00	0.25	0.32	0.25	0.50	0.25	0	0	0	1.25	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
August	1.40	1.00	0.80	1.00	1.25	0.95	0.75	1.20	0.80	1.00	0.00	0.00	0.00	0.00	0.00	0.75	1.00	1.25
September	0.80	1.40	0.50	0.80	1.42	0.52	1.00	1.00	0.63	2.00	0.00	0.00	0.00	0.00	0.00	0.50	0.75	1.25
October	0.00	0.00	0.00	0.52	1.00	0.80	1.25	1.00	0.75	1.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
November	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.80	0.52	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
December	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
January	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
February	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.00	0.00
May	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.50	0.00	0.00
June	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.00	0.00	1.00	0.00	0.00

I* = 1foot radius around the palm (30 cm away from base of the palm); II** = 2-3 ft away from the base of the palm; III*** = 3-4 ft away from the base of the palm

Table 2: Within field distribution of different stages of areca nut white grubs at 30 - 60 cm depth in a old garden

	Eggs			I instar			II instar			III instar			Pupa			Adult		
	I*	II**	III***	I*	II**	III***	I*	II**	III***	I*	II**	III***	I*	II**	III***	I*	II**	III***
July	0.53	0.45	1.00	0.00	0. 50	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.21
August	0.80	0.50	0.25	00.20	1.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
September	0.75	0.30	0.45	0.00	0.50	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
October	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
November	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
December	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
January	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
February	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
June	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

I* = 1ft radius around the palm (30 cm away from base of the palm); II** = 2-3 ft away from the base of the palm; III*** = 3-4 ft away from the base of the palm

Table 3. Particle size analysis in new and old traditional garden at Thirthahalli taluk and Sagara taluk, Shimoga District

Location	Garden types	Soil particle size (%)			
		Sand (%)	Silt (%)	Clay (%)	Textural class
Thirthahalli	**New garden**	51-61 %	8-13%	17-25%	Sandy loam
	Old traditional garden	35-44%	10-15%	20-30%	Silt loam –Silt clay loam
Sagara	**New garden**	50-56%	13-20%	8-13%	Sandy loam
	Old traditional garden	32-41%	7-18%	20-28%	Silt loam –Silt clay loam

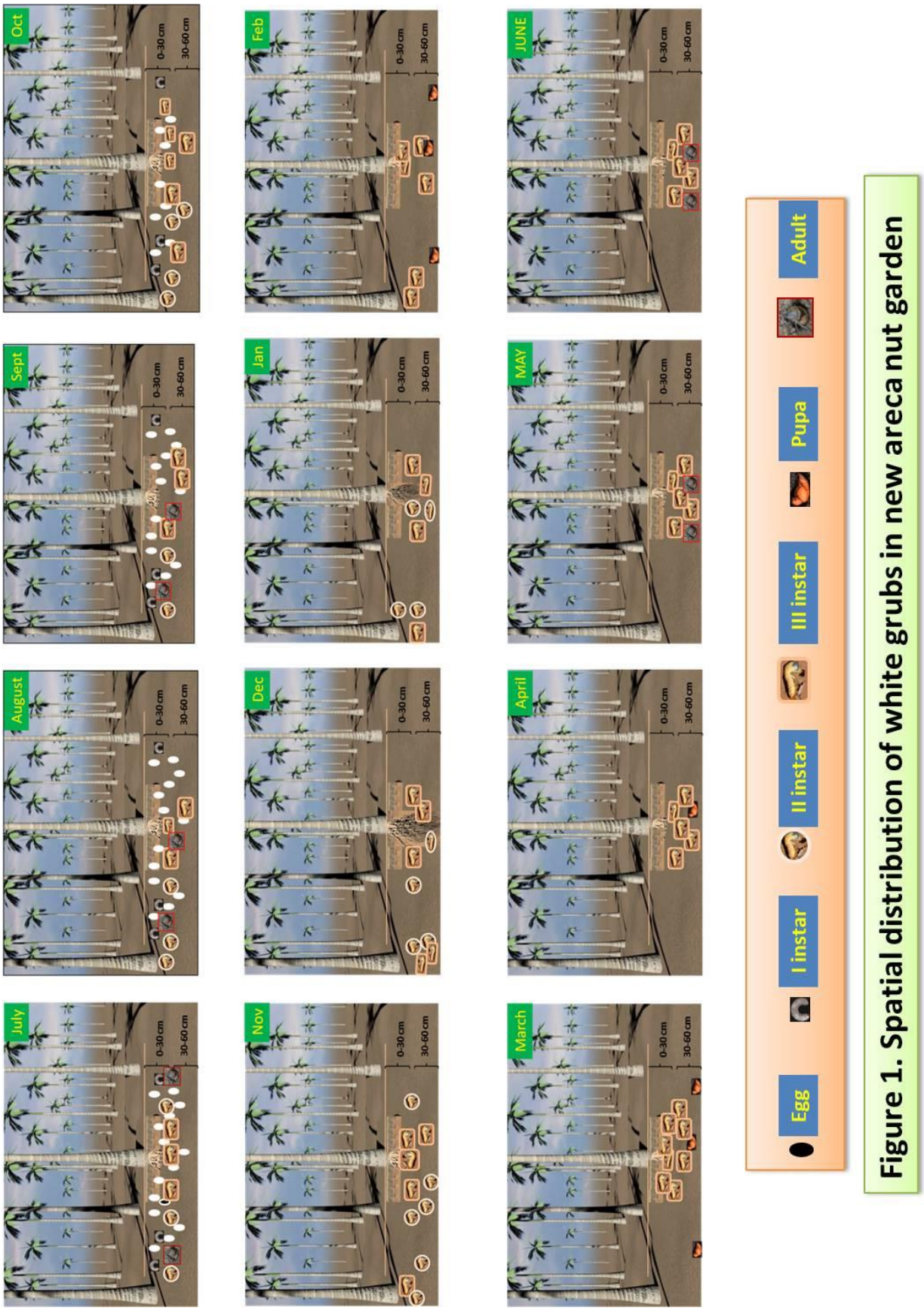

Figure 1. Spatial distribution of white grubs in new areca nut garden

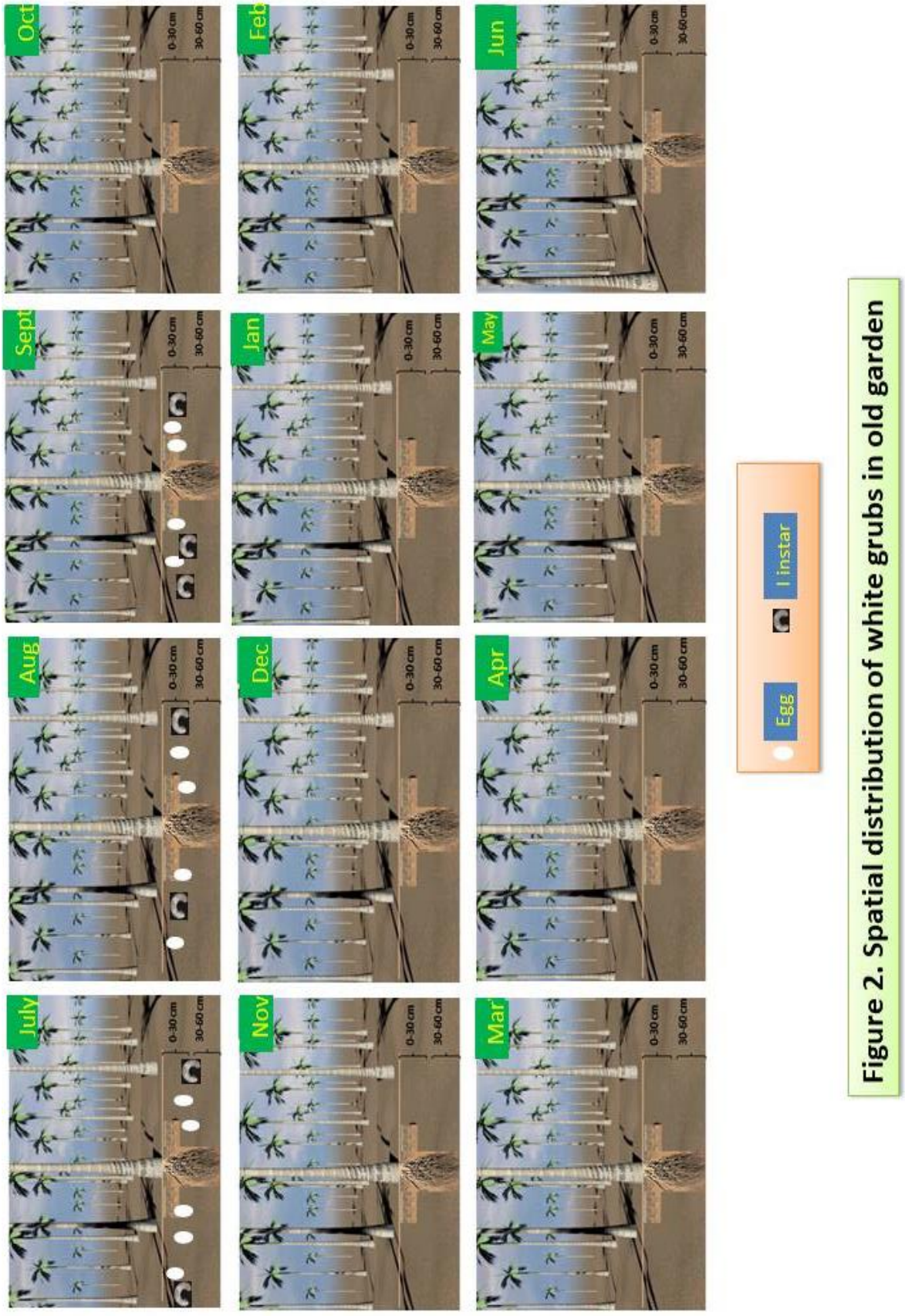

Figure 2. Spatial distribution of white grubs in old garden

Report of invasive longhorn beetle, *Aristobia reticulator* (Voet) (Coleoptera: Cerambycidae) in aonla, *Emblica officinalis* Gaertn in India

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Recently, aonla, *Emblica officinalis* Gaertn trees in the North-Eastern region of India were severely damaged by a stem borer, *Aristobia reticulator* (Voet) (Coleoptera: Cerambycidae) (Fig. 1). The first report of the heavy incidence of this borer on aonla trees in Arunachal Pradesh, India was reported by Kumawat and Wangchu, 2021. This borer is a regular pest of longan trees in China and was earlier reported by Ho *et al*. 1990. However, *A. reticulator* (= *Aristobia testudo*) was first time noticed in India in the year 1997 on guava as a stem borer (Shylesha *et al.,* 2000). Later on, it caused heavy damage in litchi, *Litchi chinensis* Sonn as a stem borer in the state of Arunachal Pradesh in the year 2017 (Kumawat *et al*., 2017). Surveys were conducted in approximately 1000 sq km area to assess the incidence of *A. reticulator* in different litchi and aonla orchards of the Arunachal Pradesh. During surveys, 88.5% trees of litchi (Fig. 2) and 58.9% trees of aonla were damaged by this pest while most of the trees were infested by more than two larvae per plant (Fig. 3).

The beetles emerged during June-August from stems by making an exit hole (Fig. 4), and thereafter they fed on the bark of tender branches. Beetles were observed feeding on bark, by girdling stems, branches, and soft twigs, while larvae tunnelled inside the stem. The grubs caused maximum damage in saplings and branches. Females cut a slit into the bark and laid egg singly under it. Newly hatched grubs first started feeding sub-cortically and then enter in the sapwood. Grubs continued to move down the branches, feeding and ejecting frass from their tunnels. The grub formed a pupal cell under the bark. Beetles emerged from the pupal cell by cutting a circular exit hole. Adult males survived longer than females. The beetle has a life cycle of approximately one year. In host preference studies, *A. reticulator* laid eggs on litchi, followed by aonla whereas guava was the least preferred host for oviposition, although beetles were also found to feed on the bark of *Cajanus cajan* (L.) but larval development was not observed.

Since, the northeastern region of India is in close proximity with China and Myanmar and the bordering area is occupied with dense forest from all around, hence this pest might have invaded from China or Myanmar, where it was found to cause heavy damage in litchi plantations. *A. reticulator* may spread to major litchi growing states like Bihar, West Bengal, Uttar Pradesh, Jharkhand and other states, if quarantine measures are not taken.

Fig. 1 Beetle, *A. reticulator*

Fig. 2 Grub feeding on litchi

Fig. 3 Grub feeding on aonla

Fig. 4 Exit hole in the stem

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Mating behaviour of fall armyworm, *Spodoptera frugiperda* on maize crop

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Maize (*Zea mays*) is a staple food in many countries and the total production of maize crop exceeds that of wheat and rice. Maize is widely cultivated throughout the world. In 2018, total world production was 1.15 billion tonnes led by the United States with 34.2 percent of total. The susceptibility of the crop to the pests, results large yield losses. Among them a novel pest fall armyworm became an insidious challenge across the world in production of maize.

In India, it was for the first time spotted in the maize research fields of the University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka (Ashokan *et al*., 2018). In Chhattisgarh, *Spodoptera frugiperda* was first reported at IGKV, Raipur (Deole and Paul, 2018). For the successful, efficient management of the pest there is a need to know behaviour. Hence, a study is being proposed with the objective of understanding the mating behaviour of the fall armyworm, *Spodoptera frugiperda*, on maize crop and effect of mating duration on fertile eggs percentage.

The investigation on mating behaviour of fall armyworm, *Spodoptera frugiperda* (J. E. Smith) was conducted in the Biocontrol laboratory of Department of Entomology, Indira Gandhi Krishi Vishwavidyalaya Raipur, Chhattisgarh during the period of July to November, 2019 under *invitro* conditions (25 ± 2 ℃, 70 ± 10 % RH).

The study was conducted by using completely randomized block design (CRD) with ten replications. For the study of mating behaviour, maize plants (‘PRO-4212’ cultivar) were grown in plastic pots and each pot was equidistantly covered with a metal pipe cage frame bearing a fine mesh screen. For the collection of adult moths, nucleus culture of fall armyworm was maintained first. The trial was conducted when the maize plant, attained the 5-leaf stage. Each replication was performed by using a pair of male and female adult moth of fall armyworm. One pair of, recently emerged unmated (<24 hr) male and female moths of *S. frugiperda* were release into each cage. Ten per cent honey solution on a cotton swab was placed inside each cage for the

moth to feed on. Moths were maintained in their cages. Observation on mating *viz.* time and duration of mating were carried out in interval of every one hour.

The observations were taken by recording the duration of copulation. The observation regarding the percent of fertile eggs were calculated by following formula –

$$\text{Percent of fertile eggs (\%)} = \frac{\text{No. of total fertile eggs}}{\text{Total number of eggs}} \times 100$$

The observation on preferred time and duration of mating of *S. frugiperda* were investigated and revealed that the mating occurred throughout the 24hours cycle, with majority of copulation starting at the evening hours spanning until 10:00 pm. The duration of copulation varied from 42 to 73 min with an average of 57.60 ± 3.49 min. Most of copulations (70%) lasted longer than 50 min. (Table 1). The percent of fertile eggs was also recorded during the experiment. It was noted that the percent of fertile eggs higher, when the mating duration was longer (Fig. 1). This is suggestive, that the longer mating duration might be associated with transfer of more sperms that are used to increase the fertility of eggs like in case of 8th replication, when mating takes place for 73 hours, the percent of fertile eggs was also higher, (i.e. 99.59 percent). The present findings confirm that, in case of *Spodoptera frugiperda*, most of the copulations (80%) lasted longer than 45 min, which corroborates with the findings of Marti and Simmons, 1992, who also reported that the mean duration of mating averaged 130 min.

Table 1. Percent of fertile eggs with respect to duration and preferred time for mating in moths of *S. frugiperda.*

S. N.	Duration (Min)	Time of mating (IST)	No. of eggs laid by female moth after mating	No. of fertile eggs	Percent of fertile eggs
1.	71	19:32 to 20:43	471	467	99.15
2.	47	08:07 to 08:54	262	203	77.48
3.	42	19:15 to 19:52	203	141	69.45
4.	60	20:31 to 21:31	293	270	92.15
5.	63	19:01 to 20:04	299	281	93.97
6.	57	20:37 to 21:34	279	245	87.81
7.	45	11:55 to 12:00	251	197	78.48
8.	73	18:11 to 19:24	493	491	99.59
9.	67	19:27 to 20:34	269	253	94.05
10.	51	19:53 to 20:44	271	230	84.87

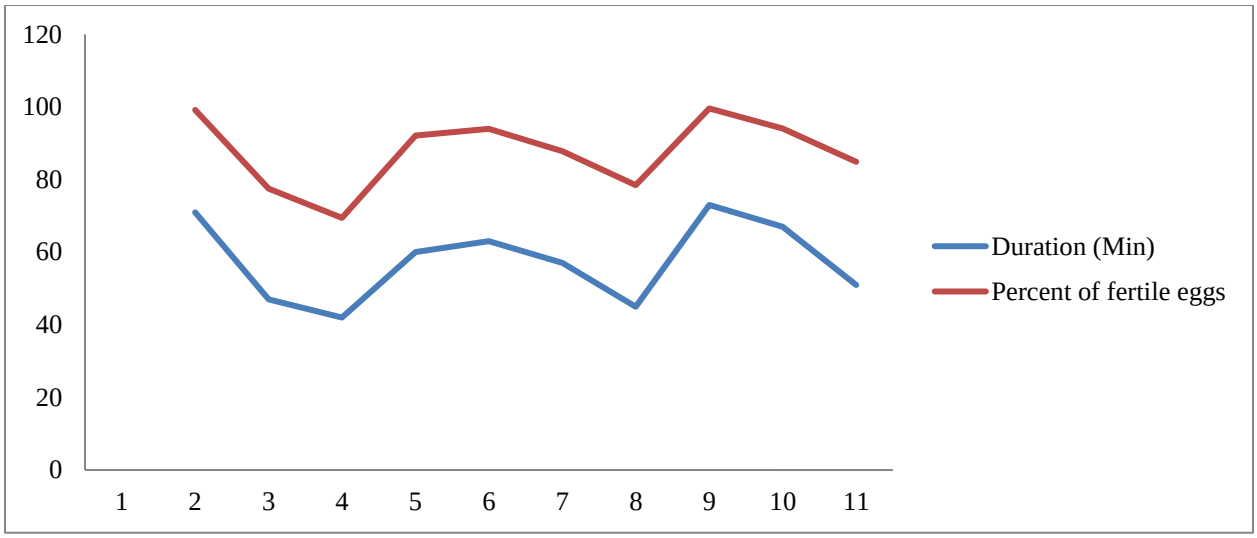

Fig. 1: Relationship between the duration of mating and percent of fertile eggs

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Record of dung beetles in Jnanagangotri Campus, Davangere University, Chitradurga.

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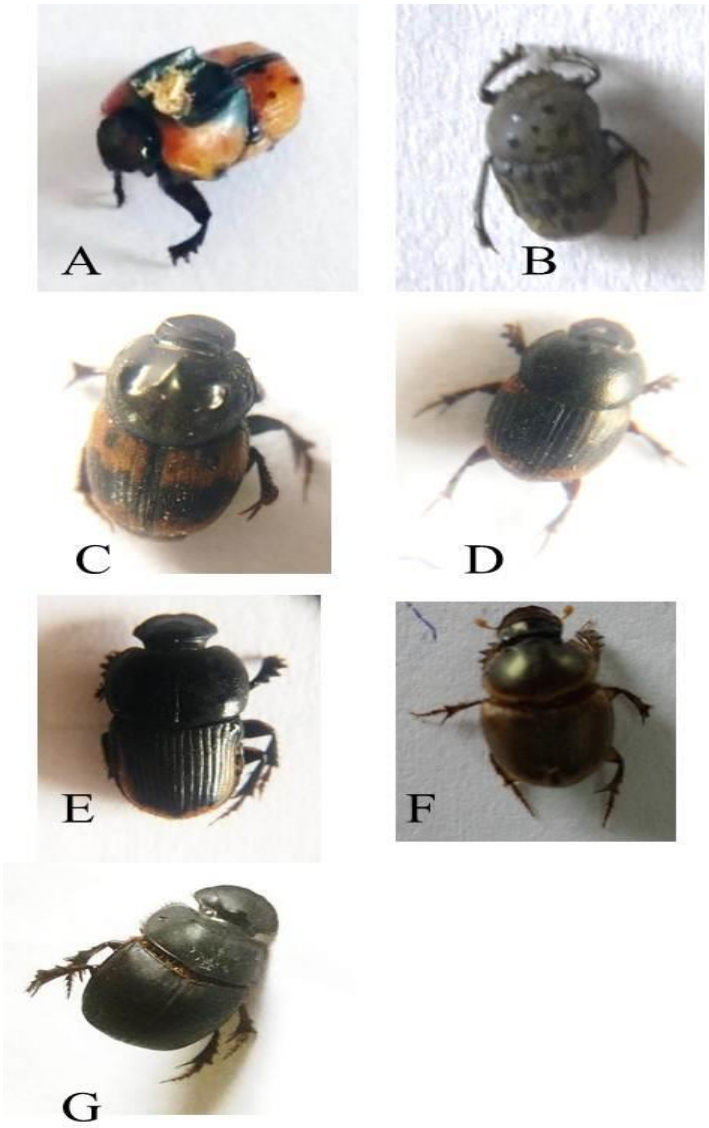
Insects are the most dominating and diverse organisms on earth. They are found all over and very recognizable individuals from the phylum Arthropoda under the class Insecta. Dung beetles belong to the family Scarabaeidae and refer to those present at the faecal deposits of animals (Halffter and Matthews, 1966). These beetles fall into three basic nest building categories: tunnelers (paracoprids), dwellers (endocoprids), and rollers (telecoprids). Each group of these beetles improves the nature of soil by reducing pasture fouling, adding supplements to soil, increasing percolation, introducing organic matter into the soil and reducing non-point sources of organic pollution (Fincher,1992). Therefore dung beetles have been widely used as bio-indicators of ecological change and as model frameworks of biological system (Elizabeth, 2019).

