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Insect Environment

(Quarterly journal to popularize insect study and conservation)

ISSN 0975-1963

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

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

Author guidelines

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

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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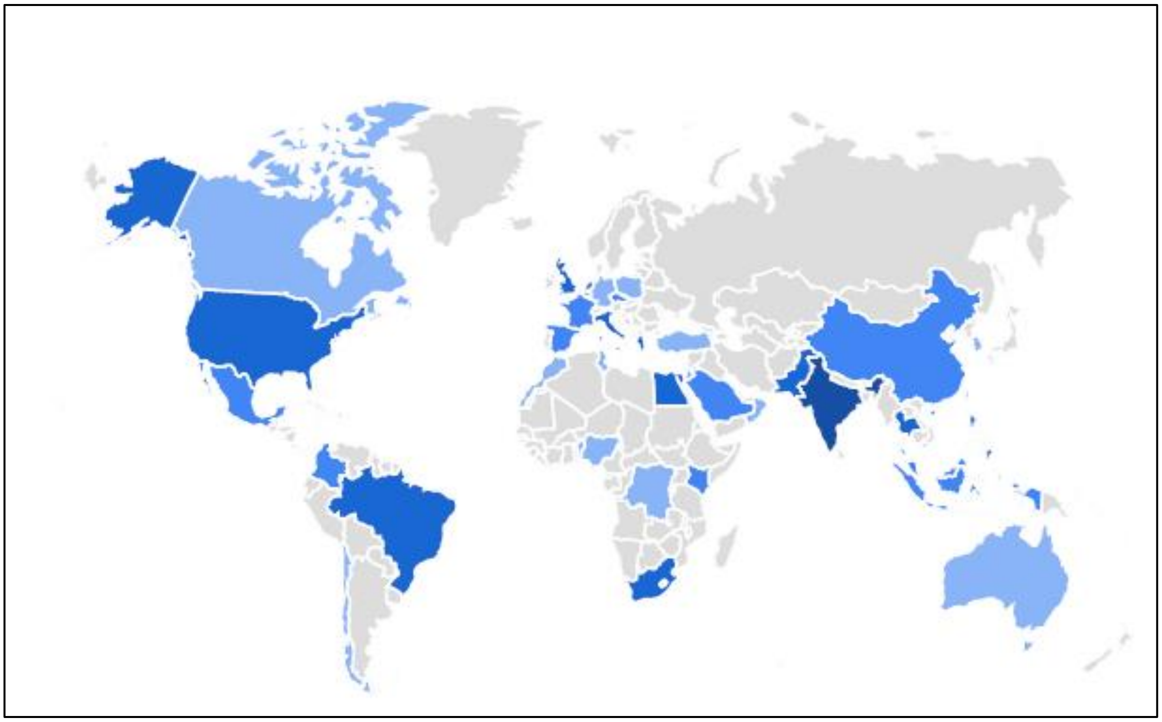

*** Spread of IE website visitors as of 23 June, 2021**

Editorial

Pantomime: The mask effect!

Pan-pandemic pandemonium has seen a wave of bedlam across the globe like horrendous waves of the oceans. The waves were tsunamic in scale indeed, and stalled every routine- mundane or otherwise. As I write this, limited travel and businesses have begun. As we breathe a partial respite, there's news of another wave! Talking of waves, the media have umpteen stories on waves, mutants, variants, vax types, oxygen concentrators, black fungus (this never made much news in the first wave) intervals between vax-doses etc. The year is now filled with newer normal that man is adapting to lifestyles that makes him look queerer (with a mask and a vizor). Have you ever wondered what our animalia- dogs and cats, donkeys and goats think of our looks? That's if they've ever thought of our looks before! Strange bedlam indeed! The mask effect has seen less talk and more pantomime!

The first quarter of the year 2021 seemed like a roll back to normal. Entomologists were on expeditions, seminars with physical participation seemed restorative, award functions begin to chime, farmers' fares and exhibitions were being held and calls for interviews, board exams etc. began to revive. It seemed like weaning and quits from on-lines. Alas, these were ephemeral joys. We were all told of an imminent lockdown and advisory for restricted movements were sounded. All of us retracted to our homes and were pinned down to our systems much like the pinned insects in our museums. Amidst such gory scenario, our entomology authors have done well. We kept receiving very interesting notes and blogs and we had to say 'no' to a few decrepit articles which had no updated currency. We however, appreciate essays on modern themes though especially from students as IE is a builder and encourager of, young insect-friends and authors.

We are not as finicky as certain 'dollar' (corporate) journals. While we eye for originality and truth we do not pretend to be fastidious peer-reviewers! We firmly believe all peers are not 'experts of all' and many may not accept an out-of-the-box revelation or idea. We do not always swing with peer contention but look beyond at the substance in the articles. Therefore, our reviewers (who also double-in as mentors) are carefully selected top-notch entomologists with an eye for the natural history and the unusual. And, isn't the insect world always throwing up the unusual or the less obvious? And isn't IE capturing them all?

While insects as food is gaining much ground in the West and South East Asia, isn't it interesting to know that at least in some parts of India insects are a delicacy. So look out for the article by Dr. Badal Bhattacharyya in this issue.

Diet patterns in many insects are changing and are becoming more and more obvious. When I was a B. Sc Agri graduate student, I was taught that the tea mosquito bug *Helopeltis* spp. was a pest on tea. Then, we learnt it would come also on cashew and guava and now I see that it is a grave pest on cocoa and drumstick. Now in this issue you will read Dr. Srikumar's article with many more host records from Indonesia. The little bug is becoming a poly host creature and we are glad we are capturing the host ramifications of *Helopeltis* spp in this issue for you. Incidentally there are more than a dozen *Helopeltis* spp in the Oriental alone.

I am sure many entomologists are seized with the news that has been in the air, of the decline of insect numbers. This is not of species extinction but a dwindling of numbers spatially and temporally. Funny as it seems, man blames man- destruction of habitats, forests, air pollution, agri-expansion and one group thumbs all these up to account for conservation failures and faunistic declines. Even more funny is school students holding placards that depict clichés like 'conserve nature' 'protect environment' etc. and sloganeering on roads or standing on pavements in the hot sun. For to who are these messages meant to be? Well, as someone put it, it makes no harm to make some noise. Yes, indeed, but the point we are making is, that measures being taken by the Government are in consonance with conservation. These must be appreciated and taught to children and entomologists. Most of us know for example, how difficult it is to set up an innocuous malaise trap in a conserved sanctuary. Then the Government much against industrial lobby has been banning several pesticides that are harmful to bees, butterflies and even birds. 70% of India's agriculture has no access to fertilizers and pesticides. Yes 70% are nearly organic. All these should augur well in insect conservation. So in my opinion man and Government cannot always be entirely blamed!

Contextually, I relate an interesting insect decline story here. Elizabeth Pennisi writing for *Science* (4 May 2021) highlights about ALAN- artificial light at night. Lights on bridges close to rivers and water bodies attract emerging short-lived adults of mayflies which even before ensuring next generation (its progeny) are killed. Should we then have these lights? Come to think of it, the same must be happening in our urban, peri-urban and rural environs. Electrification is certainly a symbol of progress but may be a death knell to many insects. ALAN effect is yet to be properly documented in Asia. In this issue there is an interesting article by Rakesh Das on decline of bees foraging on sweetmeats- they get stuck or swatted!

Insect taxonomy is complete only when integrated with natural history- the biosystematics- which brings in a lot of life into Entomology. Should issues on economical or ecological arise, conferring with taxonomists is highly essential. The best model to emulate would be the ICAR- National Bureau of Agricultural Insect Resources where biosystematics, biotechnology, bioecology and biocontrol all converge. In the last issue, the article on *Thrips occidentalis* by R. R. Rachna was appreciated by many for it breathed economic entomology through the lens and pen of a Thysanopteran taxonomist. In this issue there is another very interesting and similar article by S. Salini *et al* on Scutellarids. We have also our editorial advisor, Dr Romeno Faleiro, FAO expert, turning on his experience on economic insect study in a special editorial.

From litter to light- that's how the nuisance beetle has been storming into homes in Kerala. Read this interesting article by Dr Sabu Thomas. In spite of his busy schedule as the Principal of St Josephs College, Calicut, he took time off to wrie for IE.

Documenting diversity is crucial as indicated by S N Pawara *et al* on hawkmoths in Maharashtra and diversity studies by Devi Thangam and her students in Bangalore.

Insect Environment celebrated World Bee Day on 20th May, World Biodiversity Day on 22nd May and World Environment Day on 5th June through posters and virtual presentations. These prompted many students to send small notes and poems to us. We would advise students to get their write-ups vetted by their teachers mainly for authenticity and clarity. Our team will support with grammar and prose logistics; one such we publish in this issue. I am sure you will be touched by an undergraduate student, Pooja's article, "I am a bee." The IE team also extends free support to undergraduate students in learning Entomology. In this issue we feature such an endeavour at St Joseph's College, Bangalore.

Small is big. Insignificant is significant. There are always 'betweens' between two research lines. These hold well in biological research too. Insect Environment would like to capture these smalls, insignificants and 'betweens'!

Many novel and crazy ideas that spark '*eureka*' responses are not peer accepted! But at IE we nurture them. Of course we look into the research validity, photographs, and correctness of scientific names etc. Today's odd behaviour and uncommon events on insects may evolve to tomorrow's common behaviour. It is important we watch insects and document the segmental natural history however small.

In this issue we publish an article on insectivorous birds including an omnivore, the common crow *Corvus splendens* which is a plough/tractor-follower, devouring grubs raked up in the soil. In cities it seems to be declining, at least in urban Bangalore, an IT and BT hub in south India. The early morning deafening *caws* by flocks of crows flying from their roost sites are not heard much in cities these days. Certainly this is a matter for ornithologist and economic entomologists to investigate.

Lockdown had slowed down our team for most of April. Our teams are still on physical restrictions and movements. Hope things will open up. It is our endeavour to release this issue of June 2021 on schedule by 30th June.

WFH- writing from home: Authors (and Lens contributors) of IE run this journal. Therefore, we consider IE as an *atmanirbhar* initiative by Indian entomologists for global entomology. I compliment our photographers; your pictures make insect science pleasing as well as making pictorial documention of species in different geographical locations. In the years to come these photographs will have lots of ecological, biodiversitical and conservational values.

We stand by our objective to popularise insect science through information dissemination. Our blogs (indexed in this issue) are highly informative and popular.

Do go to our website and re-browse them! You can contribute to our blogs for that super speed publication –all within a week. Blogs should be about 150 words, one relevant photograph, catchy title, worthy of popular lay reading too.

We are too delighted to put a cover picture of the snout syrphid sent by Dr Sevgan Subramanian from Kenya. We profusely thank him and look forward to more! Our special thanks to Dr D N Nagraj whose pictures we've been using liberally on the cover for the past issues. Photographs are mini 'papers' that speak volumes of the insect, enveloped in aesthetics, as a bonus. IE therefore promotes them.

Our special welcome to Dr Badal Bhattacharyya and Dr. M. Jayashankar to the editorial team. Both are active biologists, writers and conservationists.