Dung beetle sampling was done on every month (2 days/week) from, June to October 2020 in and around Jnanagangotri campus, Davangere University, GR Halli, Chitradurga located at 14.23°N 76.4°E with an average elevation of 732metres. Standard methods were used for collection of specimens, like pitfall traps and hand picking methods. The specimens were collected and photographed. In this study 7 species of dung beetles belonging to Scarabaeinae (subfamily) were observed and identified by following the Indian biodiversity port and Bin-Hong Ho, 2018. Earlier studies by Veenakumari and Veeresh (1997) reported 61 species of Scarabaeinae from Bangalore, Karnataka, India. Further Deepak *et al*., 2014 also reported 24 species from Bangalore University Campus. In our sampling, for the first time we observed an abundant number of dung beetles in the surroundings of the Jnanagangotri campus, Chitradurga. This observation calls for a detailed study and analyses of dung beetles in the area which will contribute to the domain knowledge of dung beetles elsewhere. The details of collected specimens are as follows:

List of dung beetles collected from PG Center, Davangere University, Chitradurga



Species
Catharsius pithecius
Gymnopleurus miliaris
Liatongus rhadamistus
Onthophagus trituber
Onthophagus cervus
Digitonthophagus gazelle
Onticellus cinctus

A. Liatongus rhadamistus, B. Gymnopleurus miliaris, C. Onthophagus trituber, D. Onthophagus cervus, E. Onticellus cinctus, F . Digitonthophagus gazelle, G. Catharsius pithecius

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Reporting the incidence of grass web-worm moths in St. Joseph's College (Autonomous) Campus, Bengaluru

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Observations on two grass moth species, *Herpetogramma licarsisalis* and *H. bipunctalis* were made at St. Joseph's College (SJC) campus (12.9629°N; 77.5964°E), Bengaluru. The campus has 8.44 acres of land (including 7.961m^2 of total built in area), during December 2020. Visual survey on moth resting spots (walls, plant bushes) was done during the day by walking around the four blocks of the campus *viz*., Science, New, Aruppe and Magis blocks. Random sampling and opportunistic collection of moths during the day was undertaken and identification was done *via* online identification website (http://www.pathangasuchaka.in/)

Grass web-worm moth, *H. licarsisalis* (Walker, 1859) (Lepidoptera: Crambidae) is native to New Zealand, Hong Kong, Queensland etc., and an introduced species in different parts of the world including different parts of India (Fig. 1). They appear brown and have fawn wings with rows of indistinct dark spots. The wingspan of this moth is about 20 mm (Atlas of Living Australia ala.org.au). The species is reported from various parts of India (www.mothsofindia.org). The numbers counted during the present observations are depicted in figure 1. The campus has a huge lawn-ground next to the newly built Magis block. This explains the reason behind the highest count in Magis block. Many moths were resting on the walls facing towards the lawn. There is a small garden next to the Aruppe block, wherein the second highest count was recorded. Moths were observed resting in two ways viz., tectiform (Forewings cover

hindwings and are usually held tent like over the body or on the other side of the body) (Figure.2) and planiform (All four wings are stretched away from the body and horizontally touch the surface on which they rest so both hindwings and forewings are visible) (Figure 3). Map 1. Satellite Image of Distribution of *Herpetogramma licarsisali* (www.mothsofindia.org)

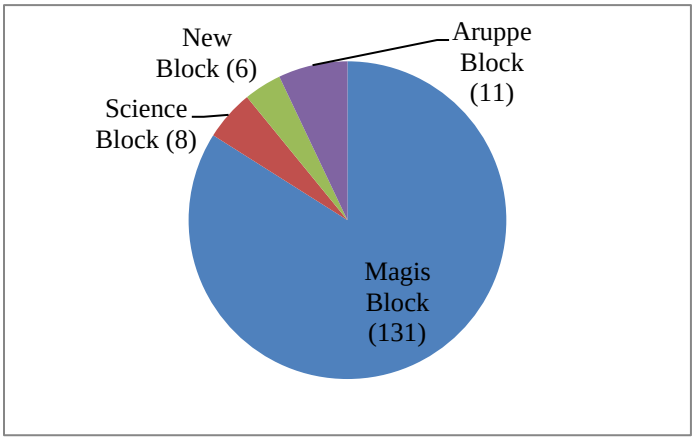

Fig. 1. Observed number of grass worm moths in each block of the college campus

The other species observed was the two-spotted Herpetogramma, *Herpetogramma bipunctalis* (Fabricius) (Fig. 4).The larvae of these moths feed on various grasses hence their common name grass worm-moths and are considered pest of turf and pastures. The ground at SJC is sprayed with water every day and fertilized at regular intervals. Considering the present numbers of the moths, a survey to examine the number of larvae and the possible damage they inflict needs to be undertaken.

Fig. 2. Tectiform resting position

Fig. 3. Planiform resting position

Fig. 4. *H. bipunctalis* observed in a grass patch in the campus

Checklist of cow bugs (Hemiptera: Membracidae) in and around Tiruvallur district of Tamil Nadu, India

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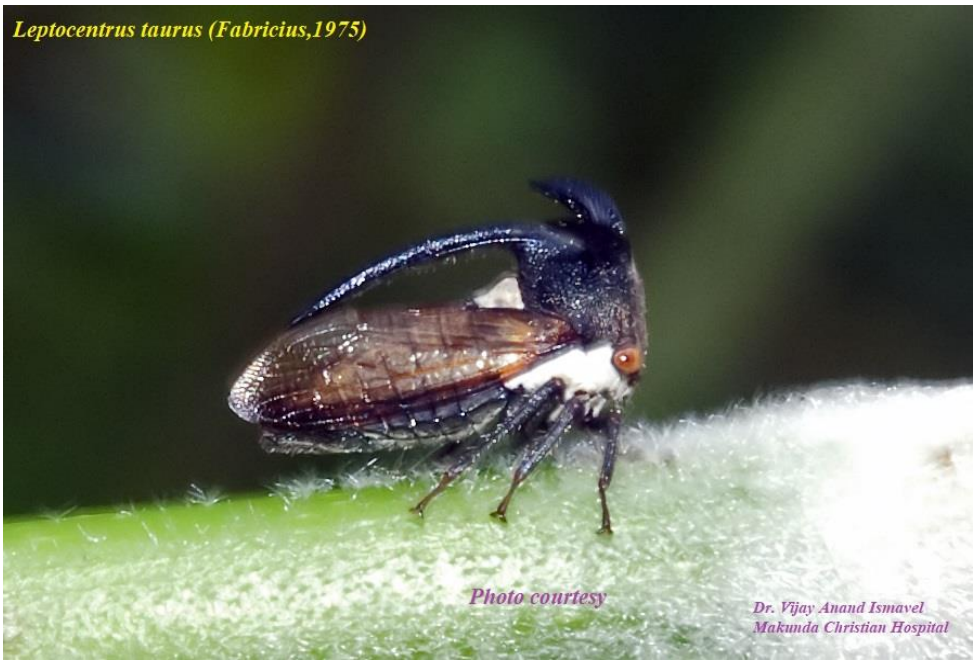
Introduction

The family Membracidae comprises of a distinct group of small phytophagous insects belonging to auchenorrhynchous homoptera. The members of the family can be easily recognized by the peculiar structure of the pronotum which frequently conceals the scutellum and takes different shapes. Horn-like processes of the pronotum, very often assuming curious shapes in different species, have earned them the name "cowbugs" or "horn bugs". Although endowed with powers of flight, they prefer to hop about when disturbed and this habit has earned them the popular name "treehoppers". These bugs feed by sucking the sap of trees, shrubs and cultivated crops and most species are host specific. Even though they are not destructive to the extent of assuming pest status, the principal damage or injury caused to host plants is either by feeding or egg laying. These treehoppers excrete sugary substance called 'honey dew' which serves as food for ants, bees and wasps. In turn, this group of bugs frequently benefit from the interaction with ants that provide house cleaning services and often protect the hoppers from predators in exchange of the honey dew. These phytophagous bugs are solitary, gregarious or sub social and some species guard their eggs and immatures. Parental care and ant – mutualism are common in some families. Globally, the family Membracidae comprises of 3200 extant species accommodated under 400 genera. 235 species under 41 genera so far are reported from India (Thirumalai and Prabakaran 2010). The classification followed here is after Ananthasubramanian, 1996 and Deitz and Dietrich, 1993.

The taxonomy of the membracid fauna of India received little attention after the pioneering and outstanding contributions of Distant (1908, 1916a-e) and Funkhouser (1922, 1929a, 1929b, 1933). Ananthasubramanian and Ananthakrishnan (1975a, 1975b) studied the common species of Indian membracids from their taxonomic and bioecological standpoints and stressed on the value of nymphal characters in the taxonomy of the family. Ananthasubramanian (1978, 1980a, 1980b, 1982, 1984), Thirumalai and Ananthasubramanian (1981, 1985) and

Ananthasubramanian and Ghosh (1987a, 1987b) also contributed to the taxonomy of Indian Membracids. The faunistic constituents of membracidspecimens were inventoried in the present paper are based on the information recorded in scientific literature and collected from the different localities of Tiruvallur District in Tamil Nadu from the scrub jungle area with different habitats. A total of 29 species belonging to 7 genera and 2 subfamilies are reported from Tiruvallur district.



Systematic list

Suborder: Auchenorrhyncha
Infra Order: Cicadomorpha
Super family: Membracoidea
Family: Membracidae Refinesque, 1815
Subfamily: Oxyrhachinae Haupt, 1929
Tribe: *Oxyrhachini* Distant, 1908
Genus: *Oxyrhachis* Germar, 1835

1. *Oxyrhachis brevicornutus* Ananthasubramanian and Ananthakrishnan,1975

1975. *Oxyrhachis brevicornutus* Ananthasubramanian and Ananthakrishnan, *Rec. zool. surv. India*, 68:180.

Distribution: INDIA: Tamil Nadu: Tiruvallur and Chennai; Karnataka: Bangalore.

2. *Oxyrhachis minusculus* Ananthasubramanian and Ananthakrishnan, 1975

1975. *Oxyrhachis minusculus* Ananthasubramanian and Ananthakrishnan, *Rec. zool. Surv. India*, 68: 173.
Distribution: INDIA: Tamil Nadu: Poonamallee, Tiruvallur.

3. *Oxyrhachis rufescens* Walker, 1851

1851. *Oxyrhachis rufescens* Walker, *List Hom.*, ii:506.
1851. *Oxyrhachis rudis* Walker, *List Hom.*, ii:509.
1916. *Oxyrhachis rufescens* Distant, *Fauna Hr. India*, 6:146.
1975. *Oxyrhachis rufescens* Ananthasubramanian and Ananthakrishnan, *Rec. zool. Surv. India*, 68: 171.
Distribution: All over India.

4. *Oxyrhachis taranda* (Fabricius, 1798)

1798. *Membracis taranda* Fabricius, *Ent. Syst. Suppl*.: 514.
1803. *Centrotus tarandus* Fabricius, *Syst. Rhyng*.: 19.
1835. *Oxyrhachis tarandus* Germar, *Rev. ent. Silb*. 3: 232.
1908. *Oxyrhachis tarandus* Distant, *Fauna Br. India*, 4: 4.
1903. *Polocentrus rufus* Buckton, *Mon. Memb*.: 254, Pl.58, f.2-2b.
1903. *Polocentrus neuter* Buckton, *Mon. Memb*.: 254, Pl. S8, f.3-3b.
1962. *Oxyrhachis taranda* Capener, *Entomology Mem. Dept. Agric. S. Afr*., 6: 11.
Distribution: All over India.

5. *Oxyrhachis krusadiensis* Ananthasubramanian and Ananthakrishnan, 1975

1975. *Oxyrhachis krusadiensis* Ananthasubramanian and Ananthakrishnan, *Rec. zool. Surv. India*, 68:178.
Distribution: INDIA: Tamil Nadu: Tiruvallur, Ramanathapuram, Pamban.

6. *Oxyrhachis tuberculus* (Walker, 1858)

1858. *Oxyrhachis tuberculalus* Walker, *Ins. Saund*.: 109.
1908. *Xiphistes tuberculatus* Distant, *Insecta Transvaaliensis*, 9: 210.
1932. *Xiphistes tuberculatus* Goding, *J. N. Y. ent. Soc*., 40: 231.
1962. *Oxyrhachis tuberculata* Capener, *Entomology Mem. Dept. Agric. S. Afr*., 6: 33.
1980. *Oxyrhachis tuberculatus* Ananthasubramanian, *Entomon*, 5(2): 113.
1996. *Oxyrhachis tuberculus* Ananthasubramanian *Fauna of India*: 54.
Distribution: INDIA: Tamil Nadu (Madras).

Subfamily CENTROTINAE Amyot and Serville, 1843
Tribe *Tricentrini* Ahmad and Yasmeen, 1974
Genus *Tricentrus* Stal, 1866

7. *Tricentrus decornis* Ananthasubramanian and Ananthakrishnan, 1975

1975. *Tricentrus decornis* Ananthasubramanian and Ananthakrishnan, *Rec. zool. Surv. India*, 68 :236.

Distribution: INDIA: Tamil Nadu: Tiruvallur and Chennai; Karnataka: Mysore.

8. *Tricentrus indicus* Funkhouser, 1942

1942. *Tricentrus purpureus* Funkhouser, J. N. Y. Ent. Soc., 50: 62.

1975. *Tricentrus purpureus* Ananthasubramanian and Ananthakrishnan, *Rec. zool. Surv. India*, 68: 230.

1996. *Tricentrus indicus* Ananthasubramanian *Fauna of India*: 93.

Distribution: INDIA: Tamil Nadu: Tiruvallur and Kodaikanal.

9. *Tricentrus pilosus* Ananthasubramanian and Ananthakrishnan, 1975

1975. *Tricentrus pilosus* Ananthasubramanian and Ananthakrishnan, *Rec. zool. Surv. India*, 68: 225.

Distribution: INDIA: Tamil Nadu: Tiruvallur, Chennai; Karnataka: Bangalore; Kerala: Trivandrum; Andhra Pradesh: Hyderabad and Andaman Islands.

10. *Tricentrus transversus* (Distant, 1908)

1908. *Centrotus transversus* Distant, *Fauna Br. India*, 4: 48.

1933. *Tricentrus transverses* Funkhouser, *Indian For. Rec*., 17(10): 4.

Distribution: INDIA: Tamil Nadu: Tiruvallur and Krishnagiri and Assam: Margherita.

Tribe *Leptocentrini* Distant 1908

Genus *Lanceonotus* Capener, 1968

11. *Lanceonotus indicus* Ananthasubramanian, 1980

1980. *Lanceonotus indicus*Ananthasubramanian, *Entomon*5(2): 110.

Distribution: INDIA: Tamil Nadu: Tiruvallur and Courtallam.

Genus *Leptocentrus* Stal, 1866

12. *Leptocentrus bajulans* Distant, 1916

1916. *Leptocentrus bajulans* Distant, *Fauna Br. India*, 6: 155.

1975. *Leptocentrus bajulans* Ananthasubramanian and Ananthakrishnan, *Rec. zool. Surv. India*. 68: 192.

Distribution: Tamil Nadu: Tiruvallur.

13. *Leptocentrus* Ananthasubramanian and Ananthakrishnan, 1975

1975. *Leptocentrus bauhiniae*Ananthasubramanian and Ananthakrishnan, *Rec. zool. Surv. India*, 68: 203.

Distribution: Tamil Nadu: Tiruvallur and Chennai.

14. *Leptocentrus leucaspis* (Walker, 1851)
1851. *Centrotus taurus* Walker, *List Hom.,* 2: 602.
1858. *Centrotus leucaspis* Walker, *List Hom*. *Suppl*.: 235.
1903. *Leptocentrus leucaspis* Buckton, *Monogr. Membrac*.: 235.
1908. *Leplocenlrus leucaspis* Distant, *Fauna Br. India*, 4: 30.
1975. *Leptocenlrus Leucaspis* Ananthasubramanian and Ananthakrishnan, *Rec. zool. Surv. India*, 68 :194.
Distribution: INDIA: Tamil Nadu: Tiruvallur and Chennai; Karnataka: Bangalore; Andhra Pradesh: Vijayawada and Guntur.

15. *Leptocentrus mangifera* Ananthasubramanian and Ananthakrishnan, 1975
1975. *Leptocentrus mangiferae* Ananthasubramanian and Ananthakrishnan, *Rec. zool. Surv. India*, 68:188.
Distribution: INDIA: Tamil Nadu: Tiruvallur and Chennai.

16. *Leptocentrus moringae* Ananthasubramanian and Ananthakrishnan, 1975
1975. *Leptocentrus moringae*Ananthasubramanian and Ananthakrishan, *Rec. zool. Surv. India*, 68: 205.
Distribution: INDIA: Tamil Nadu: Tiruvallur and Chennai.

17. *Leptocentrus nigra* Ananthasubramanian and Ananthakrishnan, 1975
1975. *Leptocentrus nigra*Ananthasubramanian and Ananthakrishnan, *Rec. zooI. Surv. India*, 68: 201.
Distribution: INDIA: Tamil Nadu: Tiruvallur

18. *Leptocentrus rhizophagus* Ananthasubramanian and Ananthakrishnan, 1975
1975. *Leptocentrus rhizophagus* Ananthasubramanian and Ananthakrishnan, *Rec. zool. Surv. India*, 68:185.
Distribution: INDIA: Tamil Nadu: Tiruvallur and Southern States.

19. *Leptocentrus varicornis* Ananthasubramanian and Ananthakrishnan, 1975
1975. *Leptocentrus varicornis* Ananthasubramanian and Ananthakrishnan, *Rec. zool. Surv. India*, 68: 196.
Distribution: INDIA: Tamil Nadu: Tiruvallur and Chennai.

20. *Leptocentrus taurus* (Fabricius, 1775)
1775. *Membracis taurus* Fabricius, *Syst. Ent*.: 676.
1778. *Cicada taurus* Goeze, *Hemiptera*, 2: 147.
1792. *Membracis taurus*: Olivier, *Enc. Meth*. 7: 665.
1798. *Membracis rupricapra* Fabricius, *Ent. Syst. Suppl*.: 514.
1803. *Centrotus rupricapra* Fabvricius, *Syst. Rhyng*.: 18.
1803. *Centrotus scutellaris* Fabricius, *Syst. Rhyng*.: 19.
1803. *Centrotus taurus* Fabricius, *Syst. Rhyng*.: 20.

1829. *Membracis tricornis* Hardwicke, *Zool. Jour*., 4: 114.
1851. *Centrotus terminalis* Walker, *List Hom*., 2: 604.
1851. *Centrotus vicarius* Walker, *List Hom*., 2: 605.
1869. *Leptocentrus taurus* Stal, *Hem. Fabr*., 2: 50.
1885. *Leptobelus scutellaris* Atkinson, *J. Asiat. Soc. Bengal*, 54: 83.
1903. *Leptocentrus gazella* Buckton, *Monogr. Membrac*.: 235.
1908. *Leptocenirus taurus*: Distant, *Fauna Br. India*, 4: 28.
Distribution: All over India.

21. *Leptocentrus majesticus* Ananthasubramanian, 1980
1980. *Leptocentrus majeslicus* Ananthasubramanian, *Entomon*, 5(2): 115.
Distribution: INDIA: All over Tamil Nadu.

22. *Leptocentrus ustus* Buckton, 1903
1903. *Leptocentrus ustus*Buckton, Monogr. *Membrac*.: 236.
1908. *Leptocentrus ustus* Distant, *Fauna Br. India*, 4: 32.
Distribution: INDIA: Tamil Nadu: Tiruvallur and Chennai.

Genus *Otinotus* Buckton, 1903

23. *Otinotus indicatus* (Melichar, 1903)
1903. *Centrotus indicatus* Melichar, *Hom. Faun. Ceylon*: 111.
1908. *Centrotus indicatus* Distant, *Fauna Br. India*, 4: 46.
1975. *Otinotus indicatus* Ananthasubramanian and Ananthakrishnan, *Rec. zool. Surv. India*, 68:219.
Distribution: INDIA: Tamil Nadu: Tiruvallur and Chennai.

24. *Otinotus oneratus* (Walker,1858)
1858. *Centrotus oneralus* Walker, *Ins. Saund. Hom*.: 78.
1869. *Centrotypus oneralus* Stal, *Ofv. Vel.-Ak. Forh*.: 256.
1903. *Oxyrhachis lignicola* Buckton, *Monogr. Membrac*.: 261.
1908. *Olinolus oneratus* Distant, *Fauna Br. India*, 4: 40.
1975.*Otinotus oneratus* Ananthasubramanian and Ananthakrishnan, *Rec. zool. Surv. India*, 68 :274.
Distribution: All over INDIA.

25. *Otinotus obliquus* Ananthasubramanian and Ananthakrishnan, 1975
1975. *Otinotus obliquus* Ananthasubramanian and Ananthakrishnan, *Rec. zool. Surv. India*. 68: 222.
Distribution: INDIA: Tamil Nadu: Tiruvallur, Chennai, Coonoor; Karnataka: Bangalore; Kerala: Trivandrum.

Tribe *Gargarini* Distant, 1908

Genus *Gargara* Amyot and Serville, 1843

26. *Gargara extrema* Distant, 1916
1916. *Gargara extrema* Distant, *Fauna Br. India*, 6: 171.
1975. *Gargara extrema* Ananthasubramanian and Ananthakrishnan, *Rec. zool. Surv. India*, 68: 246.
Distribution: All over INDIA

27. *Gargara hraswa* Walker, 1870
1870. *Centrotus minusculus* Walker, *Proc. Linn. Soc. London*, ll., 10: 191.
1915. *Gargara minuscula* Distant, *Ann. Mag. nat. Hist*., 8(16): 492.
1978. *Gargara minuscula* Ananthasubramanian, *Entomon*, 3(2): 291.
1996. *Gargara hraswa* Ananthasubramanian, *Fauna of India*: 272.
Distribution: INDIA: Tamil Nadu: Tiruvallur and Chennai; Kerala: Ernakulam.

28. *Gargara madrasensis* Ananthasubramanian and Ananthakrishnan, 1975
1975. *Gargara madrasensis* Ananthasubramanian and Ananthakrishnan, *Rec. zool. Surv. India*. 68: 244.
Distribution: INDIA: Tamil Nadu: Chennai and Tiruvallur.

Genus *Coccosterphus* Stal, 1869

29. *Coccosterphus minutus* (Fabricius, 1798)
1798. *Membracis minuta* Fabricius, *Ent. Syst. Suppl*.: 514.
1803. *Centrotus minutus* Fabricius, *Syst. Rhyng*. : 22.
1851. Scaphula minula Walker, *List Hom. B.M.*, 2: 589.
1869. *Coccosterphus minutus* Stal, *Hom. Fabr*. 8: 51.
1903. *Scaphula minuta* Buckton, *Monogr. Membrac*.: 149.
1908. *Coccosterphus minutus* Distant, *Fauna Br. India*. 4: 71.
Distribution: INDIA: Tamil Nadu: Chennai and Tiruvallur; Kerala: Trivandrum; West Bengal: Calcutta.

Conclusion

The paper presents the checklist of Membracids of Tiruvallur district in Tamil Nadu along with their known distribution only from the District. Twenty-nine species belonging to 7 genera and 2 subfamilies are reported from Tiruvallur district. Major studies in Tamil Nadu were undertaken only from Dr. K.S. Ananthasubramanian *et al.*, (1975a, 1975b)Hence further investigations from various parts of Tamil Nadu are very essential to know the diversity of this group.

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Management of tea mosquito bug in *Moringa oleifera*

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Introduction

Moringa oleifera is one of the most important vegetable crops in many countries including India, Ethiopia, and Philippines etc. It is rich in proteins, vitamin A, B and C and some minerals. It is the most suitable annual or perennial crop for majority of the regions. Pests and diseases are major problems in crop production. Currently tea mosquito bug, *Helopeltis antonii* Signoret (Miridae: Hemiptera) is one of the important pests in *Moringa* ecosystem (Fig 1and 2). Hence studies on its nature of damage and life cycle pave a good way to manage it.

Damage symptom

The nymphs and adults suck the sap from young shoots of *Moringa*, forming lesions on shoots. Due to continuous feeding the lesions coalesce, resulting in drying of twigs (Fig 3). Feeding also leads to exudation of gum (oozing) (Fig 4). The young instars mainly congregate on growing tips, which dry first. Later due to continuous feeding of bugs the whole twig used to dry and the leaves wither (Fig 5). Under severe infestation on the same tree, entire leaves fall-off and the plant resemble the snag.

Alternate hosts

The alternate hosts reported are tea *(Camellia sinensis)*, cashew *(Anacardium occidentale)*, guava (*Psidium guajava)*, neem *(Azadirachta indica)*, cotton (*Gossypium* spp.), cardamom (*Elettaria cardamomum)*, grape vine *(Vitis vinifera*), pepper (*Piper nigrum)* (Saroj *et al.*, 2016) and some weed species such as *Terminalia paniculata* Roth, *Leea* sp. (Vanitha *et al.*, 2014)

Life cycle

The life cycle of *H. antonii* has three stages namely egg, nymph and adult. The gravid females oviposits individual eggs on the young shoots of *Moringa*. Presence of two prominent hairs on either side of egg and black colour will be visible externally. The egg period is 3-5 days. The nymphs hatched undergoes four moults and instars emerged differ in their size. Colour of nymphs varies from red to reddish brown. The young instar nymphs congregate over young shoots for feeding. The nymphal period lasts for 15-18 days. The adult will be in black colour with red thorax and scutellar horn in it. Adult lives for 2-4 days.

Management

For effective control of tea mosquito bug, all possible management practices should be integrated. Since all the stages of the bug are destructive, management of all stages is important.

Cultural and Mechanical practices

- Since many weeds act as alternate hosts, field should be kept weed-free.
- Pruning the infested shoots regularly will result in minimum damage.
- Avoid trees such as neem, guava, cashew etc. around the field, which act as alternate hosts for tea mosquito bug.
- Monitoring the field at regular intervals is the first and foremost step in managing tea mosquito bug.
- Collection and destruction of damaged twigs, reduces the hatching of the next stage.

Biological control

- There are many free living natural enemies *viz.* predators, parasitoids that maintain tea mosquito bug population at lower level.
- Predators like reduviids, black ant, red ant, some spiders, green lace wing, preying mantid etc. check the tea mosquito bug population.
- The successful parasitoid that is reported for tea mosquito bug is *Telenomus* sp.

- *Beauveria bassiana* at a concentration of 10^8 spores/ml has potential for managing tea mosquito bug. It is pathogenic to both nymphs and adults.

Chemical control

Spraying chemicals is the final solution for controlling any pest. For tea mosquito bug spraying chemicals on the whole plant will be effective. Spraying any one of the following chemicals will check the tea mosquito bug population.

- Clothianidin 50% WDG 120 g/ha
- Thiacloprid 21.7% SC 500 ml/ha
- Thiamethoxam 25% WG 100 g/ha

For effective control the chemicals may be sprayed three times at regular intervals from new flush emergence to pod formation.

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Tea mosquito bug damage in annual moringa PKM-1

Fig 1. Tea mosquito bug-adult

Fig 2. Tea mosquito bug in Moringa

Fig 3. Angular lesions

Fig 4. Oozing out symptoms

Fig. 5. Completely drying due to the infestation of tea mosquito bug

Incidence of leaf defoliator, *Catopsilia pyranthe* (Linn.) (Lepidoptera: Pieridae) in *Senna*

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Senna is an economically important crop which is internationally and widely accepted for its medicinal values. Being drought tolerant, *Senna* is grown over one lakh hectare area in semi-arid regions of the country (Jat, 2015). India is the largest producer and exporter of leaves and pods of this plant which have high demand in the global market for its laxative and other medicinal properties (Sathiyabalan, 2019). Few insects were reported to be the pest of *Senna* and remain active in late summer months (Veeraragavan, 2018).

We encountered the severe incidence of leaf defoliator, *Catopsilia pyranthe* (Lepidoptera: Pieridae) in *Senna sophera* (L.) Roxb. and other *Senna* sp. near C-Block Farm of Bidhan Chandra Krishi Viswavidylaya, Kalyani, West Bengal ($22^0$59'31" N Latitude and $88^0$26'54" E Longitude) during post-monsoon period of 2020. The plants were raised for the medicinal as well as for the ornamental purpose. The peak activity of the pest was noticed during October and November months with a maximum of three larvae in a plant (Fig. 1) and found infesting leaves, tender shoots, flower buds and flowers (Fig. 2).

Adult female butterfly laid eggs singly on both the sides of the leaf. The egg (Fig. 3) is white coloured, erect and spindle-shaped. During the investigation, more than one egg was found on the same leaflet of the plant. There were five larval instars. The newly emerged larva (Fig. 4) was cylindrical with a pale yellowish-green body and a round pale coloured head. The larvae excreted a huge amount of black and granular faeces. The mature larva devours the leaf only keeping the midrib intact (Fig. 5). Soon after completion of the final instar, the caterpillar secreted silken thread to secure itself firmly during pre-pupation stage (Fig. 6) and constructed the pupa, called chrysalis (Fig. 7). The pupae (Fig. 8) had pointed head, pale green body and yellow lateral lines on each side.

The adult (Fig. 9) is popularly known as a mottled emigrant, medium-sized butterfly; wings are greenish-white and forewings have a black apical border. Atluri *et al*. (2004) reported that *C. pyranthe* breeds throughout the year and the developmental period from egg to adult requires 22 to 29 days with several overlapping generations in a year. The adults are mostly generalist but the larvae are specialized in different species of *Cassia* (Kunte, 2006). Being the medicinal and consumable crop, the use of insecticides in *Senna* is not advisable. However, the release of egg parasitoid *Trichogramma chilonis* @ 1.5 lakh per hectare per week may check the population and could control the pest effectively.

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Fig. 1. *Catopsilia pyranthe* defoliation on *Senna*

Fig. 2 Infestation of leaves and floral parts of *Senna* by larvae

Fig. 3. Egg

Fig. 4. Early instar larva

Fig. 5. Late instar larva

Fig. 6. Pre-pupation stage

Fig. 7. Newly formed pupa

Fig. 8. Mature pupae

Fig. 9. Adult butterfly

Nest counts of *Ropalidia jacobsoni* (du Buysson, 1908) (Hymenoptera: Vespidae) in a residential building in Bengaluru, India

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Ropalidia spp are the common eusocialpaper wasps native to Indian subcontinent belongs to the family Vespidae. Their common name comes from their nest-making ability from cellulose mixed with their saliva. Of the 180 species currently recognized, 27 species have been recorded from the Indian subcontinent, including 16 species so far known to be endemic to the subcontinent (Kojima*et al*., 2007). They are reported as bio-control agents and pollinators (Das and Gupta, 1989; Kojima, 1993). Social wasps are known to build their nests in dry, safe and strong structure with easy access to food. In the Indian subcontinent, two species of the *Ropalidia* group are recognized *viz*., *R. variegata* (Smith, 1852) and *R. jacobsoni* (du Buysson, 1908) (Kojima *et al*., 2007). The latter is reported in different parts of India (Girish and Gaurav, 2014). The following characteristics about the species are reported by Sôichi (1986): Colony founded by single or multiple (2–4) foundresses, dominance interactions between females were very weak and mostly non-tactile, task allocation observed between females and exhibit serial polygyny.

Nest counts of *R. jacobsoni* in a residential building in urban Bengaluru are presented in this article. Forty nests were observed during December 2020 and the mean number of cells considering the total nests/ floor is presented in Table 1. The nests were found on porch ceilings, overhangs, below stair cases and even on potted plants. Nests were observed popping in different spots in the building and this gregarious nesting habit reflects the rising numbers of individuals in the colony. The inactive/abandoned nests are generally not reused by subsequent generations of wasps.

Wasps were found in four nests each in first and second floors and one in the third floor. They defend their colony vigorously by stinging. Unlike bees, wasps are able to remove their

stinger from their victim after stinging; therefore, they can inflict multiple painful stings. Some nests in the building were destroyed by the residents due to this fear.

Table 1. Nest count of *R. jacobsoni* during the present observations

Floor	Number of nests/ floor	Mean number of cells/floor
Ground	4	6.25
1st	10	10.1
2nd	23	9.8
3rd	3	10.3

Fig. 1. *R. jacobsoni* nest on *Aloe vera* plant

Fig. 2. Nest in the building ceiling

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Awareness and extension in Andhra Pradesh to manage the invasive rugose spiralling white fly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae) on coconut and oil palm

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The coconut crop is mainly confined to the four southern states of India, accounting for 90% of the area under coconut, among which Andhra Pradesh shares about 1.15 lakhs ha area with a production of 1,377.53 m nuts. Recently, an invasive rugose spiraling whitefly (RSW), *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae) has entered India and has been reported on coconut palm (*Cocos nucifera* L.) for the first time during August-September, 2016 at Pollachi taluk, Coimbatore district in Tamil Nadu and Palakad taluk in Kerala (Sundararaj and Selvaraj, 2017). In Andhra Pradesh it was first reported at Kadiyam nurseries during December 2016 (Chalapathi Rao et al., 2020) probably entering Andhra Pradesh through infested coconut seedlings obtained from Kerala. The RSW 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.

As per the Department of Horticulture, Government of Andhra Pradesh statistics in February 2019 the coconut and oil palm plantations of East and West Godavari districts of Andhra Pradesh had a severe (more than 30 spirals/leaflet) incidence of this pest. The West Godavari district was found to be more affected as compared to other coconut growing districts probably due to contiguous areas of coconut and oil palm (Table 1).

As compared to 2018-19 the incidence of RSW in coastal Andhra Pradesh decreased in 2020-21 particularly due to massive awareness campaigns carried out both by Department of Horticulture, Government of Andhra Pradesh in association with Horticultural Research Station, Ambajipeta, DRYSR Horticultural University.The management strategies were adopted for RSW on a collective scale in a community based approach. The data collected on incidence and intensity of RSW in four selected villages in East and West Godavari districts revealed that the

incidence of RSW in the case study villages decreased by 30 to 42 percent and intensity by 24 to 59 percent (Table 2) .

Table 1: Extent of area infested by RSW in Andhra Pradesh (February 2019)

Name of the district	Number of orchards affected	Area affected with RSW			GPS Coordinates
		Coconut (ha.)	Oil Palm (ha.)	Total area (ha.)	
West Godavari	63	4428.20	9092.60	13520.80	16^0 55'48"--NL 81^0 37'48"--EL
East Godavari	155	1535.80	2461.50	3997.30	17^0 23' 14"-NL 82^0 46' 64" -EL
Krishna	1	2.80	0.00	2.80	16^0 61'00"--NL 80^0 72'14"--EL
Srikakulam	36	2185.25	129.00	2314.25	18^0 33' 53" –NL 83^0 95' 92"-EL
Vizianagaram	36	1336.0	45.00	1381.00	18^0 07' 29" –NL 83^0 65' 94"-EL
Visakhapatnam	28	738.20	16.00	754.20	17^0 66'61"--NL 82^0 61'05"--EL
Total	**319**	**10226.25**	**11744.10**	**21970.35**	

Source : Department of Horticulture ., Govt of AP 2019

The continuous monitoring of the pest in 2019 and 2020 and massive extension programs created awareness on this invasive. The wide publicity given through print and electronic media coupled with utilisation of the staff (village horticulture assistants and agriculture assistants) working in Rythu Bharosa Kendras (RBKs) (Farmer Assurance Centres) of Government of Andhra Pradesh lead to up scaling of extension activities against RSW. The VHAs and VAAs are technical and skilled youth with horticulture and agriculture education employed in villages. The staff were thoroughly trained for monitoring and promoting management of RSW and updating of field status of the pest to Horticulture department officials who in turn coordinated with technical staff of the university. This new concept of Rythu Bharosa Kendras at village level improved the services of government in qualitative and quantitative terms especially, to deliver the farm advisory services.

Table-2: Impact of extension activities and decrease in RSW incidence and intensity on coconut in selected villages of A.P during 2018-2021

Year	Pulleitukuru (East Godavari)		Kadiyapulamka (East Godavari)		Chagallu (West Godavari)		Kalavalapalli (West Godavari)	
	Incidence* (%)	Intensity (%)	Incidence (%)	Intensity (%)	Incidence (%)	Intensity (%)	Incidence (%)	Intensity (%)
2018-19	41.35±1.25	45.06±1.65	43.50±0.89	67.82±3.50	48.92±1.65	42.80±2.10	58.81±1.89	62.60±2.65
2019-20	22.04±2.21	37.33±3.56	27.02±3.25	37.15±3.56	25.24±1.50	31.56±1.45	32.47±1.70	24.71±1.60
2020-21	11.73±3.25	17.66±2.21	9.57±3.45	13.30±3.56	13.93±3.01	18.53±2.20	16.36±3.56	13.43±1.70

*values in the table are mean followed by standard error.

Incidence = Number of leafs infested in palm/Total no of leafs in palm x 100

Intensity = Number of leaflets infested in leaf /Total no of leaflets in leaf x 100

a. Capacity building program on bio agents mass production to oil palm processing companies

Training on multiplication of *Corcyra cephalonica* and neuropteran predator *Pseudomallada astur* was given to stakeholders especially to oil palm processing companies with focus on augmentative bio control.

b. Capacity building programs to farmers and staff of RBKs on entomopathogen- *Isaria fumosorosea* NBAIR pfu-5 production :

Fifteen training programs on production of entomopathogenic fungus *I.fumosorosea* were conducted. A total number of 365 farmers including 49 RBK staff were trained to produce this fungus on broken rice in their own farms and villages at a low cost (Table 3).

Extension activities: During 2018-21 the scientists of Horticultural Research Station, Ambajipeta participated in a total of 95 farmers training and awareness programs on RSW in association with Horticulture department in all the coastal districts and a total number of 5000 farmers attended these training programs and awareness on management of RSW was imparted.

Extension activities during Covid -19: The Dr.YSR Horticultural University declared 2020-21 as Dr. YSRHU year of Coconut. Due to prevailing Covid -19 pandemic the university

took innovative steps to reach farmers and started plant protection advisory cell, farmer's advisory cell and phone- in live programs in which various webinars in vernacular language were organised on coconut with emphasis on bio control based management strategies for RSW. A tremendous impact was created through various extension functionaries creating a positive impact on managing RSW.

Table-3: Training programs on production of entomopathogen *I. fumosorosea* NBAIR pfu5 in association with Horticulture Department

Sl. No.	Dates	Village and District	No. of progressive farmers/RBK personal trained	GPS Coordinates
1	08.02.19	Kothapeta, East Godavari	34	16^0 71'60"—NL 81^0 89'58"--EL
2	12.02.19	Ainavilli, East Godavari	20	16^0 66'01"--NL 82^0 01'14"--EL
3	14.02.19	P. Gannavaram, East Godavari	30	16^0 58'91"—NL 81^0 89'05"--EL
4	15.02.19	Rollapalem, East Godavari	18	16^0 55'06"--NL 81^0 99'85"--EL
5	21.02.19	Sakhinetipalli, East Godavari	34	16^0 42'43"—NL 81^0 71'85"--EL
6	22.02.19	Kadiyam, East Godavari	20	16^0 53'48"--NL 81^0 49'28"--EL
7	23.02.19	Ramachandrapuram, East Godavari	23	16^0 49'39"—NL 82^0 2'11"--EL
8	25.02.19	Kadiyapulanka, East Godavari	24	16^0 53'34"--NL 81^0 49'12"--EL
9	27.02.19	Peddapuram, East Godavari	28	17^0 03'31"—NL 82^0 08'08"--EL
10	28.02.19	Narsipatnam, Vishakhapatnam	27	17^0 66'61"--NL 82^0 61'05"--EL
11	01.03.19	Kalavalapalli, West Godavari	21	16^0 58'48"—NL 81^0 46'48"--EL
12	02.01.20	Kaviti, Srikakulam district	23	18^0 33' 53" –NL 83^0 95' 92"-EL
13	04.01.20	Kanchili, Srikakulam	23	18^0 59' 45"-NL 84^0 36' 40"-EL
14	07.01.20	Tekkali, Srikakulam	22	18^0 60' 58"-NL 84^0 23' 02"-EL
15	09.01.20	Ranasthalam, Srikakulam	18	18^0 11' 27"- NL 83^0 42' 37"-EL
		Total	**365**	

RSW Infested coconut palm

RSW infested oil palm

RSW adult

Field diagnostic visit to RSW infested gardens

Awareness through electronic media

Training on production of entomopathogen *I. fumasorosea* NBAIRpfu 5 to farmers

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Damage of *Acalolepta nivosa* (White, 1858) (Lamiinae: Cerambycidae) on *Nerium oleander* (Apocynaceae)

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The adults of *Acalolepta nivosa* (White, 1858) (Lamiinae: Cerambycidae) was originally described from Sri Lanka with speculation on its distribution in India. Later, it has been documented in Madhya Pradesh, Himalaya (Majumdar *et al.*, 2014), Maharashtra (Bhawane *et al.*, 2015) and Kerala (Namboodri and Ghosh, 2020).

Nerium oleander (Apocynaceae) planted for ornamental purpose in the highways of Dharmapuri (12.2227° N, 78.1923° E) in the in some home gardens of residential area and temple premises of Tamil Nadu Agricultural University, Coimbatore (11.0168° N, 76.9558° E) exhibited swellings at the base of the plants. On examination of the swellings, grubs and pupae of *Acalolepta nivosa* were observed inside the swollen portion (Fig. 1). The adults (Fig.2) were also collected from these plants. Previously, *A. nivosa* has been observed as a pest on *Artocarpus heterophyllus* (Moraceae) (Gavas, 2018). Further, it has also been reported feeding on *Calotropis gigantea*, *Stephanotis floribunda* (Apocynaceae) and *Kydia calcinea* (Malvaceae) (Beeson and Bhatia, 1939). The adults of *A. nivosa* have been observed on dead rotting wood in Maharashtra (Bhawane *et al.*, 2015).

The study on its distribution and detailed study on the biology on different hosts remains to be studied.