Be safe!

Dr. Abraham Verghese

Editor-in-Chief

Special Editorial

Insect Environment: In Service to the Plant Health Community

Insect Environment is a unique Journal covering diverse aspects of insect science in a distinctive style where the focus is delivering the most through short, crisp and informative articles. I feel honored to pen this editorial for this issue of Insect Environment at a time when invasive insect species are being widely reported from diverse agro-ecosystems in India and the world over. Climate change due to global warming coupled with intensive farming practices that often rely on monoculture cropping systems along with rapid modern transportation means is impacting flora and fauna the world over at a pace like never before. This, combined with the current pandemic of Covid-19 has made insect pest control a challenging task. The red palm weevil *Rhynchophorus ferrugineus* (Olivier) is a classical example as how a pest with its home in South Asia on coconut has rapidly spread its geographical and host range since the mid-1980s and adapted to palm based agro-ecosystems in the Middle-East, North Africa, Europe and Latin America, leading to wide spread damage to date palm and the Canary Island palm. The pandemic has only worsened local and global efforts to control this pest.

National, regional and international plant protection organizations are faced with difficult task of dealing with evolving pest problems, which is compounded in these difficult times of the pandemic. Under the present circumstances where lockdowns and restrictions on travel are becoming common, local capacities both in terms of human and material resources need to be strengthened and augmented to enable appropriate delivery of desired IPM practices. Information technology is another vital link in the chain of effective management of the pandemic and also in dealing with growing pest problems. Thanks to the global web, sharing of information through webinars, e-journals and other digital resources is the norm of the day.

In these challenging times it is heartening and refreshing to see Insect Environment making an impressive comeback, providing all those interested in the study of insect science a platform to publish recent developments in the field of entomology, through popular and semi-technical research articles. The journal serves as a valuable document to teachers, farmers, students, researchers and policy makers.

Dr Jose Romeno Faleiro

FAO Expert (Red Palm Weevil)

Research Articles

New host plants for *Helopeltis theivora* and *Ragwelellus* sp. (Hemiptera: Miridae) in *Eucalyptus* plantations of Indonesia

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Abstract

Helopeltis theivora Waterhouse, 1886 and *Ragwelellus* sp. Odhiambo, 1962 (Hemiptera: Miridae) are polyphagous sucking insects identified as important pests of *Eucalyptus* L'Hér. (Myrtaceae) plantations in Indonesia. Damage signs and symptoms were determined and insects were sampled on seven species of plants in *Eucalyptus* plantations of which one constitute new plant associations for *H. theivora* and three for *Ragwelellus* sp. The plant species *Triadica cochinchinensis* Lour. (Euphorbiaceae) is for the first time mentioned as host plant infested by *H. theivora*. This is additionally a first documentation of host plants, *Mikania micrantha* Kunth (Asteraceae), *T. cochinchinensis* and *Melastoma malabathricum* L. (Melastomataceae) for *Ragwelellus* sp.

Keywords: hosts, *Eucalyptus* plantations, mirid bugs, polyphagous

Introduction

The genus *Helopeltis* Signoret, 1858 belongs to the tribe Dicyphini, that is prominent from other groups of Bryocorinae by way of the elongate, cylindrical body shape, the structure of the pretarsus, the reduced numbers of meso and metafemoral trichobothria, with strongly tuberculate bothria and vague trichomae, the metathoracic scent efferent system lacking developed ostiole and evaporative area on metaepisternum, and the eggs with respiratory horns (Schuh, 1976). *Helopeltis* is outstanding from other members of the tribe via the large, spine like process on the scutellum and by using traits of the male and female genitalia, mainly the structure of the genital chamber of the female (Stonedahl, 1991). Palaeotropical distribution of *Helopeltis* has been reported, extending from West Africa to New Guinea and northern Australia (Stonedahl, 1991).

Wide-ranging reviews (Schmitz, 1968: 1988; Stonedahl, 1991, Stonedahl *et al*., 1995; Sundararaju and Sundarababu, 1999) reported the occurrence of 41 recognized species of which 26 are restricted to Africa and 15 prevalent in Asia and Pacific region (Saroj *et al*., 2016). *Helopeltis* spp. has been recorded from a vast number of plants in the Oriental and Australasian Region (Stonedahl, 1991; Sundararaju and Sundarababu 1999). *Helopeltis* spp. are most serious pests of some of the economically important plants such as cashew tree (*Anacardium occidentale* L., Anacardiaceae), cocoa tree (*Theobroma cacao* L., Malvaceae), common guava (*Psidium guajava* L., Myrtaceae), tea plant (*Camellia sinensis* (L.) Kuntze, Theaceae), neem (*Azadirachta indica* A. Juss., Meliaceae), black pepper (*Piper nigrum* L., Piperaceae), and eucalyptus (*Eucalyptus* L'Hér. spp., Myrtaceae).

Ragwelellus Odhiambo, 1962 is similar to *Helopeltis* in structure, except for absence of a scutellar spine that is feature for both subgenera of *Helopeltis* (Namyatova and Cassis, 2013). Characterized by the spot of clavus and by the color of scutellum. Scutellum with general coloration shining reddish brown to purple with light yellow to lutescent areas: head dark brown with a light median spot, neck red laterally. *Ragwelellus* sp. and *Ragwelellus festivus* (Miller, 1954) are recorded as important pest of *Eucalyptus* plantations of Indonesia (Srikumar *et al*., 2020).

Materials and Methods

Surveys in *Eucalyptus* plantations in Riau Province, Sumatra, and East Kalimantan, Indonesia were carried out irregularly, from January 2018 to December 2020. Survey focused on plant species located in and around *Eucalyptus* plantations having the damage signs and symptoms and life stages (egg, nymph and adult) of mirids damaging *Eucalyptus* (*H. theivora* and *Ragwelellus* spp.). Sampled life stages of mirids were placed in 1 liter plastic containers and brought to the Entomology Laboratory of Riau Andalan Pulp and Paper (RAPP) in Pangkalan Kerinci, Riau, where they were kept at 26 ± 2 ºC, 75 ± 15% RH and 14:10 (L:D) h photoperiod.

Mirids have been identified based totally on morphology and genitalia examination (Stonedahl, 1991; Srikumar *et al*., 2020).

Flowered branches of alternate plant hosts were collected, placed in brown paper bags and taken to a laboratory of RAPP, where they were analyzed and identified.

Results and Discussion

Helopeltis theivora (Figure 1a) was documented related with four plant families (Asteraceae, Euphorbiaceae, Melastomataceae and Solanaceae). The plant species recorded were *Chromolaena odorata* (L.) R.M. King & H. Rob, *Mikania micrantha* Kunth (Asteraceae), *Macaranga peltata* (Roxb) Mueller, *Triadica cochinchinensis* Lour. (Euphorbiaceae), *Clidemia hirta* (L.) D. Don, *Melastoma malabathricum* L. (Melastomataceae) and *Solanum* L. sp. (Solanaceae) (Table 1 and Figure 2). These plant species are generally recorded as weeds in *Eucalyptus* plantations. It is noteworthy given than *T. cochinchinensis* is reported for the first time as host plant for *H. theivora*. Reported host plants for *H. theivora* are *C. sinensis* (Mann, 1902: 1907), *Cinchona* L. sp., *Mussaenda frondosa* L. (Rubiaceae), *Ochlandra travancorica* (Bedd.) Benth. ex Gamble (Poaceae), *P. guajava* and *Solanum* spp. (Anstead and Ballard, 1922); *Cinnamomum camphora* (L.) J. Presl. (Lauraceae), *Erythrina* L. sp., *Tephrosia* Pers. sp. (Fabaceae), *Melia azedarach* L. (Meliaceae), *Maesa* Forssk. sp. (Primulaceae), *Polygonum* L. sp. (Polygonaceae), jack (*Artocarpus heterophyllus* Lam.) (Moraceae), *Jasminum* L. sp. (Oleaceae), ornamental *Camellia* L. sp. (Theaceae), *Coffea* L. sp. (Rubiaceae), *Bidens pilosa* L. (Asteraceae), *Ipomoea batatas* (L.) Lam. (Convolvulaceae), *Mangifera* L. sp. (Anacardiaceae), *T. cacao* and *Passiflora* L. sp. (Passifloraceae) (Rao, 1970); *M. malabathricum*, *Maesa ramentacea* (Roxb.) A. DC., *Eurya acuminata* DC. (Pentaphylacaceae), *Jasminum scandens* (Retz.) Vahl. and *M. micrantha* (Das, 1984); *Similax* L. sp. (Smilacaceae) and *Phlogacanthus* Nees sp. (Acanthaceae) (Somchoudhury *et al*., 1993); *C. odorata* (Srikumar and Bhat, 2013); *Duranta repens* L. (Verbenaceae), *Phlogacanthus thyrsiflorus* (Roxb.) Nees, *Piper* L. sp. (Piperaceae), *Ficus* L. sp. (Moraceae), *Sida cordifolia* L. (Malvaceae), *Persea bombycina* King ex Hook. f. (Lauraceae), *Cannabis sativa* L. (Cannabaceae), *Ixora* L. sp. (Rubiaceae), *M. micrantha*, *Acalypha* L. sp. (Euphorbiaceae), *J. scandens*, *Oxalis acetosella* L. (Oxalidaceae), *E. acuminata*, *Morus* L. sp. (Moraceae), *Neolamarckia cadamba* (Roxb.) Bosser (Rubiaceae), *Syzygium cumini* (L.) Skeels.

(Myrtaceae), *Cordia dichotoma* G. Forst. (Boraginaceae) and *Hibiscus* L. sp. (Malvaceae) (Tocklai, 2010); *Acalypha wilkesiana* Müll. Arg., *Annona squamosa* L. (Annonaceae), *C. hirta*, *Cyclea* Arn. ex. Wight sp. (Menispermaceae), *Dioscorea* L. sp. (Dioscoreaceae), *Ludwigia peruviana* (L.) H. Hara (Onagraceae), *Malvaviscus* Fabr. sp. (Malvaceae), *Pentas lanceolata* (Forssk.) Deflers (Rubiaceae), and *Plectranthus amboinicus* Lour. (Lamiaceae) (Srikumar *et al*., 2016).

It is usually difficult to assess if a plant species in reality represents a host plant considering the complex courting among plants and mirids (Wheeler, 2001). Occasional occurrences of adults on various plants might constitute as site visitors or suggest that they use the plant as an opportunity feeding aid. For *H. theivora* the plants species such as *C. odorata*, *M. micrantha*, *T. cochinchinensis*, *C. hirta* and *M. malabathricum* can be considered as host plants because we consistently collected eggs and nymphs on these plants.