Right: Grubs of *Acalolepta nivosa* within the swelling in *Nerium oleander,* Left: *Acalolepta nivosa*

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Rearing of mango leafhoppers both in field and laboratory conditions using the natural host

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Rearing of insects using various hosts is important to understand their biology and behaviour patterns (Sorensen *et al*., 2012). Mass rearing for a couple of generations is critical when insects are economically important pests. One such group which required rearing was leafhoppers. They constitute an important group of insects which are either pests or vectors of various crops (Bentz and Townsend, 2005). Among different leafhoppers, the mango leafhopper is economically important as they attack mango. They are monophagous and rearing was difficult.

An attempt was carried out to rear the mango leafhoppers *viz*., *Idioscopus nitidulus* Walker, *Idioscopus nagpurensis* Pruthi and *Amrasca splendens* Ghauri. *Idioscopus nitidulus* feed and breed on tender shoots and inflorescence of mango, *A. splendens* feed and breed only on tender shoots whereas *I. nagpurensis* feed and breed on mango inflorescence (Viraktamath, 1989).

Studies were carried out in the mango orchards and laboratory at the department of Entomology, ICAR-Indian Institute of Horticultural Research (IIHR) 13.13 N; 77.49 E. Different rearing protocols were carried out to artificially rear them both in the field and in the laboratory. Finally, they were successfully reared for three to four generations. Cages were made from poly propylene meshes of mesh size 40. The meshed cage of 10 x 30 inches was stitched in such a way that one side was left open so that it could be tied to a young shoot or inflorescence. On one side velcro was attached so that it could be opened to release the hopper adults into it. Hundred such nets were made.

From the fields, tender shoots or inflorescence in their bud stages were initially selected and caged with the meshed nets (Fig. 1a and b). Adults of *I. nitidulus*/*A. splendens*/

I. nagpurensis were randomly collected (n=30; this ensured availability of both sexes) using polythene bags from the mango orchards and released into the mesh cages at the phenotypic stage when the bud transformed into tender shoot/inflorescence. Adults of mango leafhoppers were allowed to infest the shoots/inflorescence (Fig. 4a). The nymphs (Fig. 5b) which emerged sucked the sap of the shoots/inflorescence which led to drying and before it completely dried the shoot/inflorescence was nipped at the base, with the hoppers intact and the cage was transferred to a new feeding niche. The same procedure was repeated and hoppers were successfully reared for three generations on inflorescence and four generations on shoots.

In the green house laboratory, rearing was done for *I. nitidulus* and *A. splendens*. In this method, a 5x4 sq feet open cage held at the corners by stone poles and bounded on all four sides by poly propylene mesh to a height of seven feet was fixed. Mesh was stitched on all the sides and an open-close loose end was provided for one person to enter into the cage (Fig. 2). In the empty plot, a sand bed of 6 inches height was made ready and necessary manure was added. During mango season, clean and dried mangoes seeds (n=500) were first clipped at the tip to hasten sprouting. Clipped seeds were sown on the sand bed at a spacing of 12 inches. Care was taken to sprinkle water daily so that mango saplings do not dry. When the saplings reached 12 inches, the leaves were selectively and mildly pruned to ensure sprouting and continuous supply of tender shoots for rearing of mango leafhoppers.

The mango saplings were next planted in earthen pots and covered with meshed nets as described above. Once this setup was ready, adult *I. nitidulus*/*A. splendens* were randomly collected from the mango orchard using polythene bags. The adults (n=30) were released into the caged pots (Fig. 3). The adults were allowed to infest the shoots (Fig.4 b). The nymphs that emerged (Fig. 5 a) out sucked the sap causing the shoots to dry. Before complete drying the next lot of mango saplings were made ready and each used cage was carefully removed with the nymphs from the previous pot and tied to the new pot containing fresh sapling. The same protocol was repeated for four generations.

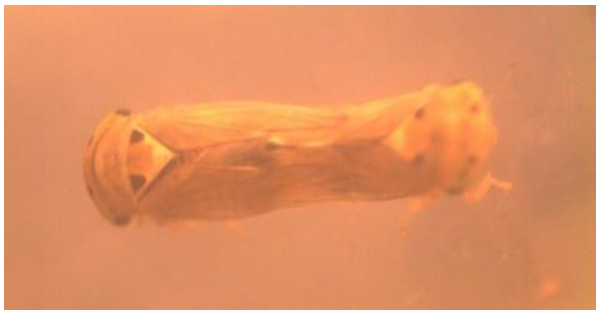
Thus mango leafhoppers were reared for four generations on the mango shoots and three generations on the inflorescence. This rearing protocol was important to study the morphology, feeding behaviour, egg laying and varietal preferences.

Figure 1 a: Caging the shoots in the field conditions

Figure 1 b: Caging the inflorescence in the field conditions

Figure 2: Enclosed plot for growing the mango saplings

Figure 3: Rearing in the laboratory using caged pots



4 a) *I. nagpurensis*

4 b) *A. splendens*

Figure 4 a and b: Mating of leafhoppers

5 a) *I. nitidulus*

5 b) *I. nagpurensis*

Figure 5a and b: Nymphs of mango leafhoppers

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Surveillance of tephritid fruit flies in the sapota orchards of South Gujarat

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Abstract

Studies were carried out in Navsari and Valsad districts of South Gujarat, India during the month of January 2021 to find out species diversity of fruit flies in the sapota fruit orchards. The roving survey was conducted by taking count of fruit flies attracted to an open cotton swab/plywood block of ethyl alcohol, methyl eugenol and DDVP mixture (6:4:1) in 30 minutes. The results revealed that the maximum population of fruit flies belonged to Genus *Bactrocera, Bactrocera dorsalis* (Hendel) was found predominant in the survey area.

Keywords: Tephritid fruit flies, species diversity**,** *Bactrocera dorsalis,* etc

Introduction

South Gujarat is leading in fruits and vegetable production in Gujarat state of India. Three districts *viz.,* Surat, Navsari and Valsad are included in agri-export zone for fruits and vegetables, which require quality production. Fruit flies are the major constraint which cause considerable loss in terms of quality and production. Moreover, these flies are good fliers and thereby their spread is also very high and hence area wide adoption of management strategy can only be useful against the flies. Fruit flies, although a serious pest, are largely uncontrolled or controlled by cover sprays of insecticides which are undesirable in fruits and vegetables. Intensity of damage recorded was high as over 30 per cent in mango and sapota, while 20-40 per cent in cucurbitaceous vegetables. Navsari Agricultural University has designed and commercialized an eco-friendly, economical and easily adoptable fruit fly trap popularly known as "Nauroji-Stonehouse Fruit Fly Trap" through Male Annihilation Technique (MAT). To know the diversity of different species of sapota fruit fly prevailing in the South Gujarat, the present study was undertaken.

Materials and Methods

The roving survey of fruit fly in sapota orchards was conducted in fifteen villages of various taluka of Navsari (20.7695° N, 73.1350° E) and Valsad districts (20.4925° N, 73.1350° E) through Male Annihilation Technique (MAT) by taking count of fruit flies attracted with an open cotton swab/plywood block of ethyl alcohol, methyl eugenol and dichlorvos (DDVP) mixture (6:4:1) in 30 minutes. The collected fruit flies were counted and brought to the Research laboratory, Department of Entomology, N. M. College of Agriculture, Navsari Agricultural University, Navsari for primary identification and further samples were sent to the NBAIR, Bengaluru, Karnataka India for further identification and confirmation up to species level. Moreover, the Nauroji-Stonehouse Fruit Fly Trap was also installed for the monitoring of the fruit flies at surveyed orchards.

Results and Discussion

The data presented in Table-1 indicated that the fruit fly abundance ranged between 0 to 60 flies per 30 minutes during the month of January 2021 in the sapota orchard from different locations in south Gujarat. From the different villages surveyed, the maximum (60 Nos.) fruit fly population caught in 30 minutes was from Gadad village of Gandevi taluka and the minimum (01 Nos.) fruit fly observed from Vagaldhara village of Valsad taluka. Among the fruit flies collected, *B. dorsalis* was found predominant in the survey area. The present findings are accordance with Nandre and Shukla (2014) who revealed that the fruit fly population in sapota prevailed throughout the year and the maximum activity (172.1 flies/trap) was found during March to August and population was found to be low during month of December and January (11.1 to 21.3 flies/trap). According to Bansode (2009), there are three species of fruit flies present in south Gujarat. Among them, *Bactrocera zonata* was pre-dominant (62.05 %) species of fruit fly followed by *Bactrocera dorsalis* (37 .27 %) and *Bactrocera correcta* (< 1 %).

Table 1: Relative abundance of Tephritid fruit fly species at different locations in south Gujarat

Sr. No.	District	Taluka /Block	Name of village	No. of flies trapped in trap within 30 min	Abundance of Tephritid fruit fly species
1	Navsari	Navsari	Navagam	10	*Bactrocera dorsalis* (100)
2	Navsari	Navsari	Vegam	47	*Bactrocera dorsalis* (100)
3	Navsari	Navsari	Eru	23	*Bactrocera dorsalis* (100)
4	Navsari	Gandevi	Gadad	60	*Bactrocera dorsalis* (100)
5	Navsari	Gandevi	Ajarai	41	*Bactrocera dorsalis* (100)
6	Navsari	Gandevi	Kachholi	44	*Bactrocera dorsalis* (100)
7	Navsari	Chikhli	Aamdhara	00	00
8	Navsari	Chikhli	Vankal	00	00
9	Navsari	Chikhli	Majigam	00	00
10	Navsari	Chikhli	Bhairavi	00	00
11	Navsari	Jalalpore	Ancheli	05	*Bactrocera dorsalis* (100)
12	Navsari	Jalalpore	Abrama	09	*Bactrocera dorsalis* (100)
13	Valsad	Valsad	Valandi	13	*Bactrocera dorsalis* (100)
14	Valsad	Valsad	Bhoma pardi	12	*Bactrocera dorsalis* (100)
15	Valsad	Valsad	Vagaldhara	01	*Bactrocera dorsalis* (100)
Total flies			--	**265**	--

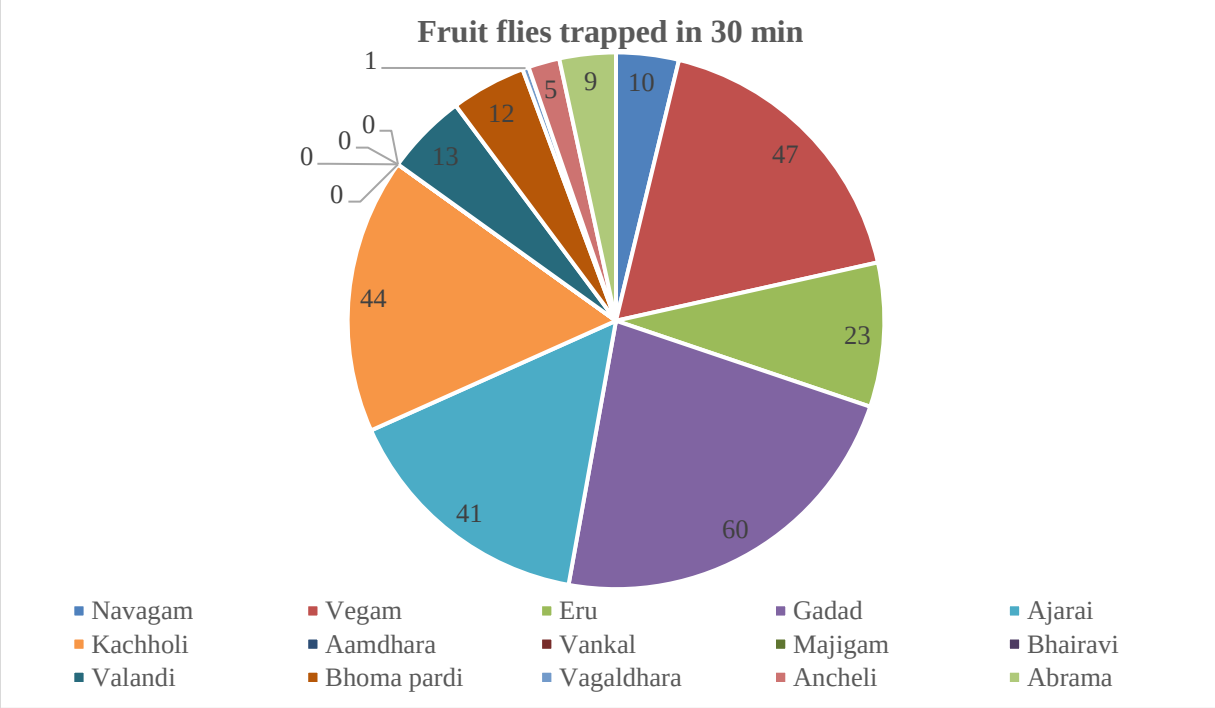

Figure 1: Total number of fruit flies attracted to an open cotton swab/plywood block of ME mixture for 30 min of exposure period

Plate 1: Fruit flies attaracted and killed in open ME mixture

Plate 3: Fruit fly, *B. dorsalis* under binocular microscope

Plate 2: Nauroji-Stonehouse Fruit Fly Trap in sapota orchard

Plate 4: Preparation of an open cotton swab/plywood block of ME mixture

Acknowledgments:

The authors are highly grateful to Dr. K. J. David, Scientist, ICAR-NBAIR, Bangalore for the identification and confirmation of the fruit fly species collected during the course of investigation.

Disclaimer: DDVP was used for trapping/killing of fruit fly species. Now, we are working on replacement chemical/lure toxicant for our popular technology i.e., Nauroji-Stonehouse Fruit Fly Trap. Moreover, use of DDVP was made for only purpose of research and not for sale.

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First record of a Buprestid leaf miner, *Trachys* sp. on okra from Odisha, India

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Okra, *Abelmoschus esculentus* is a malvaceous vegetable grown widely in India. It is an affordable source of protein, carbohydrates, minerals and vitamins, dietary fiber and health promoting fatty acids (Gemede*et al*., 2015). Okra mucilage is also having medicinal applications as a protective food additive against irritating and inflammatory gastric diseases and also used as a tablet binder (Ofoefule *et al*., 2001, Lengsfeld *et al*., 2004). Chakraborty *et al.*, (2014) recorded a total of 112 insect species (including 26 species of Lepidoptera, 24species each of Coleoptera and Hymenoptera, 12 species of Hemiptera, 10 species of Odonata, 9 species of Orthoptera, 3 species of Diptera, 2 species of Dictyoptera and 1 species each of Neuroptera andThysanoptera) under 56 families and 10 orders from okra ecosystem.

Although the leaf mining insects are known from four major orders *viz*. Diptera, Lepidoptera, Coleoptera and Hymenoptera, the greatest diversity of forms and number of species are in the order Lepidoptera (families: Cosmopterygidae, Gelechiidae, Gracillariidae, Heliozelidae, Incurvariidae, Lyonetiidae and Nepticulidae), then in Diptera (families: Agromyzidae, Anthomyiidae, Drosophilidae and Ephydridae), and relatively fewer in the Coleoptera and Hymenoptera (family Tenthredinidae). Coleopteran leaf miners mostly belong to three families; Buprestidae, Chrysomelidae and Curculionidae. The Buprestid leaf miners are placed in the subfamily Trachyinae and are primarily tropical in distribution (Hespenheide, 1991).

This observation records a Buprestid leaf miner, *Trachys* sp. infesting okra plants in a backyard vegetable garden from village Puruna Tigiria in Cuttack district, Odisha (Location: 20°26'52.0"N 85°31'03.9"E) during October-November, 2020. Blotch mines were observed on okra leaves with grubs feeding inside. Adults were also found on the foliage. The grub is yellowish white with prominent segmentation, each segment with a black spot centrally (running in the form of a line throughout the body length). Adults are small, wedge shaped metalic beetles of about 2.5 to 3 mm lengthwise and 1.2 to 1.5 mm at the broadest point of thorax, body is

covered with minute yellowish hairs (Fig.1). A search through the available literature yielded no reports of this beetle from Odisha. So this observation perhaps makes the first record of this genus, *Trachys* sp. infesting okra from the state.

Fig.1. *Trachys sp.*: a) and b) Blotch mines on okra leaves with grubs inside, c) Grub, d) Adult

Earlier records of this leaf mining beetle (*Trachys sp.*) from India dates back to 1914 by E.P. Stebbing in his book "Indian Forest Insects of Economic Importance: Coleoptera" with mentions of *Trachys lilliputana* (Host unknown) from Belgaum, Konbir and Chota Nagpur, and *Trachys bali* (Hosts: *Albizia lebbeck, Abutilon asiatica* and *Coelospernum gossypium*) from Pondicherry. David *et al.,* (1964) recorded *Trachys* sp. as a pest of *Barleria cristata* from South India and studied its biology. The grubs were found to make blotch mines on the leaves and adults cut deep notches in leaves and sepals. Nair (2007) mentioned *Trachys bicolor* as a leaf miner on *Butea frondosa.* Mukherjee *et al.,* (2011) reported this leaf mining beetle, *Trachys* sp. as an efficient biological control agent for the aquatic weed, *Hygrophila polysperma.* Chavan and Kumar (2014) reported this beetle from South Gujarat causing leaf minings on *Butea monosperma*. Grubs of *Trachys dasi* and *Trachys herilla* mine the leaves of jute and okra, respectively (David and Ramamurthy, 2017). There are reports of *Trachys puncticollis obscurella* from France and Italy, *Trachys* sp. from Iran and *Trachys troglodytes* from Greeceon theweed, *Convolvulus arvensis* (Campobasso *et al*., 1999).

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Review Articles/ Short Notes/Essays

Hitchhiking on a vehicle to travel between trees: 'Phoresy' in nature

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We all know about the system of exchange of commodities between people - 'the barter system', that existed in the early years of the formation of human civilization. The system ensured a mutual benefit to both the partners. Similar beneficial relationships are found in nature right around us. Fig trees are a keystone species that share an obligate mutualistic relationship with tiny insects called fig wasps. The fig wasps help the trees in pollination while the trees provide an egg-laying space for the wasps. Interestingly, each species of the fig tree is associated with a particular species of pollinating fig wasp. Firstly, female fig wasps enter the fig inflorescence and pollinate the small flowers. They also lay eggs inside the flowers. Eventually, the adult female wasps emerge out of the fig inflorescence through the holes made on the walls of the fig inflorescence by the male adult wasps - to carry the pollen along with it to the next fig tree; thereby continuing the cycle.

Several living organisms are found to interact with this fig tree - fig wasp mutualism. *Ficus racemosa* is a fig tree that is known to share a mutualistic association with *Ceratosolen fusciceps* species of fig wasp; the pollinating females of which house nematodes inside their abdomen. These nematodes belonging to the three genera namely S*chistonchus* (Aphelenchoididae), *Teratodiplogaster* (Diplogasteridae) and *Pristionchus* (Diplogasteridae) - ride on their fig wasp vehicle to enter the fig inflorescence through an opening. They disembark from the fig wasp abdomen to mate and lay eggs inside the inflorescence. The eggs mature into adults and hitchhike on the female pollinating fig wasps to finally move out of the fig while traveling inside the vehicle's abdomen in order to get dispersed onto the next fig tree. Such natural interactions that involve the movement of living organisms via hitching a ride on a vehicle - are scientifically referred to as 'Phoresy'.

One might wonder about the nature of this interaction between the hitchhikers and their vehicles and plant hosts. Are the nematodes helping their fig wasp vehicles and plant hosts or are they harming them both? It has been found that, out of these three genera of nematodes, S*chistonchus* - reduced the volume and the number of seeds of the fig inflorescence, thereby acting as a plant parasite, and *Teratodiplogaster* -decreased the life span and the flight duration of the pollinating female fig wasps, therefore behaving like an animal parasite. Thus, in this case, the intervention of a third party - the hitchhiking nematodes- proves to be detrimental for the fig tree-fig wasp mutualism. Well, then how does the long-standing ancient strong mutualistic interaction between the fig tree and the fig wasp, maintain its stability?

It is now known that only fig wasp vehicles with lower numbers of hitchhiking nematodes can reach the next fig tree. On the contrary, the fig wasps loaded with higher numbers of the nematodes being heavier, move slowly and get increasingly exposed to their ant predators and therefore, do not make it to the next fig tree. It is quite amazing to observe and learn, how every living organism always finds a way to thrive and co-exist with one another - without demolishing anyone in the process!

Fig. 1: Inflorescence on *Ficus racemosa*
Picture Credit: Satyajeet Gupta
Location: Indian Institute of Science Campus, Bangalore-560012, Karnataka, India

Reference:

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Greater wax moth: A major threat to beekeeping in Karnataka

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Honeybees are attacked by many diseases and pests which can greatly hinder the advancement and reduce the economic benefits of beekeeping worldwide. Among pests, the wax moth is considered as a notorious pest of honeybee colonies which is well distributed throughout the world. There are two species of wax moth, the greater wax moth (*Galleria mellonella* L.) (Plate 1) and lesser wax moth (*Achoria grisella*). *Galleria mellonella* L. (Lepidoptera: Pyralidae) causes heavy economic losses, sometimes reaching to up 60-70 percent of the beekeeper's income in the developing countries like India (Hanumanthaswamy, *et al.*, 2009). Larvae feeds on honey wax, cast-off honeybee pupal skins and brood, creates tunnels in the comb and leaves masses of webs in the comb and on the frame. Damage occurs as the larvae create silk-lined tunnels through the hexagonal cell walls and over the comb surface. The tunnels and borings made by the larvae on the cell caps makes holes through which honey leaks out. The silken threads entangle emergent bees, which as a result, die of starvation, a phenomenon described as galleriasis (Plate 2). Moreover, large scale infestation of colonies by larvae of the greater wax moth often leads to colony loss and absconding.

Management of the wax moth comprises of cultural practices like maintaining good sanitation which includes, keeping the colony strong with adequate food sources, sealing cracks andcrevices, replacing and destroying infested combs (Charriere and Imdorf, 1999). Chemical control consisting of fumigants such as sulphur, acetic acid, ethylene bromide, calcium cyanide, methyl bromide, phosphine, paradichlorobenzene (PDB) naphthalene, and carbon dioxide (Gulati and Kaushik, 2004). However, the above listed fumigants (except carbon dioxide) pose health risks to the handler and lead to residues in hive products such ashoney, rendering the product inconsumable. In this context, greater emphasis is being laid on safer methods such as biological agents and bio-products including *Bacillus thuringiensis* Berliner (H-serotype V) (Bt), *Bracon hebetor* (Say), *Trichogramma* species, the redimported fire ant (RIFA) (*Solenopsis invicta* Buren and *Solenopsis germinita* Fabricius), and the use of themale sterile technique (MST) which have

been found to be effective and safe control methods for management of greater wax moth (Kwadha *et al*., 2017). In addition to this, yellow sticky traps with older honeybee combs are being used for the management of the wax moth at present (Vijayakumar *et al*., 2019; Plate 3).

In order to record the incidence of this pest, surveys were taken by All India Coordinated Research Project on Honey Bees and Pollinators on honeybees and pollinators in potential beekeeping areas ofKarnataka during 2015 to 2019 (Figure 1). Apiaries in the plain and hilly regions of Karnataka were visited every year and recorded the percent infestation in each year. Among thirteen selected beekeeping areas, the maximum infestation was recorded in Udupi and Chitradurga with more than 50% infestation followed by other 12 locations with less than 50% infestation. The least infestation was recorded in Chamarajnagar (6.2%) followed by Mysore (10%) and Mandya (12.5%) as indicated in the figure 2. The infestation of wax moth occurs during most of the seasons due to its overlapping generations in a year. Abandoned combs and weak colonies constantly occur at different beekeeping regions in Karnataka, and they become important reservoir for the multiplication of *G. mellonella* population. It is active from March to October (Garg and Kashyap, 1998) and continued up to November (Ramachandaran and Mahadevan, 1951; Gupta, 1987).

In south India, maximum infestation was recorded during the dearth period (Viraktamath *et al*., 2005) that coincided with the weak population in the colony. Wax moth damage is the major biological constraint in the beekeeping industry. Therefore, controlling wax moth with safe management practices has great economic importance (Turker *et al*., 1993). More research on safe control methods like use of biological agents and bio-products are the need of the hour.

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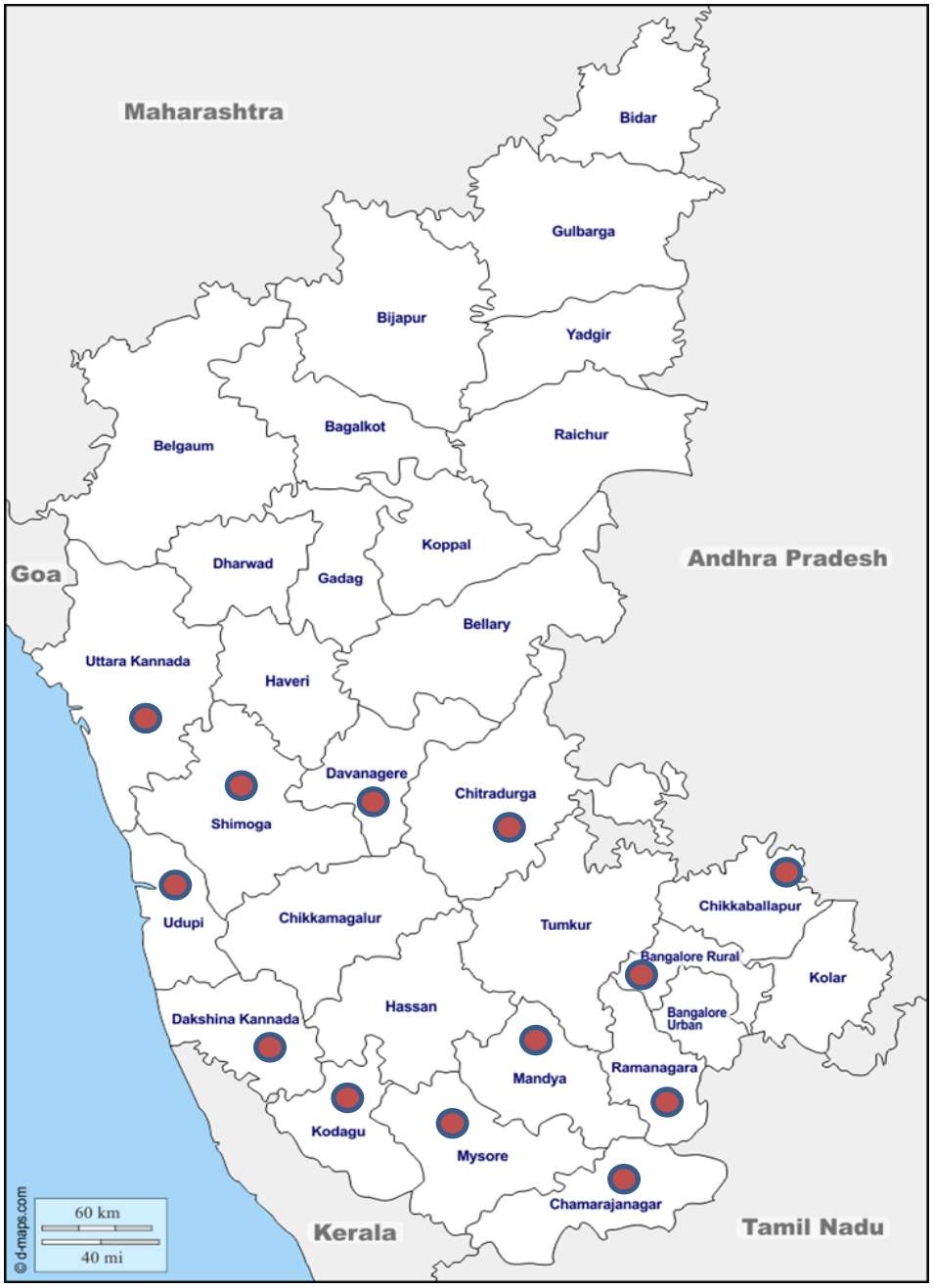

Fig. 1. Selected districts for survey on pest and diseases of honey bees in beekeeping areas of Karnataka

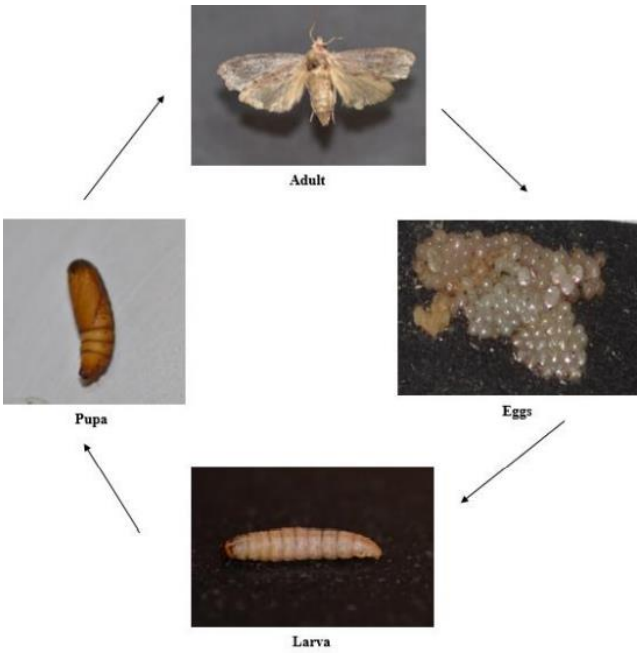

Plate 1. Life cycle of *Galleria mellonella*

Plate 2. Damage caused by *Galleria mellonella* in *Apis cerana* combs

Plate 3. Yellow sticky trap installed at Apiary to trap *Galleria mellonella*

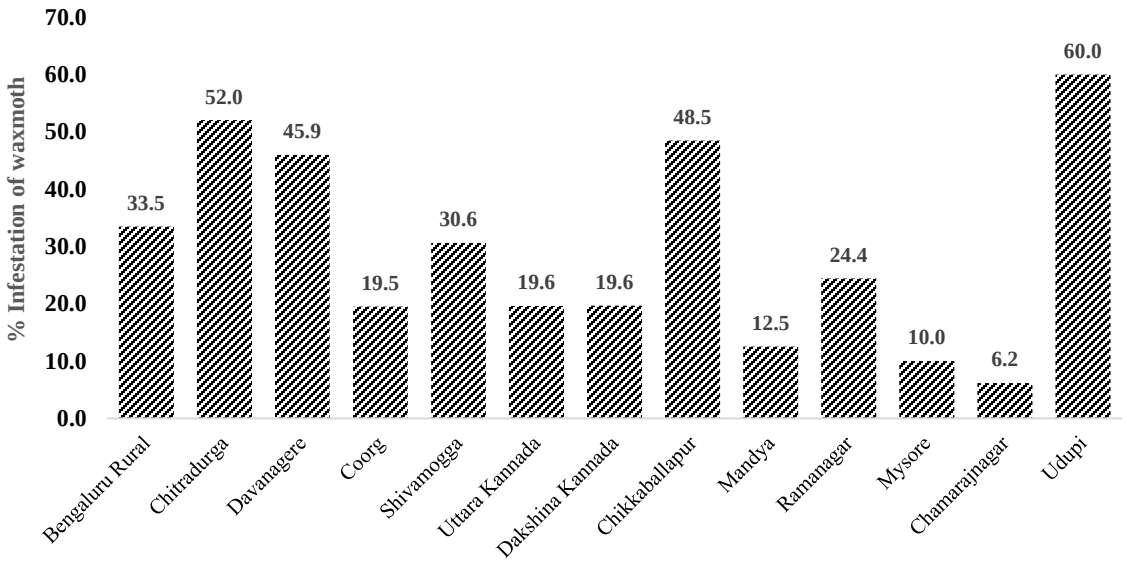

Fig. 2: Average percentage of greater wax moth infestation in different parts of Karnataka from 2015-2019

Adopted standards for pest management in export of wood and wood packaging material

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Abstract

Wood packaging materials (WPM) provide a suitable habitat for pests which enable them to spread globally in transit. Major pests associated with WPM belong to different orders of insect *viz.*, Coleoptera, Lepidoptera, Isoptera, Diptera, Hymenoptera and others. In order to manage the risks associated with WPM due to these pests, International Plant Protection Convention (IPCC) has developed International Standards for Phytosanitary Measures with the goal to eliminate the risk of quarantine pests and other pests by means of either heat treatment or methyl bromide fumigation of WPM. Complete avoidance of introduction or spread of pests is impossible while, the risk of pests has to be minimized within the least possible delay by following these approved phytosanitary measures.

Introduction

The increasing international trade has been responsible for the inadvertent introduction of many exotic (non-native invasive) insect pests and plant pathogens, of which several have become highly invasive and causes serious environmental and economic impacts to multiple habitats worldwide. For instance, emerald ash borer (*Agrilus planipennis*; Buprestidae) introduced to North America from Asia in the 1990s has killed millions of ash trees (*Fraxinus*) with economic impacts in the billions of dollars (Kovacs *et al.*, 2011).The phytosanitary measures play major role in relation to possible introductions. Phytosanitary measures are not only applied to exported timber, wood products, but also to wood packaging materials that are used for moving commodities. In 2019, global services trade was valued at US$6.1 trillion, recording a slight increase of two per cent on 2018, and of almost 70 per cent on ten years earlier. With this scenario there is lot of chances for introduction of invasive pests through dunnage mainly wood if proper mitigating measures are not taken. In recent years, introductions of several, particularly damaging wood-infesting insects and pathogens have focused public and regulatory attention on the pathways that transport these pests (FAO, 2018). Wood-feeding

insects commonly associated with wood packaging material includes items such as pallets crates and dunnage (wood used to brace cargo). Packaging for overseas shipments is commonly made from wood as they are relatively inexpensive, generally abundant, renewable and, easily manufactured and repaired.

Unfortunately, wood used to construct WPM can be infested with a wide variety of bark and wood pests and thereby serve as a pathway for pest movement. As international trade volumes soared in recent decades, many countries became concerned about repeated introductions of invasive forest insects and disease organisms such as Asian longhorned beetle, *Anoplophora glabripennis* (Coleoptera: Cerambycidae), which is believed to have entered the United States in solid wood packing material from China. The pinewood nematode, *Bursaphelenchus xylophilus* (Nematoda: Aphelenchidae) is a causal agent of pine wilt diseasecausing death of million pines in Japan, Korea, China and Portugal introduced from North America (Futai, 2013).

Pest Association with Wood Packaging Material

Pests commonly associated with WPM include beetle (Coleoptera) families *viz.*, Buprestidae, Cerambycidae, Curculionidae, Platypodinae and Scolytidae, the wood wasp (Hymenoptera) family Siricidae, and the moth (Lepidoptera) families *viz.*, Cossidae and Sesiidae. Elsewhere, in the world there are many other wood pests of concern to specific countries, including species of powderpost beetles (Bostrichidae, including Lyctinae), wood boring flies (Diptera), termites (Isoptera), as well as wood-decay fungi and nematodes. It is important to note that many powder post beetles and termites are secondary colonizers of treated wood and therefore are rarely the target pests when ISPM 15 treatments are applied to newly constructed WPM.

Nature of the Problem

The risks associated with the movement and introduction of quarantine pests in WPM are well documented. The introduction of destructive tree pests associated with the international movement of WPM may present the following risks:

1. Exotic pests with limited distribution in the country may spread to new areas.
2. Native pests with limited distribution mayspread to new areas increasing environmental stressors, which in turn may make native forests more susceptible to these pests.
3. Pathogens vectored by established exotic or native insects may spread to new areas.

Phytosanitary Measures

In response, members of the International Plant Protection Convention (IPPC) developed and adopted International Standards for Phytosanitary Measures No. 15 (ISPM 15) in 2002, which provided details on approved phytosanitary treatments for WPM used in International trade. A core value of these international standards is 'Harmonization of national regulations, which facilitates trade the original stated goal of ISPM 15 in 2002 was to "practically eliminate the risk for most quarantine pests and significantly reduce the risk from a number of other pests" by means of either heat treatment or methyl bromide fumigation WPM. ISPM 15 was slightly revised in 2006, and in 2009 the IPPC adopted several important changes such as lengthening the fumigation exposure time, requiring WPM to be made from debarked wood, requiring debarking prior to fumigation, and specifying tolerance limits on the maximum allowable size for individual patches of residual bark. In addition, the goal of ISPM 15 was revised in 2009 "to reduce the significant risk of introduction and spread of most quarantine pests" associated with WPM. The next version of ISPM 15 was established in 2011, but consisted of simple changes in the text formatting. The newest version of ISPM 15 (Fig. 1) was approved in 2013 and formally adopted heat treatment using dielectric heating (e.g. microwave). This standard has been adopted by over 177 countries. The material which has undergone the treatment will will have a ISPM mark (Fig.2) which is universal over all the adopted countries.

Approved treatments associated with Wood Packaging Material

The approved treatments may be applied to units of wood packaging material or pieces of wood packaging material or to pieces of wood that are to be made into wood packaging material.

1. Heat treatment:

Various energy sources or processes *viz.,* conventional steam heating, kiln-drying, heat enabled chemical pressure impregnation an dielectric heating (microwave, radio frequency) may be suitable to achieve the required treatment parameters.

a. Conventional steam or dry kiln heat chamber:

When conventional heat chamber technology is used, the fundamental requirement is to achieve a minimum temperature of 56^{o}C for a minimum duration of 30 continuous minutes throughout the entire profile of the wood including its core.

Alternatively, when using kiln-drying heat chambers or other heat treatment chambers, treatment schedules may be developed based on a series of test treatments during which the core temperature of the wood at various locations inside the heat chamber has been measured and correlated with chamber air temperature, taking into account the moisture content of the wood and other substantial parameters such as species and thickness of the wood and air flow rate and humidity. The test series must demonstrate that a minimum temperature of 56^{o}C is maintained for a minimum duration of 30 continuous minutes throughout the entire profile of the wood.

b. Dielectric heating

Where dielectric heating (e.g. microwave) is used, wood packaging material composed of wood not exceeding 20cm when measure across the smallest dimension of the piece or the stack must be heated to achieve a minimum temperature of 60^{o}C for 1 continuous minute throughout the entire profile of the wood including its surface. The prescribed temperature must be reached within 30 minutes from the start of the treatment.

c. Methyl Bromide Treatment

Wood packaging material containing a piece of wood exceeding 20 cm in cross section at its smallest dimension must not be treated with methyl bromide. The fumigation of wood packaging material with methyl bromide must be in accordance with a schedule specified that achieves the minimum concentration-time product (CT) over 24 hours at the temperature. This CT must be achieved throughout the profile of the wood, including its core, although the

concentrations would be measured in the ambient atmosphere. The minimum temperature of the wood and its surrounding atmosphere must not be less than 10^{o}C and the minimum exposure time must not be less than 24 hours. Monitoring of gas concentrations must be carried out at a minimum at 2, 4 and 24 hours from the beginning of the treatment. In the case of longer exposure times and weaker concentrations, additional measurement of the gas concentrations should be recorded at the end of fumigation.

These treatments described are significantly effective against most pests of living trees associated with wood packaging material used in international trade. These treatments described are combined with the use of debarked wood for construction of wood packaging, which also acts to reduce the likelihood of re-infestation by pests of living trees. These measures have been adopted based on consideration of "the range of pests that may be affected, efficacy of the treatment and the technical and / or commercial feasibility."

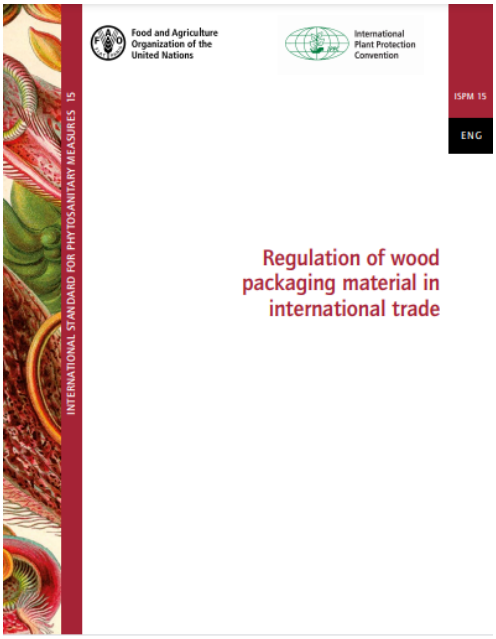
Secure disposal of non-compliant wood packaging material

Secure disposal of non-compliant wood packaging material is a risk management option that may be used when an emergency action is either not available or is not desirable.

1. Incineration, if permitted
2. Deep burial in sites approved by appropriate authorities (The depth of burial may depend on climatic conditions and the pest intercepted, but is recommended to be a least 2 m. The material should be covered immediately after burial and should remain buried. The deep burial is not a suitable disposal option for wood infested with termites or some root pathogens.).
3. Processing (Chipping should be used *only* if combined with further processing in a manner approved for the elimination of pests of concern, e.g. the manufacture of oriented strand board.)
4. Other methods endorsed as effective for the pests of concern.
5. Returning to exporting country, if appropriate.

Conclusions

Approved phytosanitary measures that significantly reduce the risk of pest introduction and spread viawood packaging material should be followed such as the use of debarked wood and the application of approved treatments. The application of the recognized ISPM mark ensures that wood packaging material subjected to theapproved treatments and is readily identifiable. In order to minimize the risk of introduction or spread of pests, secure disposal method, required should be carried out within the least possible delay. Still it is likely to be very challenging to set the treatment standards for WPM that were acceptable and achievable by most of the countries, given that tree species, pest species and the availability of the phytosanitary treatment facilities vary from country worldwide.



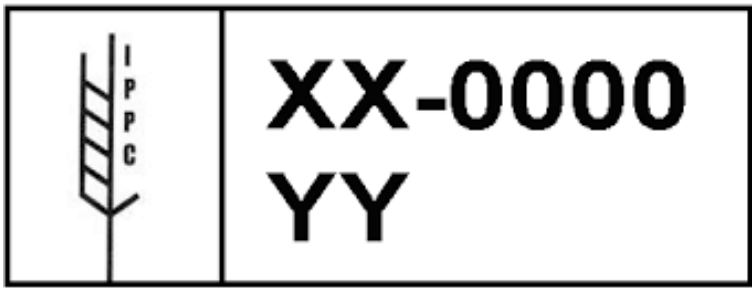


Fig. 1 **Fig.2**

Fig. 1 ISPM 15, Regulation of wood packaging material in international trade

Fig.2, ISPM Mark IPPC certification symbol (this is a registered trade mark).

XX- represents the two letter ISO country code where the wood was treated, 0000- represents the unique certification number (which ensures that the wood packaging material can be traced back to the treatment provider and/or manufacturer),

YY- is the treatment abbreviation where:

HT: is the code for heat treatment using conventional steam or dry kiln heat chamber to a minimum of 56º C for a minimum of 30 minutes

MB: is the code for methyl bromide fumigation

DH: is the code for heat treatment using dielectric heat

SF: is the code for sulphuryl fluoride fumigation

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Camouflage and mimicry- An evolved strategy of common mime *Chilasa clytia* Linnaeus

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In nature, insects have evolved tactics, to avoid becoming something else's food. This adaptation includes behavioral traits to scare away predators or anatomical adaptations to give these animals an advantage in evading their predators. Camouflage and mimicry, two strategies of the insects are well studied in the science of Entomology (Suzuki *et al.,* 2019).