Table 1. Plant association of *Helopeltis theivora* and *Ragwelellus* sp. (Hemiptera: Miridae) in Indonesia

Family	Plant species	Mirid species recorded	Stages of pest recorded
Asteraceae	*Chromolaena odorata* (L.) R.M. King & H. Rob[a]	*H. theivora*	Eggs, nymphs and adults
	Mikania micrantha Kunth[a]	*H. theivora* and *Ragwelellus* sp.[A]	Eggs, nymphs and adults
	Macaranga peltata (Roxb.) Mueller	*H. theivora*	Adults
Euphorbiaceae	*Triadica cochinchinensis* Lour.	*H. theivora*[A] and *Ragwelellus* sp.[A]	Eggs, nymphs and adults
Melastomataceae	*Clidemia hirta* (L.) D. Don[a]	*H. theivora*	Eggs, nymphs and adults
	Melastoma malabathricum L. [a]	*H. theivora*[A] and *Ragwelellus* sp.[A]	Eggs, nymphs and adults
Solanaceae	*Solanum* sp.	*H. theivora*	Adults

Species with [a] indicates important weed plant in *Eucalyptus* plantations; species with [A] indicates new plant association for *H. theivora* and *Ragwelellus* sp.

Ragwelellus sp. (Figure 1b) was recorded from three families of plant species consisting of *M. micrantha*, *T. cochinchinesis* and *M. malabathricum*. All these plants were first time report for *Ragwelellus* sp. Host plant species mentioned for *Ragwelellus horvathi* (Poppius, 1912) is *Cinchona* sp. and cardamom (*Amomum* Roxb. sp., Zingiberaceae) from Papua New Guinea (Smith, 1977; Carvalho, 1981). The adults and nymphs feed on leaves of cardamom leaving clear empty cells between the veins inflicting excessive damage.

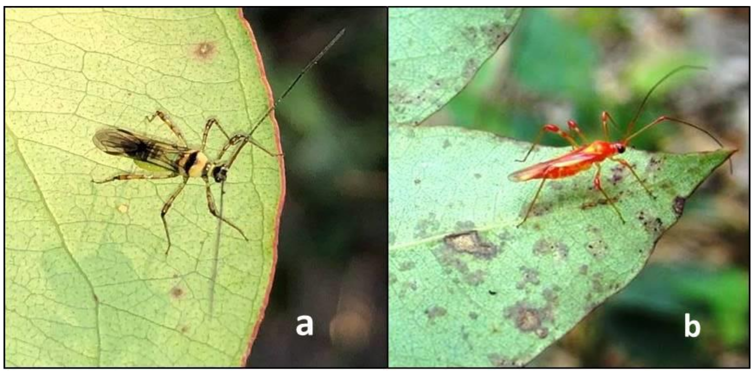

Figure 1. a. Adult of *Helopeltis theivora* and b. *Ragwelellus* sp. (Hemiptera: Miridae).

Figure 2. Plant species with damage symptoms of *Helopeltis theivora* and *Ragwelellus* sp. (Hemiptera: Miridae). a. *Mikania micrantha*, b. *Chromolaena odorata* (Asteraceae), c. *Melastoma malabathricum* (Melastomataceae), d. *Solanum* sp. (Solanaceae) e. *Triadica cochinchinensis*, f. *Macaranga peltata* (Euphorbiaceae) and g. *Clidemia hirta* (Melastomataceae) recorded in *Eucalyptus* (Myrtaceae) plantations.

Acknowledgments

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Conflict of interest

The authors declare that there is no conflict of interest

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Scutelleridae as potential pests of star gooseberry (*Phyllanthus acidus*) (L.) Skeels

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Abstract

Phyllanthus acidus (L.) Skeels, is one of the minor and underutilized fruit crops, was found infested by the scutellerid bugs, *Scutellera perplexa* (Westw.) and *Chrysocoris stockerus* (Linn.). Of these, *Chrysocoris stockerus* is recorded for the first time feeding on this crop. Both the species were morphologically characterized along with the description of male and female genitalia. Besides, a brief note on the nature of damage caused by these bugs is also given.

Key words: *Phyllanthus*, male and female genitalia, brown spots, *Chrysocoris*, *Scutellera*.

Introduction

Phyllanthus acidus (L.) Skeels, belonging to family Phyllanthaceae, is a small deciduous tree, known for its dense clusters of berries (Fig. 20) hanging from the branches. The berries are light green colored, smooth, juicy with a taste of sweet and sour ideal for pickling and many a times a dietary especially in villages of India. This is a minor fruit tree and act as a host for only a few insect pests like whiteflies, mealybugs and fruit flies (CABI, 2021).

Among the various insect pests reported, the scutellerid bug, *Scutellera perplexa* (Westwood) is an important pest, which was reported on *P. acidus* (reported as *Phyllanthus distichus* Hook. & Arn., a synonym of *Phyllanthus acidus*) by Kavadia *et al.*, 1971. These bugs are commonly called as jewel bugs and are known to feed on *Jatropha curcas* L. (Parveen *et al.*, 2010), *Buchanania cochinchinensis* (Lour.) M. R. Almeida (Onkar and Nerlekar, 2015), *Vitis vinifera* L. (Singh and Kaur, 2015) and *Ziziphus mauritiana* Lam. (Singh *et al.*, 2014). Besides, they are known as pests of several cultivated crops including horticultural crops and crops of industrial importance (Parveen, 2011). This paper deals with the taxonomy and nature of damage by *S. perplexa* and *C. stockerus* (Linn.) on Star gooseberry, (*P. acidus*). The latter is recorded as a pest of Star gooseberry for the first time from India.

Material and Methods

Star gooseberry grown in National Bureau of Agriultural Insect Resources Attur farm, Yelahanka, Bengaluru (13.1068° N, 77.5621° E) was surveyed for insect pests during August, 2020 to October, 2020. The pests were collected by using sweep net and killed using ethyl acetate. The pests were later brought to laboratory and sorted out for true bugs. The separated bugs were pinned through the scutellum at right of the median axis of body. The procedure to dissect the male and female genitalia was as detailed by Salini (2016). Photographs were made using Leica DFC 420 camera mounted on a Leica M205A sterozoom microscope and by using the software Automontage® (LAS). Photographs were edited using Adobe Photoshop CS (Version 8.0). The field images were taken using Canon EOS 77D DSLR camera. Terminology of general morphology, male and female genitalia follows Tsai *et al*. (2011) and those associated with metathoracic scent glands follow Kment & Vilímová (2010).

Specimens studied for this research work are deposited in the Indian Council of Agricultural Research- National Bureau of Agricultural Insect Resources (ICAR-NBAIR), Bangalore, Karnataka, India.

Taxonomy

Chrysocoris stockerus (Linnaeus)

Colouration: Metallic green bugs with (whole dorsum centrally with golden yellow sheen in freshly collected specimens) blue markings as follows: one central spot at head disc posteriorly, a row of three spots behind anterior pronotal margin, five on posterior pronotal disc (two each as one above the other on lateral side and one centrally), six on scutellum (three each in vertical rows laterally) and one narrow, longitudinal spot centrally on anterior half of scutellar disc. Antennae black except scape (I) (proximal half of scape ochraceous and distal half metallic green). Lateral margins of head, pronotum and hemelytra blue coloured. Ventral side of body metallic bluish green with pale markings as follows: basal margin of head on ventral side, all legs with proximal 3/4th femora, coxa, trochanter, acetabula, sublateral spots on either side of ventrite III and IV, central half of ventrite V and VI.

Structure: Head declivous, broader than long with mandibular plates a little shorter than clypeus; antennae with antennomere IIa much short and 1/5th of segment IIb; pronotum with anterolateral margins oblique and posterior margin straight; humeri not produced, subangular, base of scutellar disc with central region transversely gibbous; body glabrous; connexivum not exposed; bacculae shorter than labiomere I, labium reaching posterior margin of ventrite III; peritreme modified into peritremal disc, reaching middle of metapleuron; ventrites convex medially, smooth, lacking spine or tubercle or sulcus.

Male genitalia: Genital capsule subrectangular in dorso-posterior vew; dorsal rim (dr) emarginated and slightly concave at middle and ventral rim (vr) convex, 1+1 dorsal setal patches (dsp) laterally placed inner to dorsal rim, ventral setal patches (vsp) fused centrally. Paramere with stem (st) stout and columnar, neck distinct, crown (cr) finger-like with lateral flange bearing hairs. Phallus with phallotheca not sclerotized, three pairs of conjunctival processes, conjunctival process I (Cp-I) simple, sclerotized with apex hook-like, conjunctival process II (Cp-II) with apex membranous and the remaining parts sclerotized, conjunctival process III (Cp-III) rod-like, elongate, sclerotized except extreme base, acutely pointed at apex. Aedeagus with a dorso apical lump occupied by a voluminous inner chamber, aedeagus (ae) sharply narrowed towards apex and the distal apex pointed hook-like.

Female genitalia: Valvifers VIII (vf VIII) subtriangular, valvifers IX (vf IX) thin, transverse plate-like, shorter than laterotergite IX (lt IX), laterotergite VIII (lt VIII) fused along with tergite VIII along a transverse edge. Spermtheca with proximal and distal spermathecal duct short, proximal invagination much thicker than distal invagination, apical receptacle (ar) with proximal flange (pf) shorter than distal flange (df); apical receptacle (ar) elongate, basal half narrower than distal half and distal half globular.

***Scutellera perplexa* (Westwood)**

Colouration: Body above metallic green with bluish sheen, dorsum with markings as follows: disc of head with two thin, parallel, black longitudinal rows at middle, running from base to apex. Anterior 1/3rd of pronotal disc with 1+1 black markings, 1+1 small, sublateral spots at posterior half of pronotum, a central longitudinal line at pronotal disc black. Antennae black, lateral margins of pronotum and antero-lateral margins of hemelytra reddish orange. The thin, black line at the centre of scutellum gradually fading towards posterior end. A vertical row of three black spots on either side of the central longitudinal black line on scutellum. Ventral side orange red including legs and peritreme with the following markings: all tibiae and distal apex of all femora metallic green; all tarsi including claws black; labium mostly black. Ventral side of head, thoracic pleura and sterna, whole lateral region of whole ventrites from III–VII including spiracles metallic green with blue sheen.

Structure: Head nearly as long as wide, convex above, slightly declivous, mandibular plates a little shorter than clypeus and clypeus slightly prominent. Antennae five segmented with second segment shortest. Pronotum with anterolateral margins slightly sinuate at middle, disc of pronotum convex above, a transverse impression at anterior 1/3rd. Humeri not produced, subangular. Scutellum completely covering the abdomen till the posterior end with apex of membrane exposed. Body pilose. Connexivum not exposed. Ventral side of head with bucculae shorter than labiomere I; labium reaching middle of ventrite IV. Thoracic sterna centrally with longitudinal narrow groove. Peritreme modified into peritremal disc, nearly semicircular shaped, extending well beyond $2/3^{rd}$ of metapleuron width, but not reaching lateral margins of metapleuron. Abdomen centrally with narrow, longitudinal groove, gradually fading towards ventrite VII.

Male genitalia: Genital capsule subrectangular with 1+1 blunt lateral tubercles, ventral rim convex, medially flattened with 1+1 submedian denticles, dorsal rim deeply concave with dorsal setal patches bordering dorsal sinus. Paramere sclerotized, stem (st) elongate, columnar, neck absent, crown (cr) short, sickle shaped with a lateral flange bearing setae. Phallus with phallotheca stout, short and barrel-shaped, two pairs of conjunctival processes (Cp-II and Cp-III), symmetrical, Cp-II bipartite and sclerotized, Cp-II_1 lobe-like of lateral position, Cp-II_2 of sublateral position (enclosed by Cp-II_1) with a small, pointed tooth like heavily sclerotized apically, Cp-III heavily sclerotized and irregularly rod-like. Aedeagus (ae) sclerotized with apex truncate and bent upwards.

Female genitalia: Valvifers VIII (vf VIII) enlarged triangular plate-like sclerite with mesial and posterior margins straight. Valvifers IX (vf IX) fused and slightly sclerotized, with a median longitudinal keel. Laterotergite IX (lt IX) obliquely placed, laterotergite VIII (lt VIII) fused with tergite VIII to form a single sclerite. Spermatheca with proximal duct long, tubular and longer than distal duct, proximal (pf) and distal flange (df) nearly of equal size; apical receptacle (ar) elongate with distinct globose apex.

Nature of Damage: Both adults and nymphs of both of the above described species was found to be sucking the juice particularly from the berries. Though *Scutellera perplexa* (Westwood) had been reported to feed on *P. acidus*, *Chrysocoris stockerus* was found feeding on this crop for the first time. The bugs pierce the berries using their labium and the labrum acts as a supporting structure for sucking the juice (Figs. 22-27). Initial symptoms appear as small brown specks or pin hole like punctures on the surface of the berries which later enlarge in size along with the increase in size of the berry and appears as water soaked-sunken lesions (Figs. 28-30). Later on, these punctures serve as entry point for secondary infections like fungi and the lesion colour changes to black, which not only affects the aesthetic appearance, but also reduces the quality of the berries (Fig. 21). Moreover, the damage leads to berry drop. It was observed that >20 punctures made in a single berry when the population of bug was high. Severe shedding of berries was observed in gardens with high population of these bugs. These scutellerids can become a future threat to the production of this minor fruit crop and hence they are considered to be potential pests.

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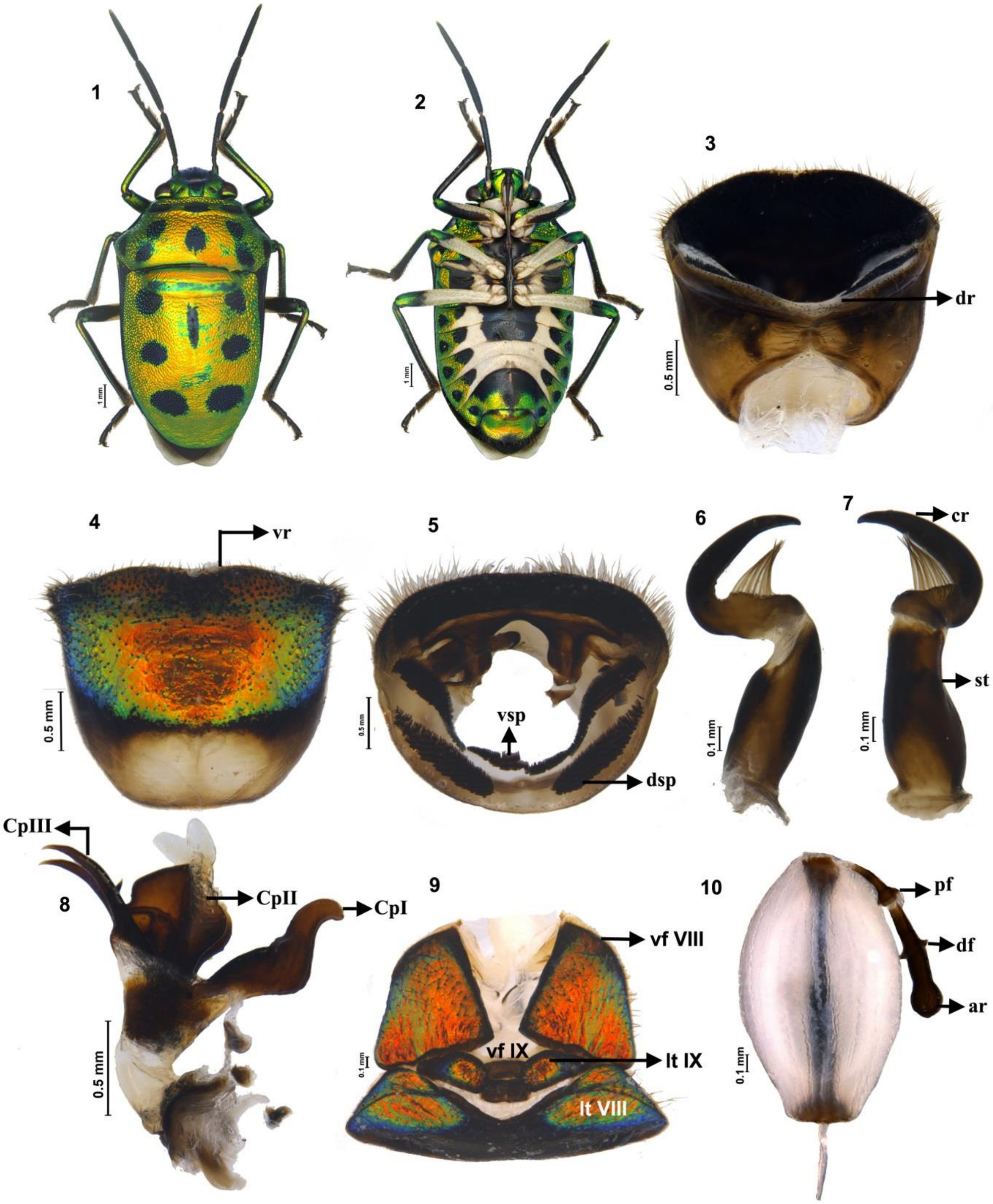
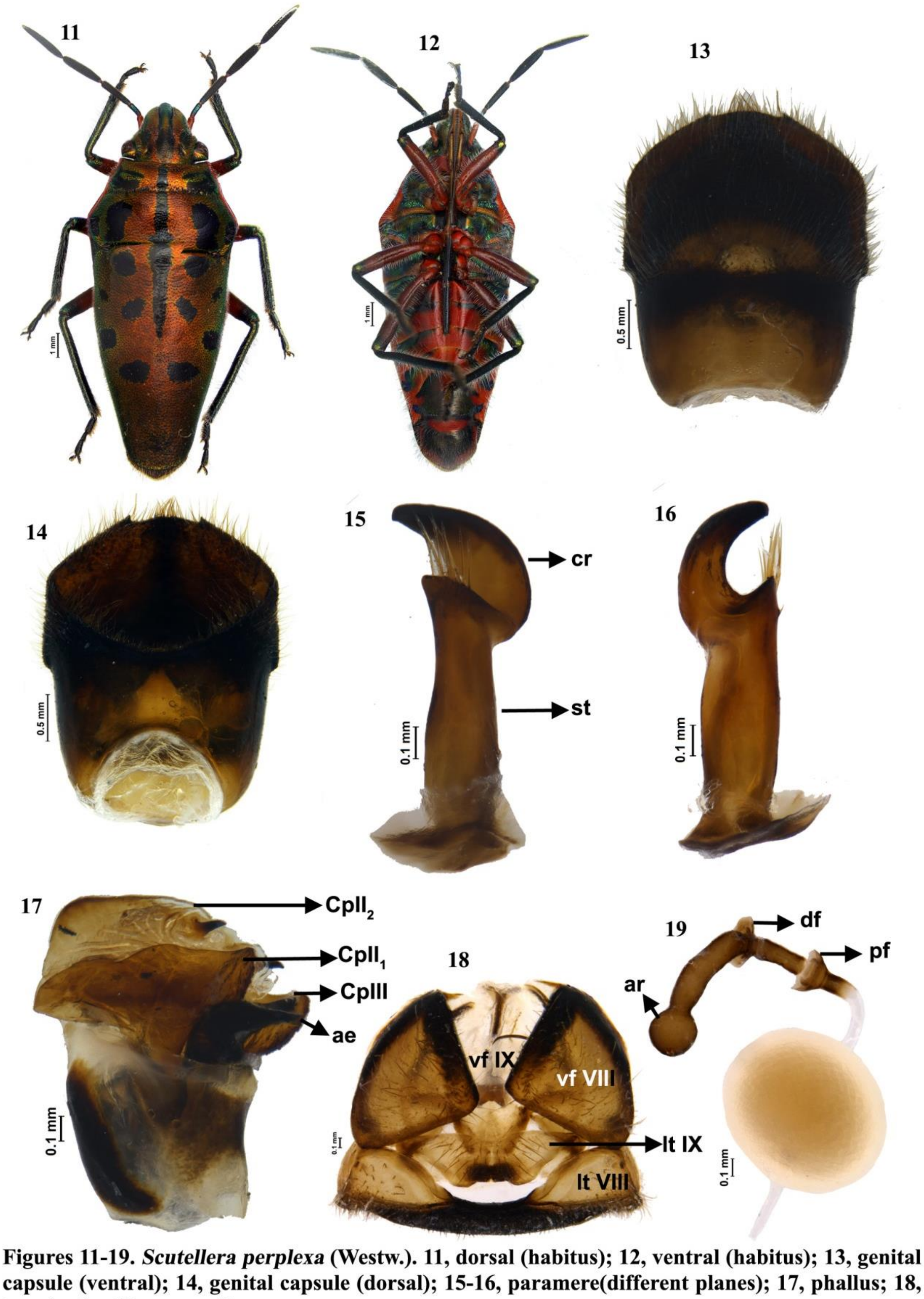