Camouflage is a defense mechanism that helps insects to amalgamate with their surroundings. They do it to obscure their presence or identity, either to delude their predators or to deceive their prey. A common camouflage mechanism is background matching. "The colour and pattern of organisms perfectly blend with the colour and texture of the background. The pattern plays an ecological role in helping the insects to catch prey or to avoid being preyed upon. Some of the grasshoppers, leaf and stick insects are common examples of camouflage (Stevens and Ruxton, 2018). Ants are probably the major group of social insects which utilize colors for camouflage (Badejo *et al.,* 2020).

Mimicry is an evolved resemblance between an organism and another object, often an individual of another species. Mimicry may evolve between different species, or between individuals of the same species. Often, mimicry functions to protect a species from predators, making it an anti-predator adaptation (King *et al.,* 2006). There are twomost common types of insect mimicry, Batesian and Mullerian. Batesian mimicry involves a non-harmful insect mimicking a harmful insect. For example, the plain tiger (*Danaus crysippus*) non-edible butterfly, which is mimicked by multiple species, like female danaid eggfly (*Hypolimnas misippus*). Mullerian mimicry is when two or more insects that are all dangerous look alike. The concept here is that if a predator learns not to eat one dangerous insect it will learn not to eat all dangerous insects that look like it. The best examples of mullerian mimicry can be found within the butterfly genus *Heliconius*.

The Genus *Chilasa* of tribe Papilionini was erected by Moore (1903) in his book entitled 'Lepidoptera Indica'. Species belonging to this genus are mimics of the subfamily Danainae and hence, they are popularly known as mimes (Revathy and Mathew, 2014). The Common Mime is primarily found in secondary growth as well as urban gardens and areas surrounding cultivated fields. The adults seem to prefer the wetter locations within those areas. It is an oligophagous pest with the immature stages feeding on the leaves (Figure.1) of the plants such as *Cinnamomum zeylanicum, C. macrocarpum, C. camphora, Litsea chinensis, L. deccanensis, Persea macrantha* and *Alseodaphne semecarpifolia* (Kehimkar, 2008).

Eggs and early stages of the Common Mime are naturally found on seedling at heights of 3-6 meter. The eggs are laid on young leaves or petioles of the host plant. The spherical eggs are creamy white with the surface encrusted with a layer of orange-yellow granulated substance. Caterpillars resemble bird droppings as they rest on the leaf surface. This evolved strategy helps younger instars to protect from the predators. All instars possess a fleshy organ called osmeterium in the prothoracic segment. The hidden osmeterium can be everted to repel any intruder when the caterpillar senses the threat. This butterfly consists of five different nymphal instars. The body of 5^{th} instar caterpillar is dark greyish black with rows of fleshy processes on segments 1 to 4 and a single row on the other segments. A crimson red spot is featured at the base of each fleshy process. Last instar larvae are repulsive to birds due to dark colour blend and pattern of osmeterium on the body. After the final moult, they form a chrysalis which resembles a broken twig. The adult of this species is sexually dimorphic so the males and females appear different than each other. Colour pattern on the wings is considered an important character to differentiate male and female.

To protect themselves from the predator, this butterfly evolved various protective strategies (mimicry and camouflage) in the life cycle. More specifically, common mime are falling in batesian types of mimicry. Various strategies concerned with different life stages of this insect are presented in Table 1.

Fig. 1. Third and fifth instar caterpillars of common mime feeding on Cinnamon

Photograph of the insect captured from ICAR-CPCRI, Regional Station, Vittal, Karnataka

(Latitude- 12°46.43' Longitude- 75°06.58'**)**

Table 1. Various strategies of Common mime to survive in nature

Life stage	**Strategy**	**Remark**
Early instars larvae	Mimicry	Resembling Bird droppings
Pupae	Camouflage	The pupa resembles very much like a broken twig. Spotting one of these can be a challenge.
Adults	Mimicry	Mimic the look of the distasteful/unpalatable butterflies like individuals belonging to subfamily Danainae (Blue Tiger and crow butterfly).

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Meliponiculture: A backbone for poor people

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Introduction

In the world, many people live in a poverty condition. Poverty is the main evil in human society. According to the Global Multidimensional Poverty Index, 2020 nearly 84.3% of poor people live in Africa and South Asian countries and 67 % of the poor people in middle income countries. Due to covid-19 on an average poverty levels will be set back by 3 to 10 years. One of the eco-friendly sustainable livelihoods for poverty eradication is meliponiculture (stinglessbee beekeeping).

Stingless bees are also known as Dammer bees and Mosquito bees (Fig. 1). Stingless bee honey isconsidered as a sacred and medicinal from ancient times. Feral colonies generally seen in the tree trunks, compound walls, old buildings etc.Average yield of honey : 500 - 600 g / colony.

Cerumen is the basic material used for nest construction. Nest mainly contains a brood area and food storage area. Brood area contains a developing larvae and in food storage area honey and pollen are stored.

Scientific classification
Kingdom: Animalia
Phylum : Arthropoda
Class : Insecta
Order : Hymenoptera
Family : Apidae
Subfamily: Meliponinae
Trib : Meliponini ,Trigonini. (Wille, 1979)

Fig. 1 Stingless bee

In India most important species are *Tetragonula (Trigona) travancorica* (in south India), *Tetragonula ruficornis* (in northern plains) *and Tetragonula calophyllae* (Shanas and Faseeh, 2019). In American continent important species are *Melipona beechi, Melipona fasciata,*

Scaptotrigona mexicana etc. In Africa *Meliponula bocandei* and ground nesting stingless bees (Black type and Red type). In Australia, *Trigona carbonaria*, *T.hockingsi*, are important

Meliponiculture provides a continuous income through its hive products and also increases the productivity of crops through pollination.

Stingless bee honey is an excellent immunity booster especially for covid-19 and also used for many diseases (Mustapa *et al*., 2020). Propolis is antibacterial, anti-inflammatory and with many health-promoting properties (Choudhari *et al*., 2012). Pollen is rich in proteins. Beewax is especially used for skin health (Kumar *et al*., 2012).

Stingless bee products increase the brand value of normal products. Any product like biscuits, for example if fortified with stingless bee honey gets a brand value.

So its products fetch a higher price in the market compared to *Apis* genera products. Colony management and domestication are easy compared to *Apis* spp. Stingless bees easily get domesticated in naturally available materials like bamboo poles, coconut shells, earthen pots etc.and stingless bees have no sting (non-functional).

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Rugose spiraling whitefly (RSW), *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae): an urban nuisance.

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During the lockdown due to Covid-19, our car was unused for many days. It was parked outside the compound next to a coconut tree; part of the canopy of the tree partially shaded the car. Parking on road sides is quiet common in a city like Bengaluru as people own houses but not the required extent of parking space. The car was gathering dust in the open space. One fine day we decided to clean the vehicle when we realized that the dust could not be removed by simple blowing or by a duster particularly in the dicky part of the vehicle. The surface of the dicky was sticky as if someone had sprinkled some sugar syrup and glued the dust on it. It required thorough washing with good amount of detergent and abundant water. Immediately, something struck to my entomologist mind and so I rushed to terrace of the house to check the coconut tree.

It was customary in the olden days in Bengaluru to have one or two coconut trees in the houses. We have one tree next to our compound wall, which is now about thirty feet. The canopy of the tree is spread over to roof of the second floor. On examination of leaflets, I found there was good amount of infestation by a whitefly. Later it was identified as Rugose Spiraling Whitefly (RSW), *Aleurodicus rugioperculatus* Martin. Then I started checking other nuisances it caused. The parapet walls lying below canopy were completely black with sooty mold. One of the panels of solar water heater was completely covered was sooty mold and dust. I found the reason for not getting required amount of hot water. Window panels facing coconut tree also had sooty mold, probably due to splashing of honey dew by wind.

RSW is found on the ventral side of leaflets, which suck the sap and release honey dew. The honey dew thus produced falls down and gets deposited on any surface underneath an infested tree. The honey dew subsequently aids in the development of sooty mold fungus due to which the surfaces appear black.

In the last half a decade, India has seen introduction of four exotic whiteflies species. One of them is Rugose Spiraling Whitefly (RSW), *Aleurodicus rugioperculatus* Martin. RSW which was first reported during 2016 on coconut from Palakkad (Kerala) and Pollachi (Tamil Nadu) and now spread to almost all coconut growing areas of the country. It is assuming major pest status on oil palm also. It is also reported on banana and many other host plants (Shanas *et al.*, 2016.).

RSW Infested tree (12.999032° N, 77.534381° E)

Sooty mold and dust on the trunck of the car

Sooty mold and dust on parapet wall

Sooty mold development on solar panel

Reference:

Shanas, S. Joseph Job, Tom Joseph and Anju Krishnan, G. 2016. First report of the invasive rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae) from the Old World, *Entomon*,41(4): 365-368.

Blogs of bugs: Interesting blogs to explore insect world

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Scientific journals form an important source of information to researchers. However, their reach and patronage is limited to academic institutions and scientific community that are seriously pursuing science. On the other hand, popular magazines cater to readers who may not be experts in a subject but are passionate about it. Similar way, the present day BLOGS of digital world are akin to the popular magazines. They not only disseminate information in an easy and interesting way but also provide platform to exchange views and hence are becoming increasingly popular. When it comes to Entomology, there are several blogs that are being run by passionate insect lovers including academically qualified Entomologists as well as those driven by their quest to explore the wonderful world of hexapods. An attempt was made to scan the web to find some of interesting blogs devoted to insects, one of the most fascinating creatures on the earth. The following are the blogs that are active and being followed by thousands of insect lovers and entomologists. There are not many blogs from India except for two we had come across. One is the 'Indian Entomologist' run by a group of dynamic entomologists from the ICAR-Indian Agricultural Research Institute, New Delhi. Though a late entry, it has already made its presence felt among the Entomology fraternity. Another is the "Insect Environment", which enjoyed a wide patronage in its earlier print version for about two decades. After a brief pause it has recently got transformed to the digital mode as Insect Environment under the umbrella of 'Special Insect Interest Group', Bengaluru and has been receiving accolades as a window of young and budding Entomologists to share their thoughts, views and research findings. The objective of this compilation is only to introduce these blogs to those interested to learn and keep abreast of happenings in the field of Entomology. In no way this could be construed as recommendation or ratification of their contents

Table 1. List of some interesting blogs related to insects

S. No.	Blog name	From where	What it deals with	USP	Link
1.	Indian Entomologist	ICAR-IARI, New Delhi, India	Latest happenings in Entomology in India and at global level	Interesting topics of Entomology; Regular insect photo contests and Interviews with eminent Entomologists with a special feature on women entomologists	Indianentomologist.org
2.	Insect Environment	Bengaluru, India	Views and thought provoking ideas and leads in Insect Science	Team mainly consists of young women Entomologists	www.insectenvironment.com
3.	What's that bug?	USA	Identification of insects	We can get our specimens identified	whatsthatbug.com
4.	Catalogue of organisms	Australia	Systematics of arthropods	Weekly articles on a specific taxonomic group	coo.fieldofscience.com
5.	Bug of the week	USA	'The Bug Guy,' Michael J. Raupp introduces an insect every week in a semi popular way	Excellent photography	bugoftheweek.com
6.	Reddit-Bug identification	California, USA	Identification of insects, mites, spiders etc.	Anybody can submit photos to get identification	reddit.com/r/whatsthisbug
7.	Bug squad	UC Davis, California, USA	Pollinators, especially honey bees and also about people who pursue them	Extraordinary photographs by Kathy Katley Garvy	https://ucanr.edu/blogs/bugsquad/
8.	Ask an Entomologist	Ecuador	One can get answers for any questions about insects	Encyclopedia of Entomology	askentomologists.com
9.	Myrmecos – little things matter	Texas, USA	This is run by an entomologist and photographer Alex Wild	Photos of very high quality which made to cover pages of magazines like Science and Current Biology	myrmecos.net
10.	Angler's Entomology Podcast	USA	Fly fishing Entomology	Aquatic insects	anglersentomology.libsyn.com
11.	Bug life	UK	Conservation of invertebrates especially arthropods	Insect identification tips	buglife.org.uk

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Adulteration in Indian Honey

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Pure honey is a sweet natural produce from honey bees of the family Apidae. They forage and collect nectar of flowers or from extra floral nectaries (complex sugar). Bees are capable of transforming these sugars to glucose and fructose (simple sugars) with the help of enzymes like invertase and diastase available in the honey bee stomach (crop) and later store them in honeycombs for ripening and sealed with bee wax (Fig. 1).

Usually water, sugars, antioxidants, vitamins, minerals, acids, amino acids are accounted as ingredients in the pure honey. Honey is an energiser since it contains 300KCal/100ml and is a good health supplement for all ages and it is totally fat free. When human intelligence understood the chemistry of honey, efforts were on to make synthetic ones and gradually many natural products drifted from its originality and many adulteration attempts were also noticed, which common man failed to recognize in the marketed produce.

The introduction of salivary enzymes which the honey bees make on the collected plant nectar results in its enrichment and the transformed product turns out to be rich sources of antioxidants, amino acids and thus blending natural honey with unique medicinal properties. This might have been a good reason for the natural honey getting accounted in traditional medicine and even it has proved to be a good immune system stimulant, particularly during the COVID 19 pandemic. Any addition of artificial sugar sources or syrups reduces its natural quality and siphon off its medicinal properties. As a sweetener, honey is more easily digested than sucrose, and energy (ATP) is released quickly.

The food safety standards authority of India *(*FSSAI) has clearly explained that if a supplier sells a product as ‘pure honey’ then no external food ingredients that includes food additives should be added to it. It should not be heated or processed such that its essential natural composition is altered and its quality is affected. Current regulations specify around 18 parameters that honey must comply with for producers to label it “pure honey (Fig. 2).”

Some honey sold in Indian markets were found adulterated with Chinese sugar syrup and they miserably failed in the key test of purity under a scientific investigation by Centre for Science and Environment (CSE) (thehindubusinessline.com). CSE food researchers selected 13 brands of raw and processed honey and subjected them to tests that are required under national food regulatory laws to be labelled as honey.

Most of the brands passed the c3, c4 tests but when subjected to one test, called Nuclear Magnetic Resonance (NMR) (that can ascertain the composition of a product at the molecular level) that was done at a lab in Germany. In the honey marketed by prominent brands, they detected the presence of Chinese sugar as an adulterant which is injurious to health.

The *FSSAI* had warned importers and State Food Commissioners that rice syrup, golden syrup (made from cane sugar) and invert sugar syrup were being used to adulterate honey. According to CSE report, Chinese importers were offering branded fructose syrup which when adulterated in honey bypassed FSSAI's 2020 standards for honey. According to Indian Market Research Company services (IMARC), even if 50-80 per cent of Chinese sugar is mixed, the common laboratories in the country could not detect its adulteration (nationalheraldindia.com).

According to a June 2019 report on Beekeeping by the Economic Advisory Council (EAC),(thehindubusinessline.com) it is reported that around four lakh people are involved in beekeeping producing 90-95 thousand tonnes of honey every year from 34 lakh bee colonies in India. India is blessed with diversified crops which can provide nectar and pollen to honey bees and hence ample scope for beekeeping. In the best interest of the bee keepers, the Government has to ensure the production of natural honey should not face competition from adulteration market.

The Food safety standards Authority of India (FSSAI) has already prescribed a number of checks on purity of honey C3, C4 tests but they have proven ineffective. Accordingly, the stricter checks like the globally accepted Nuclear Magnetic Resonance Spectroscopy (NMR) should be made mandatory and such facilities must be available across the country.

Another major concern in production of pure Honey is the inadvertent contamination by pesticides and antibiotics applied on plants. During the forage, these contaminants are carried

along with them by honey bees. The use of antibiotics such as terramycin and oxytetracycline to deal with bee health maintenance has also raised questions in European markets as contaminants. To further the scope of Indian honey reaching other countries through export, Government must raise its bar on testing, applying the latest technologies to rule out any possible adulteration and contamination. Let us hope that we should be able to successfully integrate beekeeping with organic farming initiates, which will wipe off threats of chemical contaminations in honey

Photography: Stephen Devanesan

Fig. 1 Worker bees store honey in honey combs for ripening and sealed with bee wax

Fig. 2 Natural, pure honey from honey bee colony

A brief review of *Zygogramma bicolorata* as a potential biocontrol agent of parthenium in India

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Zygogramma bicolorata Pallister, parthenium beetle so called for their feeding behavior on parthenium weed belongs to order: Coleoptera family: Chrysomelidae. Parthenium weed, *Parthenium hysterophorus* L., family: Asteraceae (Compositae), is also called as carrot weed or congress grass in India. It is a noxious herbaceous annual weed mainly found in agricultural fields, pastures and wastelands worldwide. Although this devastating weed could be controlled by mechanical and chemical methods these are most labour intensive and not cost effective methods. Chemical methods cause environment and soil hazards. Further chemical methods are practically unsuitable for large area and also not effective for long term use. Biological control is the only next best attractive option available.

Zygogramma bicolorata was introduced to India from Mexico in 1984 to control parthenium weed and since then only the leaf-feeding beetle *Z. bicolorata* has been introduced (Jayanth, 1987). In Australia eight species of insects and one rust fungi have been introduced from 1977 *viz.*, leaf feeding beetle *Zygogramma bicolorata*, stem boring weevil *Listronotus setosipennis*, stem galling moth *Epiblema strenuana*, leaf mining moth *Bucculatrix parthenica*, seed feeding weevil *Smicronyx lutulentus*, sap feeding bug *Stobaera concinna*, stem galling moth *Platphalonidia mystica*, stem gall weevil *Conotrachelus* sp. and rust fungus *Puccinia abrupta* var. *partheniicola*. Among them, six species of insects and one rust fungi have been successfully established as biological control agents but stem galling moth *Platphalonidia mystica* and stem gall weevil *Conotrachelus sp.* is not established so far (Dhileepan and McFadyen, 1997). The female beetle lays about 650-700 yellow eggs either singly or in groups on leaves, flower, stems and terminal buds of plant. Larvae hatched after 1.5 to 3 days. Larvae voraciously feed on the leaves for 12 to 16 days. After 4th instar it enters the soil and pupates below the soil. The beetles emerged after 8-10 days and completed their life cycle in 25 to 28 days. Both adults and larvae are damaging stages and are capable of feeding on the parthenium leaves (Singh *et al.,* 2017).

Adults of *Z. bicolorata* burrow the soil and entered into diapause from period of July-Dec and emerge in May-June when rain commences. *Zygogramma. bicolorata* has peculiarity in their feeding behavior which makes it an efficient biological control agent (BCA). Firstly, it defoliates parthenium plants in a particular area and then migrates and feed on plants of new area. As a result, beetles can control parthenium weed over large area. Secondly, since diapause takes place throughout the breeding season some diapausing adults are left behind at each location where newly emerged beetle tackle the recurrent growth of the weed during the following year. It eliminates the necessity of reintroduction of the beetle in the area where it was once introduced. It is not clear what triggers diapause behaviour in *Z. bicolorata*, because it also entered in diapause stage even when abundant food was available and weather conditions was favourable. But diapause can be broken by continuously exposing adults to temperatures of 30°C, 35°C and 40°C for 22 days, nine days and 10 hours, respectively during February-March (Jayanth and Bali, 1993).

Although this beetle proved as promising biological control agent resulting in up to 99.5% reduction in the parthenium weed density in Bangalore region (Jayanth and Visalakshy, 1996), soon after its introduction to India it started feeding on an important oilseed crop, sunflower *Helianthus annuus* (Sridhar, 1991). This report brought biocontrol programme to a halt. Jayanth *et al.,* (1998) then reported that this feeding was only due to falling of pollen of parthenium plant on sunflower crop. Pollen and flower of parthenium contain parthenin which is a phagostimulant specific only to *P. hysterophorus*. Adult beetle which regularly feed on parthenium crop is unable to oviposit on sunflower crop and also larva could not feed on sunflower because this parthenin content causes degeneration of ovaries in beetles. Further many host specificity tests have confirmed that *Z. bicolorata* is specialised to feed on parthenium rather than cultivated crops. Few reports of attack of beetle on other crops are also present but damage to those plants is negligible (Jayanth and Nagarkatti, 1987). Thus we can say that *Z. bicolorata* is most effective and promising BCA to eradicate *P. hysterophous* in India till now. In future more BCA should be imported to India in the line of Australia.

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A short essay on the wasp- *Delta* sp. nesting in Bangalore, India.

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Wasps are fascinating insects belonging to the order Hymenoptera, family Vespidae and sub family Eumeninae.Wasps belong to the same order of the bees and hence sometimes are mistaken for bees. As they have a narrow 'waist' they look like ants too.Wasps do look like bees and ants as they share a common ancestor.

Wasps are dreaded as they sting just like the worker bees. Unlike the bees that feed and collect nectar and pollen, wasps are carnivores and predatory insects. Adults help pollination by visiting flowers when they go looking for smaller insects

Potter wasp

Among the wasps the potter wasps or mason wasps are easily recognised as they build a beautifully designed home for themselves. Potter wasps have around 200 genera and contain a number of species. They exhibit a lot of morphological diversity. The ability to build a nest using existing cavities or finding secluded places like a letter box or a corner of a ventilator or window which is high is being smart. One wasp, *Delta* sp., an Old World species was spotted in my bathroom window. The body was black in colour, with a narrow waist and transparent wings. The wasp was found dead on the window sill and it was easy to collect the specimen.