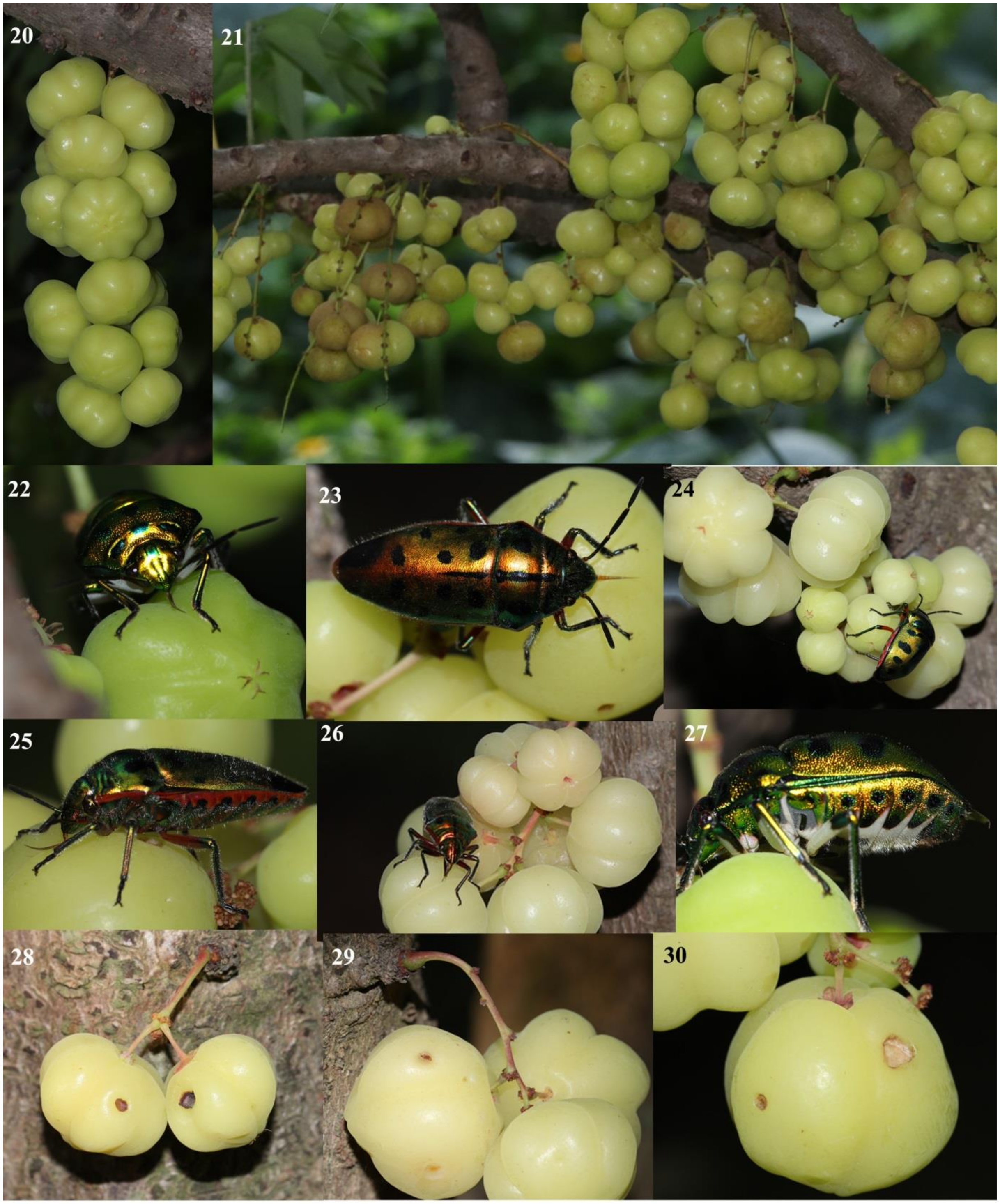
Figures 1-10. *Chrysocoris stockerus* (Linn.). 1, habitus (dorsal); 2, habitus (ventral); 3, genital capsule (dorsal); 4, genital capsule (ventral); 5, genital capsule (caudal); 6-7, parameres (different planes); 8, phallus 9, terminalia; 10, spermatheca.

Lettering: ar-apical receptacle; CpI- conjunctival process I; CpII- conjunctival process II; CpIII- conjunctival process III; cr- crown; df-distal flange; dr- dorsal rim; dsp-dorsal setal patches; lt VIII- laterotergite VIII; lt IX- laterotergite IX; pf- proximal flange; st-stem; vr- ventral rim; vf VIII- valvifers VIII; vf IX- valvifers IX; vsp-ventral setal patches.

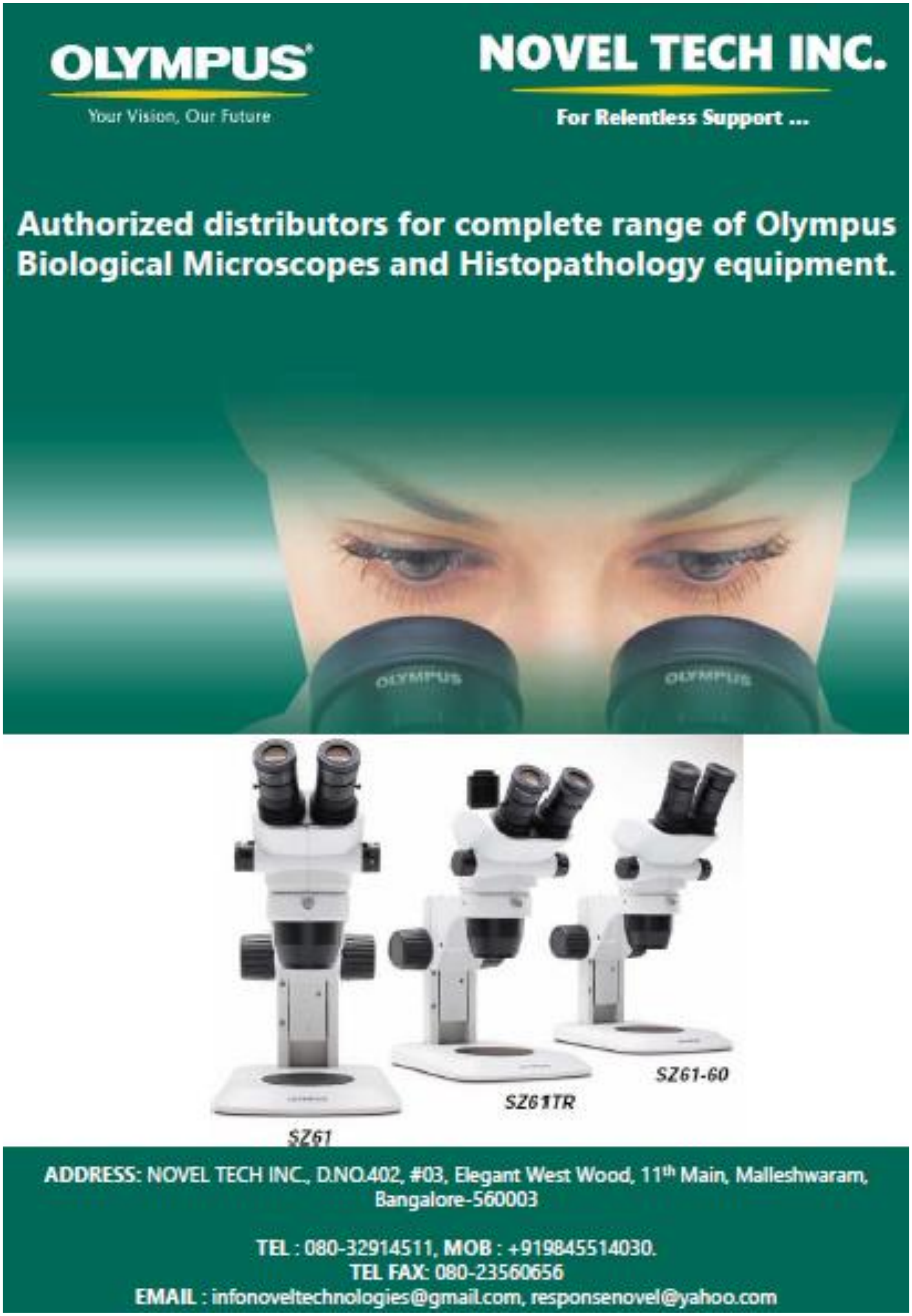


Figures 11-19. *Scutellera perplexa* (Westw.). 11, dorsal (habitus); 12, ventral (habitus); 13, genital capsule (ventral); 14, genital capsule (dorsal); 15-16, paramere(different planes); 17, phallus; 18, terminalia; 19, spermatheca.

Lettering: ar-apical receptacle; CpI- conjunctival process I; CpII- conjunctival process II; CpIII- conjunctival process III; cr- crown; df-distal flange; lt VIII- laterotergite VIII; lt IX- laterotergite IX; pf- proximal flange; st-stem; vf VIII- valvifers VIII; vf IX- valvifers IX



Figures 20-30. *Phyllanthus acidus.* 20, healthy berries; 21, affected berries; 22-27, Scutellerid bugs feeding on berries; 28-30, berries showing initial symptoms as brown punctures at the feeding site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New distributional record of invasive Neotropical coconut whitefly *Aleurotrachelus atratus* (Hemiptera: Aleyrodidae) in Tamil Nadu, India

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Abstract

Occurrence of invasive Neotropical palm infesting whitefly, *Aleurotrachelus atratus* (Hemiptera: Aleyrodidae) on coconut (*Cocos nucifera*) was recorded for the first time in Dharmapuri and Krishnagiri districts of Tamil Nadu. *Aleurotrachelus atratus* is an oligophagous pest, which prefer to feed on palm plants and is mostly distributed in tropical and subtropical regions. The infestation level observed was low (less than ten live colony or adults /leaflet) to moderate (11-20 live colony or adults /leaflet). This study also revealed the co-existence of *A. atratus* with an earlier invasive whiteflies *viz.*, rugose spiralling whitefly *Aleurodicus rugioperculatus*, nesting whitefly *Paraleyrodes minei* and Bondar' s nesting whitefly *Paraleyrodes bondari* on coconut. This quick dispersal is believed to be through transportation of infested seedling from pest affected areas. The strict domestic quarantine and sensitization of farmers and other stakeholders is to be advocated to avoid spread of this pest to other coconut and other palms growing areas in the country.

Keywords: Coconut, invasive, Neotropical, natural enemies, oil palm, Tamil Nadu

Introduction

Invasive whiteflies *viz.*, rugose spiralling whitefly *Aleurodicus rugioperculatus* during 2016, Bondar's nesting whitefly, *Paraleyrodes bondari*, nesting whitefly, *Paraleyrodes minei* during 2018 and palm infesting whitefly, *Aleurotrachelus atratus* during 2019 invaded coconut palms and raised biosecurity concerns in India (Selvaraj *et al*., 2020). They prefer to colonize on palm plants belonging to Arecaceae family. The origin of these invasive species was believed to be Neotropical regions and their interception is likely through the importation of plant materials. Both nymphs and adult whiteflies inflict direct feeding injury on the host plants while sucking sap which leads to excessive drain of sap, necrosis and premature drying. Indirectly, the honeydew which gets deposited on the upper even some times on lower surface of the infested plants lead to the growth of black sooty mould. This is the secondary infection arising out of the whiteflies infestation which is believed to interfere with photosynthesis and yield parameters.

Among these whiteflies, neotropical palm infesting whitefly, *Aleurotrachelus atratus* was recorded for the first time in India during 2019 at Mandya district of Karnataka on coconut and ornamental areca palm (*Dypsis lutescens*) (Selvaraj *et al.*, 2019). Subsequently, it spread rapidly to adjoining districts *viz.*, Ramanagara, Mysore, Bengaluru Rural, Bengaluru Urban, Hassan, Chamrajnagar and Tumkur and extended its host ranges on areca nut (*Areca catechu*) and oil palm (*Elaeis guineensis*). So far, this species was distributed in various coconut growing areas of Karnataka. Its rapid spread and establishment could be due to high fecundity, high dispersal and survival ability, voracious feeding, ability to withstand diverse environmental conditions and benefits from mutual interaction with other insects.

This communication, confirms the occurrence and spread of this species in Tamil Nadu for the first time, natural enemies and its coexistence with other invasive whiteflies infesting coconut.