The wasp nest was with mud, and was stuck tightly to the wooden frame and looked well-constructed. It had a number of cells. It was guarding its nest from intruders and would be agitated if disturbed. It collected some insects and would preserve it in the nest.

I acknowledge Dr Girish from ZSI who identified the genus. The occurrence of this wasp in an urban area like Bangalore, India seems interesting.

Webinar Reports

National Virtual Meeting on Biopesticides - Registration and Quality Assurance: Issues and Way forward held on 6 October 2020

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A national, virtual meeting on Biopesticides – Registration and Quality Assurance: Issues and Way Forward was organized on 6.10.2020 jointly by Entomology Society of India, Society for Biocontrol Advancement and ICAR–National Bureau of Agricultural Insect Resources, Bengaluru. Dr. N. Bakthavatsalam, Director, ICAR–National Bureau of Agricultural Insect Resources (NBAIR), Bengaluru welcomed the participants of the meeting and suggested that the deliberations of the day should aim at highlighting the issues related to registration and solutions to enable the farmers to reap thebenefits of cleaner and greener technologies. Dr. S. N. Puri, President of Entomological Society of India (ESI) lauded the joint efforts by ESI, SBA and ICAR–NBAIR and stressed that the biopesticides will surely help in doubling farmer incomes through reduction in input cost. In his remark, Dr. N. K. Krishnakumar, Vice President, ESI informed that this meeting would help to chalk out the points to be tabled before the policy makers and would greatly benefit the scientific community and farmers.

In the Inaugural Session Dr. S. K. Malhotra, Agriculture Commissioner, GOI flagged the issue of quality assurance and supply chain systems in biopesticide use and assured that necessary support would be extended to register many more promising products that are effective against crop pests.

Dr. Ashok Dalwai, IAS, Chief Executive Officer, National Rainfed Area Authority, GOI, New Delhi expressed that, such a meeting will help to draw the policy perspectives on biopesticide registrations. Dr Arabinda K. Padhee, IAS, Director, Country Relations and Business Affairs, ICRISAT, New Delhi spoke about the importance and scope of biopesticides. Dr. P.K. Chakrabarthy, Member, ASRB touched upon various issues related to biopesticide registrations. Though the use of biopesticides were low as compared to those of chemical

pesticides, he called upon scientist to take up location specific research so as to have local strains of bioagents that could perform better against target pests. He called upon the researchers to look into the issues related to biosafety of the biopesticides. He informed that, though *Trichoderma* is a widely used biocontrol agent against many fungal diseases; *T. reesei* and *T. longibrachiatum* behave as an opportunistic pathogen in immune compromised plants. In addition, the allergens in these microbial biopesticides have to be thoroughly studied prior to being used on a large scale. Pheromones are another range of products that are a vital tool for green pest management and the registration of pheromones for mating disruption techniques have be rationalized, he briefed.

Dr. T. P. Rajendran, Former ADG (PP) suggested that the Government should scrap registration of all those products which are more than 5 years old under 9 (3b) and for which application for their registration under section 9(3) even within the grace period was submitted be allowed by the CIB-RC. All the ICAR and CSIR institutions shall have the responsibility to provide the required data package too so as to get registration u/s 9(3) directly by their proposed clients / customers for taking up manufacture of their respective microbial biopesticide. The inaugural session ended with the vote of thanks proposed by Dr. V. V. Ramamurthy, Chief Editor, Indian Journal of Entomology (Entomological Society of India), New Delhi.

The first Technical session on Registration of biopesticides was chaired by Dr. T.P. Rajendran, former ADG, (PP), ICAR and co-Chaired by Dr.Y.P. Singh, ADG, (PP&BS), ICAR. The speakers in the session were Dr. S. N. Sushil, ICAR-IISR, Lucknow and Dr. John Peter, Varsha Biosciences Pvt. Ltd, Hyderabad. Dr. S. N. Sushil made a detailed presentation of the process involved in registration and highlighted on the data to be generated and the procedures for registration of biopesticides. Dr. John Peter presented the parameters and methods involved in generating toxicological data. Over-regulation of biopesticides registration process by following the items of essential requirement of data as for chemical pesticides resulted in large Section 9(3B) registrants who do not further apply for Section9(3) registration. CIB & RC may constitute an expert committee to review the fourteen guidelines in the light of the advancement of science in this field. There has been enormous earnestness from the genuine registrants to manufacture adequate quantity of microbial pesticides although Good Lab Practices (GLP) and Good Manufacturing Practices (GMP) would add on to the cost of the relevant microbial biopesticides.

The Chairman concluded that the session brought out discussions on the urgent need for reviewing and recasting the existing regulatory guidelines for registering biopesticides, especially the class of microbial biopesticide registration. There was also need by CIB-RC to hold hands with the researchers in NARS and ICAR systems to enable the discovery of new strains of biopesticides to be taken forward for development into appropriate formulations as well as for guiding them for registering these products through the clients /customers of these institutions to whom the entire technology including the much needed data package folders are transferred under appropriate Memorandum of Understanding bearing the responsibility for managing the quality of the products that are marketed.

The second session on quality assurance of biopesticides was chaired by Dr. R. J. Rabindra, and Co-Chaired by Dr. Chandish R. Ballal, former Directors, ICAR – NBAIR. The first speaker of the session was Dr. B. Ramanujam, former Principal Scientist (Plant Pathology), ICAR–NBAIR. He stressed on the emphasis to be laid for emergency registration for potential biocontrol agents for invasive pests. Strong sentiments were echoed on the need to provide appropriate refresher webinars for the national researchers on biopesticides formulations and packaging science by institutions such as Institute of Pesticides Formulation Technology - IPFT (Ministry of Chemicals and Petrochemicals), Gurugram (Haryana) and Indian Institute of Packaging, Mumbai respectively.

The second speaker of the session was Dr. H. B. Singh, Professor (Retd) BHU, Varanasi who delivered a talk on ‘Quality control of Biopesticides’. During his presentation, he mentioned that the national facilities of biopesticides testing laboratories of States and Union Territories should be strengthened with NABL accreditation. Currently the DNA fingerprinting of microbial isolates is done at ICAR-National Bureau of Agriculturally Important Microorganism (NBAIM), Mau. Considering the high volume of the samples being handled at NBAIM facilities at ICAR/CSIR/other institutes should be explored. There is a paucity of guidelines for consortia, nano-based bio pesticides and secondary metabolites. Guidelines on registration and production of secondary metabolite(s) based products from agriculturally important microorganism should also be developed. A surveillance mechanism is to be initiated to identify the manufacturers who do not follow the CIBRC guidelines on sustaining quality of their products.

In the concluding remarks the chair of the session expressed that the toxicity of *Pseudomonas aeruginosa* towards human should be relooked before its promotion as biopesticide. Techniques for genetic improvement of microbial bioagents using conventional approaches should also be developed. There is need for establishing GLP-GMP level of manufacturing facility with strong financial investment to improve the quality management of biopesticides. The Quality Council of India has standardized in-house quality review management (QRM) procedure that can be recommended to manufacturers through appropriate hand-holding by the research laboratories to make sure that continuing support with an eye on QRM is strongly operating in their technology for manufacture. The webinar expressed the sentiment of suggesting ICAR-NBAIM to publish on their website GLP / GMP guidelines for microbial pesticide manufacture including the procedure for effluent management.

The Panel Discussion – Plenary Session was chaired by Dr N.K. Krishnakumar, former DDG (HS), ICAR and Co-Chaired by Dr. Abraham Verghese, former Director, ICAR-NBAIR, Bengaluru and Dr. K. S. Mohan, Consultant, Rasi Seeds. Dr N. K. Krishnakumar invited the response of all participating researchers working in the field of biopesticides drawn from research institutes, scientific experts, academia and biopesticide industries.

Dr. B. Vasantharaj David suggested that GLP compliance certified CSIR-IITR, Lucknow, can take up the toxicological studies for ICAR and other govt. organizations involved in biopesticides development for registration. Manufacturing companies have a robust quality control system. Each batch has to be subjected to analysis and to maintain quality. He also urged that a protocol must be developed for the states and UTs to follow by ICAR / CSIR in consultation with CIB-RC.

Dr. T. M. Manjunath, Former Director, Monsanto Research Centre suggested that considering their host-specificity and inherent safety to non-target organisms and the environment, a simplified procedure for registration of microbial biopesticides should be evolved without compromising on the quality and safety parameters. Biopesticides should be treated altogether differently from synthetic chemical pesticides, especially with regard to toxicological data. On quality assurance, he informed that abiotic factors such as temperature and humidity play a very critical role in the performance of microbial biopesticides. Therefore, emphasis

should be laid on improving the efficacy of biopesticides, especially with regard to the temperature and humidity stress tolerance, Biotechnological options are to be explored in this context. He also mentioned that enhancing the shelf-life will go a long way in transportation and storage of biopesticides. This could be achieved only if professional packaging can supplement the efforts.

He also mentioned that sex pheromones are species specific and mostly gender specific. They have no adverse effect on other organisms and the environment. The quantity of pheromone used even for mating disruption is extremely miniscule, yet its registration under Section 9(3) seems to be irrelevant. This needs to be reviewed and a realistic pheromone blend quantity be prescribed so that this technology can see the lime light, for the management of pests such as pink bollworm which has been successfully demonstrated in other countries. An assurance of bio-efficacy based on quality and quantity of pheromone blend with exemplary shelf-life under field conditions could be the draft Guidance protocol from the Research institutions that can be notified by the central government for adoption by states and UTs.

Dr. Abraham Verghese, former Director, ICAR-NBAIR, Bengaluru suggested to set up more biopesticide production units to enhance the production of microbial biopesticides to cater the needs of the farmers.

Dr. Vimala Devi, Former, Principal Scientist, ICAR-IIOR, Hyderabad highlighted that CIB should draft guidelines for combination microbial pesticides. She suggested that the institutes licensing technologies pertaining to microbial pesticides should make it mandatory for licensees to get trained in production process and quality parameters testing. Dr. Chandish Ballal, former, Director, ICAR – NBAIR suggested that the need for recognizing more laboratories by CIBRC for the generation of DNA finger print besides NBAIM. She emphasized the need for admitting emergency registration without toxicological data to deal with invasive insect pests. Under prevailing legal framework for registration of biopesticides, the toxicology data package is elaborate and needs revision as expressed by other Panelists.She also opined that similar to the procedure adopter by US-EPA and other global regulatory systems, there could be a pre-submission meeting between the applicant and evaluators to sort out the deficiencies, if any in

the application, so that the applicants can correct those and then submit in order to avoid undue delay.

Dr A.K. Saxena, Director, NBAIM expressed the need for assuring infrastructure for quality management of microbial biopesticide formulations and on the need for additional research for developing standard formulation technologies and their packaging / transport / storage protocols.

Dr. N. Bakthavatsalam, Director, ICAR – NBAIR and Dr. Kesavan Subaharan, Principal Scientist, ICAR–NBAIR suggested that there is no need of regulating pheromone technology under the Insecticide Act, 1968. Instead suitable guidance document can be prepared by National Expert Committee on the Pheromone Quality Assurance and Technology Servicing (manufacture / packaging / transport and storage) to manufacturers and marketing entities. The Ministry of Agriculture and Farmers Welfare, Government of India could take initiative for this purpose and help States and UTs to provide a pragmatic IPM tool for their farmers.

Other Panelists, viz., Dr. K. S. Mohan, Consultant, Rasi Seeds, Dr. B. K.Pandey, ADG(Hort.),ICAR, New Delhi, Dr.Y.G.Prasad, Director, ATARI, Hyderabad, Dr.Sudha Mysore, CEO, Agri Innovate, New Delhi, Dr. M.S. Rao, former Principal Scientist, ICAR-IIHR, Bengaluru, Dr. M. Nagesh, Principal Scientist, ICAR – NBAIR , Bengaluru, Dr. R .D. Prasad, Principal Scientist ICAR-IIOR, Hyderabad, Dr. S. Balaji, Head (R & D), Coromandel International Ltd, Shri. Khandelwal, Khandelwal Group of Companies, Maharashtra, Dr. Dinesh Shetty, Ponalab, Bengaluru, Dr. Sridhar, Global consumers Products Pvt. Ltd, Pune, Dr. S. J. Rahman, Professor, PJTSAU, Hyderabad and Dr. Akshay Dwarkanath, Senior Principal Scientist, CSIR-IITR, Lucknow participated shared their views on the above matters as well as on the emphatic requirement for reviewing the regulatory process of biopesticides in the country.

The virtual meeting came to an end with vote of thanks proposed by Dr. G. Sivakumar, Secretary, Society for Biocontrol Advancement. Dr. A. N. Shylesha, Dr. G. Sivakumar, Dr. T. Venkatesan, Dr. KesavanSubaharan and Dr. M. Mohan were responsible as Organizing Secretaries for this National Virtual Meeting.

Entomology 2020: Beyond COVID-19

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Entomology-Hyderabad, a group of professionals, along with Professor Jayashankar Telangana State Agricultural University, Entomological Society of India, the Plant Protection Association of India and Agri Biotech Foundation organized a two-day webinar on "Entomology 2020: Beyond COVID-19" during 11-12 December 2020. This is in a sequel to Entomology 2018, organised by the same group.

Inaugurating the event with the keynote address, Dr. N. K. Krishnakumar, former DDG, ICAR, New Delhi, highlighted the importance of biodiversity as the foundation for sustainable development to meet the millennium goals. The role of Entomologists in this direction is more defined since COVID-19 pandemics and beyond, he added. Arthropod diversity, insect diversity, in particular, is the key factor in enriching soil health and providing ecosystem services that are vital for sustainable agriculture. Flagging key researchable issues, Dr. Krishnakumar noted that the role of symbiotic microflora in adaptation and evolution of whitefly biotypes need to be studied thoroughly and the role of honeydew excreted by homopteran sucking pests in attracting ants, fungal growth, and natural enemies need to be investigated. COVID-19 pandemic and subsequent lockdowns have paradoxically brought back clean air and biodiversity for a common man to feel and appreciate, he concluded.

Dr. Anathnarayanan Raman, Senior Scientist, CSIRO, and Adjunct Professor, Charles Stuart University, Australia, delivering his lead talk in the session on Ecological Entomology focused on gall forming insects and noted that the primary stimulus of gall induction is still not clearly understood. The primary stimuli for gall induction in plants by the gall forming insects are less likely to be hormones like IAA or kinins, as it was considered so far, but some of the high molecular weight proteins from either the salivary glands or accessory glands of the insects are more likely candidates. More studies are needed to understand this critical step.

Dr. M. Bheemanna, Dean Agriculture, University of Agricultural Sciences, Raichur, dealt with pesticide residues as the determinants of food quality, in his lead talk in the Toxicology

session. Though India is among those countries that use very low amounts of pesticides *per se*, our agricultural produce is highly contaminated with residues of these toxic chemicals that pose threat to the health of humans and livestock animals, besides being a major trade barrier. Random sampling and analysis have revealed about 2-3% of food items being contaminated with pesticides above permissible minimal residue limits. Educating farmers for the right use of pesticides, intensified monitoring with residue analysis and informing consumers about simple ways of reducing the risk are the ways forward, he emphasized.

Dr. Sudeshna Majumdar-Leighton, Professor of Botany, University of Delhi, spoke on the evolution of polyphagy in insects. Several insects have evolved to be polyphagous and can feed and survive on a wide range of plants belonging to different families. This ability stems from their counter evolution against a range of plant defense related chemicals. It is expressed as differential expression and expansion of several gene families like cytochrome P450 monooxygenases, glutathione S transferases, hydrolases, serine type endopeptidases and alike. The ability of insects to switch over to alternative lineages of serine proteases in response to plant protease inhibitors has rendered trypsin inhibitor genes as an untenable choice for developing transgenic crop plants. Monophagous insects are niche feeders and can overcome host-plant defense within their diet breadth and derive evolutionary benefits at a low fitness cost. Polyphagous insect, on the other hand, have very well developed physiological machinery to detoxify, degrade or sequester plant defense compounds. However, the adaptive response of insects to diets is plastic and influenced by the environment, she emphasized.

Dr. Jyothilakshmi V, staff scientist, National Institute on Plant Genome Research, New Delhi dealt with how plants perceive the threat of insect attack and respond. Insect herbivores are voracious feeders and damage plants more rapidly than any other biotic stress. So, plants not only have to recognize the herbivore attack rapidly but also respond quickly. Plants sense elicitors in the oral secretion of insects, that activates jasmonate mediated plant defense and plant secondary metabolite production. Early perception of insect herbivory, however, involves a rapid cytoplasmic Ca2+ elevation that activates downstream signaling pathways within minutes of insect attack. Recent studies on the Arabidopsis-Spodoptera system suggested a positive defense regulation role of one of the Cyclic Nucleotide Gated Channel (CNGC) family of genes -CNGC-19.

Other lead talks were by Dr. Gururaj Katti, Principal Scientist (Retd.) ICAR-IIRR, Hyderabad on recent advances in plant protection technologies for food crops. Research, regulations, and responsibilities are three wings of IPM that need to be strengthened to develop and provide effective and safe pest control products; regulate their quality at the point of sale and protect human health and the environment with safe application methods like those involving the drones, he opined. Further, multiple sources of information available to the farmers now on IPM practice are, at times, contradicting and confusing which needs to be avoided.

Dr. S.J. Rahman, Professor of Entomology, PJTSAU, Hyderabad spoke on issues relating to the biological control of crop pests. One of the major constraints in effective implementation of biological control of crop pests is non-availability of effective parasitoids for inundative releases for which the speaker suggested a solution to shift emphasis from mass production to production by masses – encouraging cottage industry for production of these agents. Awareness and conservation are the keys for effective biocontrol. In case of microbial bioagents, the need for genuine manufacturers with assured quality are essential.

Professor (Emeritus) TVK Singh, PJTSAU, Hyderabad, spoke on different methods for measurement of the impact of pesticides on the environment. Among a dozen or so methods available to quantify the impact of pesticides on the environment, Environment Impact Quotient (EIQ) proposed by Kovach *et al*., is the most accurate and widely adopted. It has three principal components covering farm worker, consumer and environment with equal weightage. Based on this quotient, EIQ Field Use Rating can be computed for different situations.

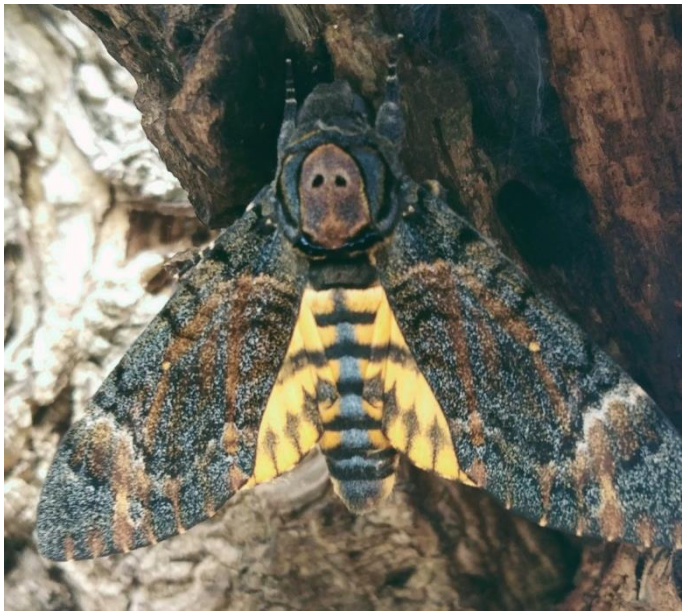
Dr. Chitra Shanker, Principal Scientist, ICAR-IIRR, Hyderabad, spoke on novel strategies of biological pest management based on the recent advancements in understanding communications between the plants and insects. Herbivory induced plant volatiles (HIPV) are part of the plant defense system that act indirectly by attracting the natural enemies of the herbivore. Recent studies have shown that HIPV can be used to develop novel biocontrol strategies of pest management she suggested.

In a special talk, Dr. Mohan K.S. Biotech Consultant, Bangalore, gave an account of the recently introduced 'Refuge In Bag' regulation for growers of Bt Cotton and its possible impact on the sustainability of cotton Bt technology in India.

There was a special panel discussion on day 2 on 'Role of Public Private Partnership in crop protection during Post-COVID era'. Panelists Drs. Pradeep Kulkarni (Adama India), G. Pampapati (Corteva Agriscience), John Peter (Varsha Bioscience) and M. Lakshminarayana (AG Biosystems) highlighted the role of the private sector in facing the recent threat of locust swarms and expressed their concern about the pending Pesticide Management Bill and summary banning of several generic pesticides in one go.

The webinar organized into eight technical sessions had eight oral presentations and 26 posters that were also presented orally. Besides, a photo competition was also held on the occasion. During the concluding sessions, awards were conferred for best presentations in different categories and best photographs. Life-Time Achievement Award was conferred on Dr. B. Vasanthraj David, former Chairman, International Institute of Biotechnology and Toxicology (IIBAT), Chennai. Dr. David participated in the event online and addressed the gathering.