Materials and Methods

Survey: Field surveys were conducted in Pennagaram (12.1348° N, 77.8928° E) and Palakkodu (12.2986° N, 78.0738° E) of Dharmapuri district and Hosur (12.7409° N, 77.8253° E) and Bargur (12.5429° N, 78.3570° E) of Krishnagiri district of Tamil Nadu to assess the occurrence and infestation of these invasive whiteflies on coconut and other host plants. Infested coconut leaf samples sent by farmers from Marandahalli village (12.3891° N, 78.0033° E) in Dharmapuri district was also examined. Whitefy samples along with coconut leaves were collected in paper covers for further species confirmation. Whitefly species confirmation was based on morphological characteristics which were achieved by permanent mounts of the puparium; the best mounts were obtained from puparial cases from which adults had emerged. During survey, the level of infestation was assessed by visual inspection using a qualitative scale as follows, 0-10 live egg spirals or adults/leaflet (low); 11-20 live egg spirals or adults/leaflet (moderate) and > 21 live egg spirals or adults/leaflet (severe). To assess this, randomly ten leaves/palm were selected consisting of upper, medium and lower strata at each location.

Field collected infested plants were sorted whitefly species-wise and placed in a separate rearing jar (21×10 cm) and observed for the emergence of parasitoid / predators. The adult parasitoids emerging from the species wase collected using aspirator and preserved in vials containing 70% ethanol for further identification. Assessment of parasitism (%) was determined based on the number of parasitized puparia as against un-parasitized pupae in the host leaves. Identification of natural enemies such as predators was confirmed morphologically.

Results and Discussion

New distributional record: Present study revealed the presence of rugose spiralling whitefly *Aleurodicus rugioperculatus*, Bondar's nesting whitefly, *Paraleyrodes bondari*, nesting whitefly, *Paraleyrodes minei* and palm infesting whitefly, *Aleurotrachelus atratus* on coconut. Occurrence of *A. rugioperculatus* (Sundararaj and Selvaraj, 2017), *P. bondari* and *P. minei* (Josephrajkumar *et al.,* 2020) in the state was reported earlier. The present study revealed the occurrence of Neotropical palm infesting whitefly, *A. atratus* in Dharmapuri and Krishnagiri districts of Tamil Nadu. The infestation of *A. atratus* was low (0-10= live egg spirals or adults/leaflet) to moderate (11-20= live egg spirals or adults/leaflet) and it seems that pest was at initial stage of invasion (Fig.1). This pest population may increase during dry months (March to May) as experienced in Karnataka. The pest might have spread from Karnataka through transportation of infested seedling from adjoining districts *viz.*, Mandya and Mysore.

Studies also revealed the co-ocurrence of *Aleurotrachelus atratus* with other invasive species such as rugose spiralling whitefly *Aleurodicus rugioperculatus*, nesting whiteflies, *P. bondari* and *P. minei* (Fig. 2). Among the species, *Aleurodicus rugioperculatus* and Bondar's nesting whitefly, *Paraleyrodes bondari* was found to be dominant with moderate (11-20= live egg spirals or adults/leaflet) to severe (30= live egg spirals or adults/leaflet) infestation and major portion of leaves infested in terms of number of colonies. These whiteflies colonize on the dorsal surface of the leaflets in groups, *A. rugioperculatus* and *A. atratus* have higher damage potential, production of intense white wax which often cover entire immature stages as compared to nesting whiteflies which produce moderate loose wax. On the other hand, the feeding damage by the nesting whiteflies has not been as intense as that of *A. rugioperculatus* and *A. atratus* with minimum honey dew and sooty mould deposits observed on coconut.

Fig.1. Symptoms of damage of palm infesting whitefly on coconut

Fig.2. Co-occurring of palm infesting whitefly with rugose spiralling whitefly (a); nesting whitefly (b-c); Bondar's nesting whitefly (d) on coconut

Occurrence of parasitiod *Encarsia guadeloupae* Viggiani (Hymenoptera: Aphelinidae) on *Aleurodicus rugioperculatus* was recorded with natural parasitism to the extent of 42-68% on coconut. *Encarsia guadeloupae* is the potential dominant parasitoid for *A. rugioperculatus* with 62-82% natural parasitism on coconut and many other host plants (Selvaraj *et al.*, 2016). In case of Bondar's nesting whitefly, *P. bondari*, nesting whitefly, *P. minei* and palm infesting whitefly, *A. atratus*, no parasitism observed so far under field conditions. Similar observation was also reported earlier in Karnataka (Selvaraj *et al.*, 2019). This shows that these invasives might have entered into India without their natural enemy's complex and this might have favoured for severe outbreak situation in short span of time. Among predators, only a generalist predator, *Pseudomallada astur* (Neuroptera: Chrysopidae) was found to feed on *A. atratus, P. bondari* and *P. minei* during survey. This quick dispersal is believed to be through transportation of infested seedling from pest affected areas. The strict domestic quarantine and sensitization of farmers and other stakeholders to be advocated to avoid spread of this pest to other coconut and other palms growing areas in the country.

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Record of massive outbreaks of Pentatomid bug, *Udonga montana* (Distant) in Idukki District of Kerala

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Introduction

A massive outbreak or swarming of medium sized (11-13mm) brown stink bug (*Udonga montana*) was observed in the Vathikudy Panchayat (Idukki district, Kerala) during the current year (June, 2021) causing public nuisance and panic among the farmers for its suspected fear of feeding damages to crops like banana, coffee, black pepper etc. An emergency survey was conducted to the locations to record the mass emergence along with the collection of specimens for both morphometric studies, recording feeding preferences (if any) and to estimate crop damage potential.

Materials and methods

Adults of *U. montana* from the mass buildup sites of two locations in Vathikudy village (9.5430°N, long 77.030°E: 730 m M.S.L, Idukki District, Kerala, South India; Figure 1) were collected to confirm the identity and to conduct further studies to record their feeding potential on the reported host plants *viz*., bamboo and horticultural crops like banana, coffee and pepper. Specimens were collected randomly from these plants, using insect net and transferred into large containers, tagged and brought to entomology laboratory, Banana Research Station, Kannara, Thrissur, Kerala. Some of the specimens were preserved in 70% ethanol and pinned as repository. Live bugs collected were kept in insect cages and provided with tender shoots of bamboo, Glyricidia, black pepper and banana seedlings (cv. Kadali and Pisang Linin) for recording their feeding nature.

Results and discussion

The bugs that exhibited mass buildups were identified as *Udonga montana* (Distant) (Hemiptera: Pentatomidae; Figure 2) from the field collected specimens. Commonly known as bamboo seed bug or bamboo sap sucker, *U. montana* is recorded as a major pest of bamboo in India, Bangladesh and Myanmar causing serious damage to flower heads and seeds in the milky stages (Varma and Sajeev, 1988). In India these bugs were recorded from Assam, Karnataka, Madhya Pradesh, Meghalaya, Tamil Nadu, Central Provinces (Salini and Virakthamath, 2015) and Kerala (Mathew and Sudheendrakumar, 1992).

Large swarms of these bugs were recorded from various parts of south India especially Karnataka (Sharanabasappa et al., 2018) in the cropped lands near forest ecosystems. The massive buildups of these stink bugs in Kerala were first recorded during 1991 and 1992 in Wayanad district and their affinity for feeding on developing bamboo seeds were recorded by Mathew and Sudheendrakumar (1992). They could also record heavy feeding and breeding by *U. montana* resulting in devastation of the seed crops of bamboo, thus affecting and delaying their flowering cycles.

At the present sites of outbreaks in Vathikudy Panchayat, hordes of these bugs were seen swarming and congregating on horticultural crops like banana, coffee, black pepper, jackfruit; shade trees like Glyricidia etc. The bugs exhibited short migration when disturbed and emitted foul nauseating smell that hampered the workers from attending to various cultural operations in their cropped areas. The movement of these bugs into the nearby houses led to severe allergic reactions to occupants. On enquiry, presence of large clumps of flowering bamboo plants inside the forest lands adjoining the aggregation sites were confirmed, thus strengthening earlier observations of 1992.

Drooping of foliages and branches due to the aggregation of the bugs lead to breaking of soft branches and in some cases drying of growing shoots (Figure 3). We could record traces of feeding/probing on fingers of banana (cv. Pisang Lilin) and spikes of black pepper in the field (Figure 4 & 5). Our observations confirm earlier record of bugs feeding on spikes of pepper by Mathew and Sudheendrakumar (1992). We could also record short bouts of probing on seedlings of cv. Kadali and coffee leaves in the laboratory.

With the previous confirmed reports of the bamboo seed bug from Kerala restricted to Wayanad district in the year 1991 and 1992 (Mathew and Sudheendrakumar, 1992; Prakasan *et al*., 1992) the present outbreak may be considered as the third massive out break coinciding with the flowering and seeding cycle of the bamboo in Kerala and in a new locality faraway from previous congregation sites. Further studies are a must to fill lacunae in its life cycle, host preferences, and feeding/probing behavior with special reference to agricultural important crops near forest fringe areas and an analysis how the insect survives in the wild for 6-7 months of their life cycle.

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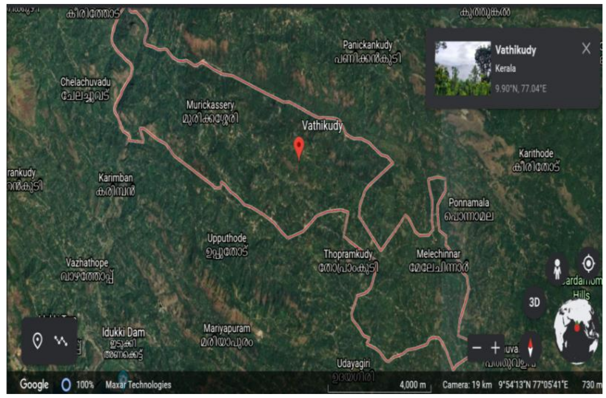

Fig 1: Collection site Vathikudy (9.5430°N, long 77.030°E):730 m M.S.L, Idukki District, Kerala, South India. (Source : Google Earth : https://earth.google.com/web/)

Fig 2: Habitus of *Udonga montana* (Distant) (Photo: Gavas Ragesh)

Fig 3: Drooping exhibited by ***Glyricdia spp.*** (Photo: Gavas Ragesh)

Fig 4: banana bunch (cv. Pisang Lilin) smothered by *U. montana* with feeding punctures (Photo: Gavas Ragesh)

Fig 5: Drooping and traces of feeding exhibited by black pepper (Photo: Gavas Ragesh)

First report on natural incidence of cucumber moth *Diaphania indica* (Saunders) (Lepidoptera: Crambidae) on watermelon in Goa

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Watermelon (*Citrullus lanatus* L.) is an important species of the Cucurbitaceae family. The fruit is botanically vegetable (cucurbit), but often sold as a fruit and has a wide commercial and nutritional importance. It is the best dessert fruit cherished by rich as well as poor. Watermelons are grown in large area in Goa especially in South district. During reconnaissance surveys of watermelon field in the month of January, 2021, green to greyish blotches and scraping of rind of watermelons were observed (Fig.1). During close inspection pale yellow green-colored larvae were seen scraping and voraciously eating the rind of watermelons causing damage to fruits. Their frasses were also seen scattered on fruits.

The larvae were collected from watermelons and reared in laboratory for analysis and identification. They were fed with watermelon fruits and allowed to grow. The larvae (Fig.2) started to construct loose silken structure, which served to shelter them in the daylight hours. Later two sub dorsal white stripes extending the length of the larvae were seen developing on their body. After eight days larvae started pupating and this stage lasted for ten days (Fig.3). The adult moth emerged after completing pupal stage and they were alive for five to six days (Fig.4).

The eggs, larvae, pupae and adults of insect pest were sent for identification (Courtesy Dr. Hussain Shaik, CCMB Center for Cellular and Molecular Biology, Hyderabad) and confirmed that it was a cucumber moth, *Diaphania indica* (Saunders) (Lepidoptera: Crambidae), a polyphagous pest mostly infesting cucurbit. Its larvae mainly attack leaves and also flowers and fruits, and cause considerable yield loss during epidemic (Nagaraju. *et al.,* 2018 and b). Larvae feed on the surface of the fruits causing scars on the surface of melons and eventually burrow into the fruit (Bina Khanzada *et al*., 2021)

Based on literature review, this seems to be the first report on natural incidence of *Diaphania indica* (Saunders) on watermelon in the state of Goa.

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Fig. 1. Green to greyish blotches on fruits (Symptoms)

Fig. 2. Larvae constructing silken structure

Fig. 3. Pupa

Fig. 4. Adult *Diaphania indica*

Photo Credit- Suresh Kunkalikar and Rajan Shelke

Luprops **beetle: How a detritivorous litter dwelling beetle becomes a monstrous nuisance pest during the rainy season**

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Luprops tristis, commonly referred to as darkling beetle (Coleoptera: Tenebrionidae), is a litter dwelling detritivore beetle common in the rubber plantation belts of south India. Its home invasion during the rainy season has led to its status as a notorious home-invading nuisance pest. The massive aggregations of them in thatched sheds made of coconut and palm fronds, firewood stocks, and woodwork supporting clay tile roofing in old buildings have led to the popular vernacular names "*Ola prani, Ola chathan, Otteruma, Oadu vandu*". It is also known as "*Mupli vandu*", after the first reporting of huge aggregations in the rubber estates at Muplium in central Kerala during the 1970s. Fallen leaves of cocoa (*Theobroma cacao,* Linnaeus 1753) and jackfruit (*Artocarpus heterophyllus*, Lamarck 1789) are the major alternate food sources of *L. tristis* in rubber plantation belts (Sabu *et al*., 2012). Presence of *L. tristis* infestation in non-rubber, non-jackfruit and non-cocoa belts in many regions of south India (personal observations) and the dry eastern slope of the south Western Ghats (Sabu *et al*., 2007), invasion into the building of many educational institutions with tree cover in Bangalore city and its generalist feeding nature (Sabu *et al*., 2008) indicate that *L. tristis* can sustain on the leaf litter of many other plants and is not confined to rubber belts alone. *Luprops* Hope, 1833, is found from tropical Africa, Asia, and Papua New Guinea with eight species reported from the Indian subcontinent. *Luprops tristis* distributed in India (Tamil Nadu, Kerala, Karnataka, Andhra Pradesh, Sikkim) as well as Sri Lanka has reached the pest level in India, while there are no records of it as a pest in Sri Lanka (Sabu *et al*., 2007). The life cycle of the beetle in rubber litter is detailed out and the same pattern can be seen with modifications related to the regional climate and phenology of the host plant in non-rubber belts.

The life cycle of *Luprops* involves larval, pupal, and adult phases. Larval and pupal stages are spent entirely in the rubber litter, and the adult phase is spent partially in the field as active beetles and aggregation shelters in a dormant phase. Beetles, adapted for life in dry litter conditions, feed and breed in the plantation litter during December - May period. With the onset of rains and wetting of rubber litter habitat in the region during April – May months, the entire population of adult beetles takes shelter in nearby residential buildings, which remains their dormancy home for 6-8 months till the return of dry conditions and the beginning of annual leaf shedding by rubber trees in plantations by November. In addition to the residential buildings in rubber plantation belts, the crevices behind rock boulders are also selected as dormancy sites by these beetles. Being a generalist detritivorous beetle, it feeds on the leaf litter of jackfruit, cocoa, cassia, wild jack, arjuna, in addition to rubber. Replacement of native vegetation by rubber plants and the availability of rubber leaf litter habitat in the vast stretches of rubber plantation 'forests' has led to its establishment as a nuisance pest in the rubber plantation belts.

The invasion of the adult *Luprops* population, which may number from thousands to millions of beetles, is triggered by the summer rains in the dormancy shelters in April –May. Shelters selected are, in most cases, the residential buildings of plantation workers surrounding the rubber plantations (Figure1). With their nocturnal activity, the beetles' attraction towards light sources, the release of a phenolic defensive gland secretion causing skin burn, make human life miserable inside these buildings. Volatile glandular secretion prevailing in the aggregation sites is an eye irritant, often leading to a particular type of conjunctivitis reported in rubber belts.

Invaded Mupli beetles remain active only for 2-3 weeks in the dormancy shelters, following which they settle down in huge aggregations of 3–4 layers deep in some undisturbed sites like the attics, thatched sheds, or firewood stocks in these buildings and enter into a state of inactivity extending for 7-8 months without food. The selection of the same buildings as aggregation sites every year forces people to abandon their homes during the rainy season, making *Luprops* a notorious nuisance pest in the belt. Attempts to control the beetles with physical and mechanical means have not been successful due to the following reasons. Residential buildings in rubber plantation regions are either tile-roofed buildings with multiple windows and doors or palm frond-thatched sheds, and both types of structures have multiple gaps allowing the entry of beetles into the buildings. The abundance of the aggregated beetles, their swift movements, difficulty to reach the aggregation sites in the attics, and the release of odorous secretion make manual collection impossible.

Active predation of Weaver ants on *L. tristis* during both nocturnal and diurnal conditions and the non-deterrence by the gland secretions indicates that weaver ants have the potential to be used as an effective bio control agent to regulate the population build-up of *L. tristis* (Aswathi and Sabu 2011; Aswathi *et al*., 2012). However, the lack of host plants for weaver ants in the monoculture rubber plantations and their aggressiveness, hinders the introduction of weaver ants as an effective predator of *L. tristis* anywhere. Recently, cosmopolitan scuttle fly, *Megaselia scalaris* Loew, 1866, has been found to be parasitizing dormant, aggregated populations of *L. tristis* and proved as the best potential biological control agent of *L. tristis* (Binsha *et al*., 2020).

Control of Mupli beetles in the rubber plantation litter habitat is impossible in the vast stretches of rubber plantations where the beetles take shelter beneath the litter layers. However, aggregation of the entire population of the beetles in specific buildings during the wet seasons and their presence inside these buildings for a long 6-8 month period in an inactive dormancy phase is an opportunity for their eradication. In non-rubber belts, litter removal towards the end of the leaf shedding period will deprive the beetles of feeding and breeding habitat. The application of Cypermethrin based pesticides in residential buildings is proven to control the home invaded beetles by sending them to an inactive knocked down state, where they can be easily removed from indoors and killed by other means. Proper implementation of this methodology by incorporating the collective effort from all the stakeholders in a specific region will prevent the field return of the dormancy aroused aggregated beetles and will control the development of the next generation beetles.

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Figure 1: Aggregation of dormant *Luprops tristis* in a residential building.

The occurrence of citrus green mite, *Schizotetranychus baltazarae* Rimando (Acari: Tetranychidae) on curry leaf (*Murraya koeningii* F: Rutaceae) in Kerala

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Curry leaves are important aromatic ingredient in Indian cuisine as they have high contents of essential volatile oils. It is considered as a leafy spice and is an important medicinal plant in traditional medicines.

Recently, curry leaves in several homesteads of Trivandrum and Kollam districts of Kerala were found with dried leaves in spite of regular watering. The infested leaves had several leaf spots on them. The spots on close observation showed clearance of chlorophyll. On microscopic examination, the underside of the leaves showed several mites feeding on them. Due to their feeding from the underside of the leaves, greyish circular spots appeared on the upper surface. The entire leaf lamina was covered with cream coloured spots. In severe infestation complete withering and drying up of plant was also observed. Infested seedlings completely dried up due to the same. The infestation was found, soon spreading to newly formed leaves of the same plant and nearby plants.

The microscopic examination of the ventral side of curry leaves with symptoms showed yellowish globular eggs and greenish yellow mites. The mites were globular to pyriform shaped and they were actively moving. It was identified as *Schizotetranychus baltazari* and was originally described by Rimando, 1962 based on specimens collected from citrus in the Philippines.

Detailed investigation on the damage and management of the pest are needed. The infestation of the mite in curry leaf from Karnataka was reported by Safeena and Srinivasa, in 2020.

a. Mite egg and adult,

b. Mite infestation initial symptoms

c. Mite infestation advanced symptoms

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Morphological adaptations of stingless bees (*Tetragonula iridipennis*) to the floral biology of salad cucumber, *Cucumis sativus*

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Abstract

The proboscis of *Tetragonula iridipennis* was shorter (1.30 mm) when compared to the corolla tube length of male flowers (6.14 mm) and female flowers (5.23 mm). Thus, in order to reach the nectaries of *Cucumis sativus* flowers, bees have to insert their head into the corolla tube. Female flowers have shallow corolla tubes and a wider gap between the wall of the corolla and the tip of the stigma compared to the same in male flowers. The head width of bees (1.74 mm), being smaller than the gap between corolla wall and stigma tip (1.91 mm), is perfectly fit for *T. iridipennis* foragers to reach nectaries at the base of female flowers. The male flowers have bowl like nectaries which are observed at the base of the stamen, while in the case of female flowers the nectaries surround the base of style forming a trough for accumulation of nectar. This position enables the pollinators for easy access to the nectar.

Keywords: Stingless bee, *Cucumis sativus***,** floral biology

Introduction

Bess and flowers have co-evolved since millions of years and their relationship is a mutual success. They evolved behavioral and physiological adaptations to gather and transport pollen more efficiently. They possess branched body hairs that are densely packed. These specialized hair groups (brushes, combs, and scrapers) help in extraction of hidden pollen and are important in the acquisition of pollen from flowers. They groom themselves and concrete the pollen loads in the specialized transport structures (corbicula) (Thorp, 2000; Shimizu *et al*., 2014). There exists a complex relationship between tongue length and proboscis of bees and flower choice. While seeking nectar from flowers, bees preferentially visit plant species with corolla depths which approximately match its own tongue length. Short tongued bees can take nectar from open shallow corollas or from longer corollas at certain times of day when they are very full. But small bees can crawl right into the corolla tube because of their small body size (Willmer, 2011).