Insect Lens



African Death's Head Hawkmoth, Acherontia styx
Author: Mr. Charles M., PGT-Zoology
Location: Puducherry
Email: mcharlesmsc@gmail.com

Prey (mealybug) - Predator (Apefly, Spalgis epius)-Protector (ant-Technomyrmex albipes)
Author: Mary Robert and Robert
Place: Hormavu, Bengaluru
Email ID: maryrobertssjc@gmail.com

Aphis craccivora (viviparous giving birth to young ones by parthenogenesis)
Author: Kishore Chandra Sahoo
Location: Tigiria, Cuttack, Odisha
Email: kcsahoo1996@gmail.com

Top: ***Naturally laid Pseudomallada astur egg (Green colour), predator of Rugose Spiralling Whitefly;*** *and below* ***that fungal infected eggs (black colour)***

Author: Viswanadha Raghuteja Puvvala

Location: SKPP Horticultural Polytechnic College, Ramachandrapuram, East Godavari District, Andhra Pradesh, India. EMail: Viswanadharaghuteja@gmail.com

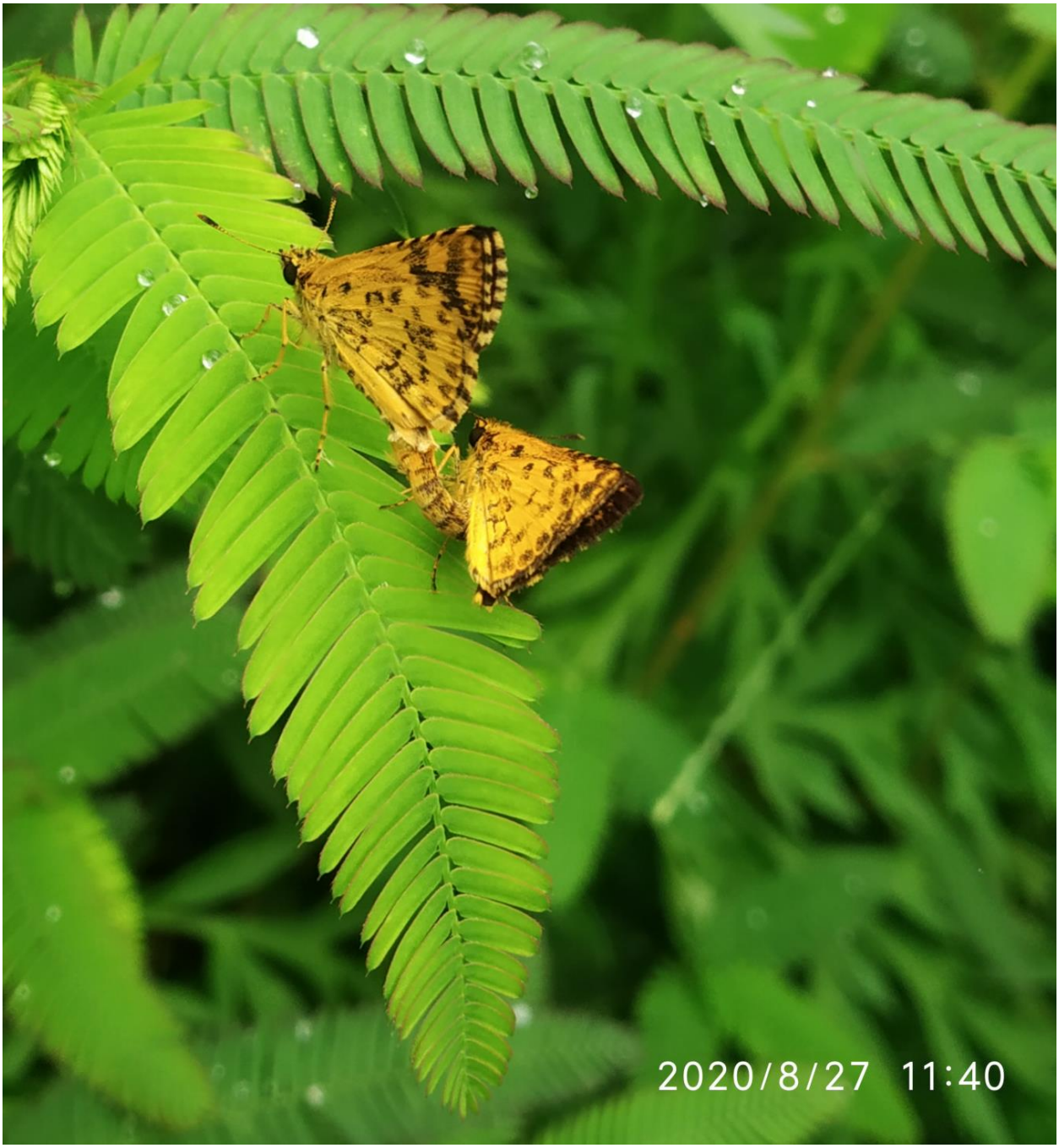
Sphaeroderma testaceum
Author: Subhadarsini Sahoo
Place: Sailang, Kendujhar, Odisha
Email: sahoo1subha1@gmail.co

Pachliopta hector

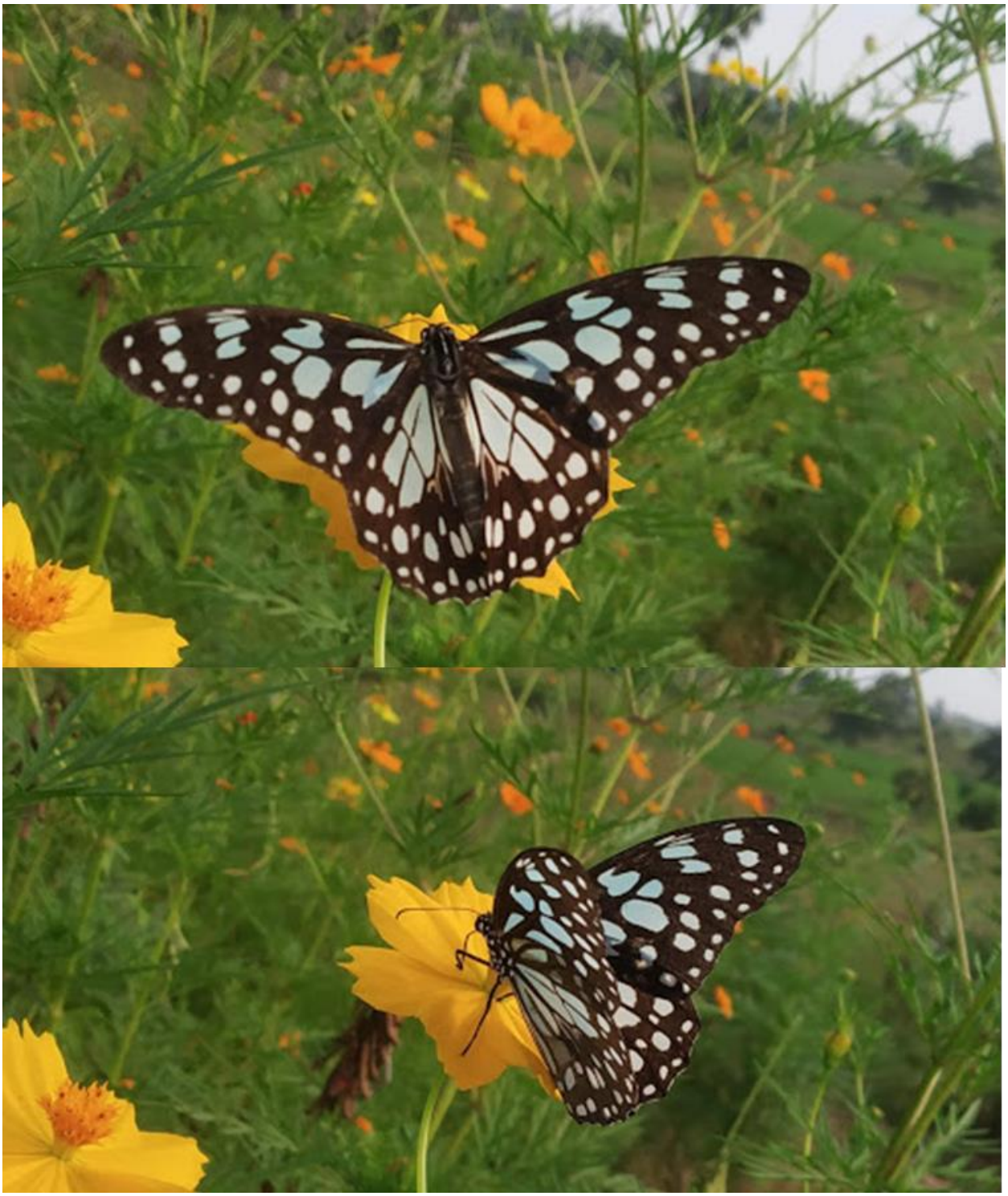
Author: Subhadarsini Sahoo
Place: Sailang, Kendujhar, Odisha
Email: sahoo1subha1@gmail.com

Neurothemis tullia *(the pied paddy skimmer)*

Author: Subhadarsini Sahoo
Place: Sailang, Kendujhar, Odisha
Email: sahoo1subha1@gmail.com



Ampittia dioscorides (Mating pair)
Author: Subhadarsini Sahoo
Place: Sailang, Kendujhar, Odisha
Email: sahoo1subha1@gmail.com



Tirumala limniace (Blue tiger)
Author: Subhadarsini Sahoo
Place: Sailang, Kendujhar, Odisha
Email: sahoo1subha1@gmail.com

Wandering Glider, The Globe Skimmer, Globe Wanderer, Pantala flavescens
Author: Ms. Sony Samuel
Place: R.T Nagar Bangalore
Email: sonysamuel19@gmail.com

Tawny coster, nymphalid, Acraea terpsicore
Location: Hire koralahalli, Taluk-Shikaripura, District- Shivamogga
Author: Meghana Prabhukumar
Email: meghana.prabhukumar@gmail.com

Indian Common Silverline, Spindasis vulcanus vulcanus (Fabricius)
Author: Sankarganesh E
Location: Mettu Sulagarai Vlg., Krishnagiri Dt., Tamil Nadu in Turmeric Ecosystem
E-mail : ganeshento33@gmail.com

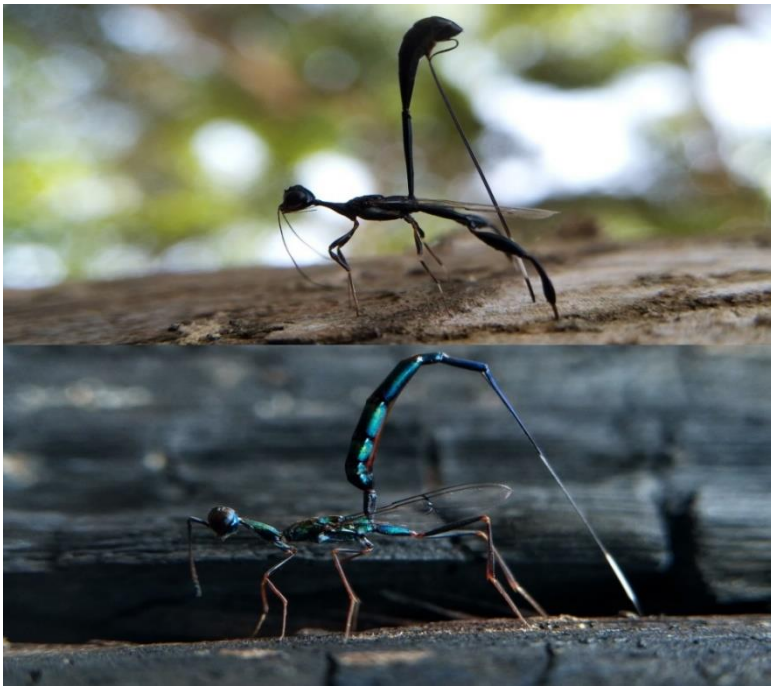
Boxer Mantis
Author: Sankarganesh E
Location: Mettu Sulagarai Vlg., Krishnagiri Dt., Tamil Nadu in Sorghum Field
E-mail :ganeshento33@gmail.com

Left

Eri silkmoth larvae
Author: M. Jayashankar
Place: Ganga Market, Itanagar, Arunachal Pradesh
Email:jay81zoology@gmail.com

Right

Spittle bug
Author: M. Jayashankar
Location: Senki Valley, Itanagar, Arunachal Pradesh
Email:jay81zoology@gmail.com



Crown Wasps
Author: Hemanth Kumar H M
Location: Belur, Karnataka.
Email: arjunkunungo@gmail.com

Vespa orientalis
Author: Mahendra Devanda
Location: Abu Road, Sirohi, Rajasthan
Email: msdewanda2@gmail.com

Ootheca of Preying mantis
Location: Hire Koralahalli, Taluk-Shikaripura, District- Shivamogga
Author: Meghana Prabhukumar ,M. Tech
Email: meghana.prabhukumar@gmail.com

Editorial Team thank the awarders

1. **Dr. Abraham Verghese,** was conferred **Rao Bahadur, Y.Ramachandra Rao Memorial Award for commendable contribution to eco-physiological and ethological research** by Dr. B. Vasantharaj David foundation, Chennai.

2. **Dr. Kolla Sreedevi,** SBA- Dr. Nagaraja Memorial Award for **Outstanding contribution to Insect Systematics (Including mites and Spiders)** by Society for Biocontrol Advancement

3. **Dr. Rashmi, M.A,** Agricultural & Environmental Technology Development Society, Uttarakhand conferred **Young Entomologist Award-2020** and Dr. B. Vasantharaj David foundation, Chennai conferred **Young Scientist Award- 2020 for her commendable contribution to Agricultural Entomology with emphasis on Bioecology of mango fruitfly**.

4. **Dr. Devi Thangam,** Dr. B. Vasantharaj David foundation, Chennai conferred **Biodiversity Conservation Award -2020 for her contribution to Biodiversity Studies in Insects**

Profile

Woman entomologist turns an entrepreneur

Dr. Anitta Mohandas MSc, MPhil, PhD is Managing Director, Bee Global, Bangalore, India, producers of quality organic processed honey and beehive products like bee pollen, royal jelly, propolis and beeswax. She is also Chairperson & Managing Trustee, Global Scientific Research Foundation Bangalore, India, a NGO involved in Scientific Beekeeping Training for Biodiversity Conservation and Extension activities.

After a post-doctoral Fulbright Environment Leadership Program Fellow 2011-2012 at the University of Montana, Missoula, Montana, USA on "Honeybee Health Management for Sustainable Beekeeping- Experience in the US and its Relevance to India" Dr Anitta has started her own venture in organic honey processing. She is a Honorary Member - Editorial Board - IJBST -International Journal of Biosciences and Technology (www.ijbst.org (ISSN: 0974 – 3987), Editor of Asian Bee Journal, an International Bee Journal of Asian Apicultural, Association, Tamagawa University, Japan, a Member of Editorial Board of Saudi Journal of Biological Sciences, College of Science, Saudi Biological Society, King Saud University, Riyadh, Saudi Arabia and a Member of Executive Council, The International Journal of Plant Reproductive Biology - Published by The Society of Plant Reproductive Biologists, Agra, India.

Her professional affiliations include: Member-International Federation of Beekeepers' Associations (APIMONDIA) Rome, Italy; Member, Asian Apicultural Association, Japan; Life Member of International Union for the study of Social Insects (IUSSI) Indian Chapter, Bangalore. A Member of Society of Life Sciences; Member, Ethological Society of India.; Member Bangalore Beekeeper's Association,; Member, Deccan Environmental Research Organization.

She has been awarded the **Eva Crane Lifetime Achievement Award for Beekeeping Development at the** 2nd International Beekeeping Congress-2008 and Ministry of Agriculture, Royal Govt. of Bhutan, Thimpu, Bhutan

Dr Anitta has headed many research schemes:

- **Principal Investigator** of the Research project**, "Enhancing agricultural productivity through increased bee visitation"** – Project sanctioned by the Directorate of Science and Technology, KVIC, Govt. of India, Mumbai. India. (2004) (INR 0.39 million)

- **Principal Investigator of** the Research Project entitled, **"Use of bee Attractants for increasing flower attractiveness for enhancing crop productivity"–**Project sanctioned by Department of Science and Technology, Govt of India, New Delhi.(2008) (INR 1.57 million)

- **Principal Investigator of** the Research project entitled **"Beekeeping and honey production for food, nutrition and income generation activity for SC/ST population in selected districts of Karnataka"** - Major project sanctioned by Department of Biotechnology, Ministry of Science and Technology, Government of India, New Delhi. (2009) (INR 1.6 million)

- **Co-Investigator** of the Research project entitled, All India Coordinated Research Programme (AICRP) on **"Reproductive Biology of RET tree species in Western Ghats for their conservation and sustainable utilization"** Sanctioned by the Ministry of Environment and Forests, Government of India, New Delhi, (2010) (INR4.0 million)

She is widely travelled in connection with apiculture; some of which are:

- Sponsored as an International delegate by the Commonwealth Forestry Association, UK to attend and present a paper during the **Fifteenth Commonwealth Forestry Conference, May 12-17, 1997, in Victoria Falls, Zimbabwe.**

- Sponsored as an International delegate by the Asian Apicultural Association, Japan to attend the **Seventh IBRA Conference on Tropical bees and Fifth Asian Apicultural Association Conference, March 19-25, 2000, Chiang Mai, Thailand**

This profile is to show how a highly qualified and trained professional lady entomologist and scientist can be a successful, self employed entrepreneur.

IE editorial team with inputs given by Dr Anitta M

Obituary

Dr. Kamalakar Gopal Phadke popularly known as *Dr. KG Phadke saab* was an Oilseed Entomologist who worked on the bio-ecology and management of pests of rapeseed and mustard group of oilseed species at the Entomology Division of the Indian Agriculture Research Institute (IARI), New Delhi.

Born on the 30th of November 1934 in Gwalior, Madhya Pradesh, he left to heavenly abode on 22nd December 2020 – at the age of 86 in Phoenix, Arizona, USA. He is survived by Ms. Kalpana, his younger son, Shri Narendra Phadke (Houston, USA) and two grandchildren. His wife, Mrs Kamalatai Phadke a Sanskrit teacher served at the Springdale School, New Delhi.

Dr. Phadke completed his Masters Degree in Zoology from Vikram University, Gwalior and received doctoral degree from IARI in 1974 with a Gold Medal.

His illustrious research career commenced in 1959 as a Beekeeping Research Scientist at IARI regional Station, Pusa, Bihar. He worked on the ecology of honey bees in enhancing crop pollination and productivity and was also associated with AICRP on honey bees. He moved to the Entomology Division, IARI in 1969 as a S-3 Scientist. His research career flourished with 70 research papers, guiding eight Doctoral scholars and one Masters. He focussed on resistance of wheat to stored grain pests, insect ecology, pest management in rapeseed, mustard crop and pest forewarning and forecasting tools.

I had the good fortune to be his penultimate doctoral student between 1986-1989, while I was working on the ecology of mustard aphids. He was an affable person with an evergreen smile endearing to everybody and making himself friendly especially with colleagues and research scholars, equally well. His first MSc student, Dr Yugal Kishore used to elaborate to me about Dr Phadke's insights in insect ecology. Dr Subhash Chander Thakur, Director, National Research Centre for Integrated Pest management, New Delhi was his last student who had done

both MSc and Ph.D under Phadke saab while specialising in pest forewarning and forecasting techniques.

I join many other Entomologists in praying for eternal peace to the departed soul and for strength and patience to the bereaved family to bear this great loss.

(Photo: Courtesy Dr. A. V. Moharir, Former Professor, Agriculture Physics, IARI).

Dr. T.P. Rajendran

Formerly ADG (PP), ICAR

OSD-Director, ICAR-National Institute for Biotic Stress Management, Raipur (CG)

Project Coordinator, ICAR-All India Coordinated Research Project for COTTON

IE in remembrance of an eminent entomologist

Dr. B R. Subba Rao

(25 August 1925 – 29 November 2020)

IE Editor-in-Chief, Former Director, ICAR-NBAIR felicitated Dr. B.R. Subba Rao for his significant contributions in the field of insect taxonomy in 2015

IE Editor-in-Chief, Former Director, ICAR-NBAIR speaking about the contributions of Dr. B. R. Subba Rao (first from the left); in the center is Dr G K Veeresh [2015] Picture courtesy, nbair.res.in


Watching
Insects
DR. ABRAHAM VERGHESE
Watching Insects
DR. ABRAHAM VERGHESE
One of the pleasures of watching nature is getting to know the various life forms that exist around us. The best way of appreciating the natural history is to watch the most abundant of creatures in the environment and to this category belongs insects which consist of almost two-thirds of all moving animals. Many of them occur very proximal to us enabling closer observation and recording. Barring the exceptions like mosquitoes, flies, cockroaches, bed bugs, head lice and fleas a vast majority of insects are either useful or interesting. Insects are so intertwined with plants, soil and other animals in a habitat that watching insects leads us to the entire gamut of life in nature. So, watching insects takes a person very close to nature. This book is written with as minimum jargon as possible, to introduce readers to the world of insects especially students and lay public. However, to avoid certain technical terms is difficult and therefore this may pop up here and there. But a single reading through the book will certainly show how varied insects are and this variation by itself should be a stimulation to go out into nature and watch these creatures. A simple hand lens, pen and pad are all that one requires to watch and record insects.
So, Happy Insect-Watching...
About the Author
Dr. Abraham Verghese, has been an entomologist for the last 35 years in ICAR. He has primarily worked in fruit entomology, developing economically and ecologically viable management strategies for all the major pests of mango, grapes, acid lime, pomegranate, jackfruit, anona etc both in north (from CISH, Lucknow) and south India (from Indian Institute of Horticultural Research, Bangalore). In early 2013 he took over as the Director of the National Bureau of Agriculturally Important Insects, Bangalore and is administering research on Biosystematics, Biocontrol, Bioinformatics and Barcoding of insects.
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