Most of the bees are pollen generalists, capable of foraging on many plant species. Stingless bees from the tribe Meliponini are true generalists. According to Primack (1987), the type of flower and amount of rewards offered by the flowers select the type of pollinators. Nunes-silva *et al.* (2013) suggested while selecting a pollinator for a particular crop, the foraging activity should overlap with the floral receptivity for a successful crop production.

Cucumber (*Cucumis sativus*) flowers are unisexual, pentamerous and axillate. Staminate flowers borne in clusters and pistillate ones are usually borne solitary on a stout peduncle. The pistillate flower is easily recognized by the large ovary at the base of the flower. The staminate flowers produce three stamens. The pistillate flower has three stigma lobes and a short broad style (Heimlich, 1927). The staminate flowers appear about 10 days before pistillate flowers appear. The ratio of male to female flowers is ten to one in monoecious cultivars (Kohli and Vikram, 2005). Studies on the adaptation of bees in relation to flower biology is scanty. The present investigation on floral biology of cucumber and morphology of stingless bee was conducted to assess the adaptation of bees in relation to flower biology.

Materials and Methods

Floral biology of both male and female cucumber flowers were studied in detail. Morphological characters of stingless bee were also recorded to analyse the extent to which they are adapted for nectar collection and thus enabling successful pollination.

Floral biology

Ten male and female flowers each were tagged at the time of flower bud initiation and observations on the number of days taken from sowing up to flower bud formation as well as to the flowering was recorded separately. For measuring flower diameter, ten male and female flowers each were selected randomly. Flower diameter was measured as the distance between end points of diagonally opposite petals using meter scale. Ten male and female flowers each were selected, petals were excised and stamen length (distance from style end to top surface of stigma) and style length (inter-distance between ovary and stigma) was measured by using image analyzing software. Petals of cucumber flowers were fused at the base forming a corolla tube. The length of corolla tube of both male and female flower was measured in order to assess their relation with pollinator biology. Apart from these, the gap between corolla tube and stamen tip in the male flower and the gap between corolla tube and stigma tip in female flower was also measured. Ovary of cucumber plant, the minor fruit like structure visible at the base of female flowers, was measured using a meter scale.

Morphology of the stingless bee

Morphology of ten worker bees of *T. iridipennis* was observed under stereo-zoom microscope and the required characters were measured by using image analyzing software. The collected bees were killed and the length of the excised proboscis was measured as the distance from the mentum to flabellum. Total length of the body, length and width of head of worker stingless bee was also measured.

Collected data on floral biology and bee morphology were analysed by taking arithmetic mean of 10 observations. Standard deviation and coefficient of variation were also calculated.

Results and Discussion

The ecology and floral biology reveals the entomophilous nature of cucumber plant. The flowers are bright yellow colour, bracteate, pedicellate, radially symmetrical, unisexual, pentamerus, epigynous, five sepals united, often deeply lobed, five petals united to form a tube, often deeply lobed and are produced in axes of leaves (Table 1.). Staminate flowers generally born in clusters in leaf axils, while pistillate flowers are born singly in independent leaf axils at less frequent intervals than males. Staminate flowers usually appear 8 to 10 days prior to that of pistillate flowers. The pollen grains were sticky. This observation was in accordance with that of Mc Gregor (1976); Ruffner and Hall (1976) who reported that the flower biology ensures the pollination requirement in cucumber.

Pollen and nectar are usually considered as floral rewards for pollinating bees (Plate 1). For plants, the pollen deposition in stigma is the prerequisite of pollination, while for bees it is the essential food for the proper growth of their larvae. Accordingly, there should be a competition for pollen and the coevolution of plant and pollinators shows a mutual exploitation.

Although pollination is happening, nectar serves an important role (Sakai, 1993; Westerkamp, 1996) which is the primary source of energy and water and is hidden at a greater depth within a flower (Nicolson *et al.,* 2007). The present study showed that the nectaries are bowl like structure observed at the base of the stamen in male flowers, whereas it surrounds the base of style forming a trough for accumulation of nectar in female flowers (Plate 2.). This position enables the pollinators for easy access to the female nectar.

The proboscis of *T. iridipennis* was shorter (1.30 mm) compared to that of corolla tube length. The average length of corolla tube of male flowers was 6.14 mm and that of female flowers was of 5.23 mm (Table 2.). In order to reach the nectaries, bees have to insert their head into the corolla tube. According to evolutionary concept, nectar depth always has to exceed tongue (proboscis) length to maintain floral fitness in terms of fruit set (Nilsson, 1988). The deeper positioning of nectaries, not only prevent nectar desiccation but also forces bees to go deeper into the flower. This finally results in an exact positioning of pollen in stigmatic surface.

In the present study, average body length of bee is 3.69 mm, length and width of the head is 1.39 mm and 1.74 mm respectively. The gap between corolla tube and stamen tip was recorded as 1.35 mm while the gap between corolla tube and stigma tip was 1.91 mm (Table 3.). It has been observed that the head width of bees (1.74 mm) is smaller than the gap between corolla wall and stigma tip (1.91 mm) and is a perfect fit for *T. iridipennis* foragers to reach nectaries at the base of female cucumber flowers.

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Table 1. Flower biology of *Cucumis sativus.*

Plant and flower parameters		Mean
Location of flower		Leaf axil
Days to flower bud initiation	Male	25 DAS
	Female	34 DAS
Days taken to flowering	Male	31 DAS
	Female	39 DAS
Flower colour		Yellow
Calyx: Sepals		5.00
Corolla : Petals		5.00
No. of stamens		5.00
No. of stigma		6.00
Location of nectarines in flower	Male	Base of the stamen
	Female	Base of the style
Forage available	Male	Pollen and nectar
	Female	Nectar
Flower duration (day)		1

Table 2. Morphological adaptations of *Tetragonula iridipennis* in relation to flower biology.

Parameter	*Corolla tube length (male flower) (mm)	*Corolla tube length (female flower) (mm)	*Gap between corolla tube and stamen tip (mm)	*Gap between corolla tube and stigma tip (mm)	*Proboscis length (mm)	*Body length (mm)	*Head length (mm)	*Head width (mm)
Maximum value	7.70	6.04	2.00	2.55	1.37	4.00	1.50	1.80
Minimum value	4.50	4.80	0.88	1.45	1.19	3.04	1.30	1.70
SD	0.86	0.47	0.43	0.38	0.07	0.28	0.06	0.03
Mean	6.14	5.23	1.35	1.91	1.30	3.69	1.39	1.74
CV	14.00	9.08	31.66	20.22	5.49	7.73	4.49	1.89

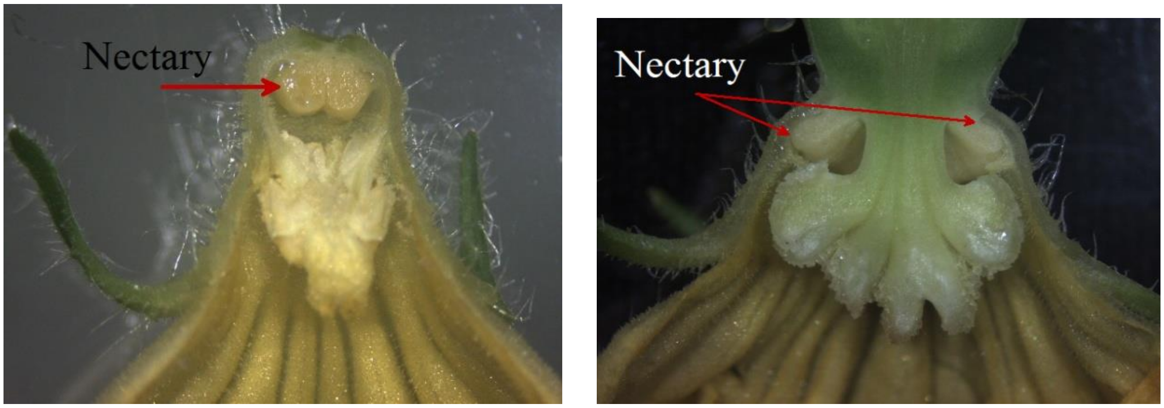
*Mean of 10 observations

Table 3. Floral biology of *Cucumis sativis*.

Parameter	*Flower diameter; Male (cm)	*Flower diameter; Female (cm)	*Stamen length (mm)	*Stigma length (mm)	*Style length (mm)	*Ovary length (cm)
Maximum value	5.60	5.50	6.00	3.55	3.54	4.30
Minimum value	3.80	3.80	3.86	2.10	2.80	2.40
SD	0.52	0.50	0.58	0.44	0.22	0.17
Mean	4.35	4.63	5.02	2.97	3.15	3.31
CV	12.08	10.87	11.64	14.92	7.26	16.57

*Mean of 10 observations

Plate 1. *Tetragonula iridipennis* on female flower of *Cucumis sativus*



(A) Nectary of male flower (B) Nectary of female flower

Plate 2. Location of nectarines in cucumber flower

Diversity of hawkmoths (Lepidoptera: Sphingidae) of Nandurbar, Maharashtra, India

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Abstract

The hawkmoth fauna of Nandurbar district is not accounted so far, therefore, the present study was planned to assess and document the hawkmoth fauna of this district. Thus, the study resulted in preliminary account of 20 species of hawkmoths belonging to 13 genera and 03 subfamilies from Nandurbar, Maharashtra, India. Out of the studied species, 10 species namely, *Agrius convolvuli* (Linnaeus, 1758); *Psilogramma increta* (Walker, [1865]); *Agnosia microta* (Hampson, 1907); *Marumba indicus* (Walker, 1856); *Marumba spectabilis* (Butler, 1875); *Clanis phalaris* (Cramer, 1777); *Daphnis nerii* (Linnaeus, 1758); *Hyles livornica* (Esper, 1780); *Hippotion rosetta* (Swinhoe, 1892) and *Hippotion rafflesii* (Moore, 1858) are reported for the first time from this district. The common name for the species *Agnosia microta* (Hampson, 1907) has been coined in this study as "Spotted Agnosia hawkmoth". This is the preliminary study covering the distribution of the reported species along with their larval host plant and common name. More extensive surveys and studies are required to properly document the diversity of Nandurbar.

Key words: moths, sphinx moth, heterocera, species, diversity profile, north Maharashtra, Nandurbar.

Introduction

Linnaeus first classified the hawkmoth in 1758 under the name 'Sphinx'. Samouelle in 1819 adopted the name Sphingidae for the family. Sphingid moths are an important component of the ecosystem due to their role in pollination of the night blooming plants. The adults are commonly known as sphinx or hawkmoths. Moths of this family are easily recognizable due to the long, narrow, pointed fore wing, short, triangular hind wing, the large eye, powerful thorax, sharply-pointed abdomen and antenna filiform or setiform. These are the characters present in majority of the hawkmoths with some exceptions. The larvae generally bear a horn on the twelfth segment and hence commonly called as hornworms. The head of the larvae strikingly resembles snake morphologically and also their behavior resembles like snake when disturbed. The pupae are usually short, cigar-shaped, rounded in front and pointed behind. The adults are moderate to large in size and are known among other moths by their rapid and sustained flying ability (Scoble, 1995; Sambath, 2011). These insects are of economic importance as their larvae feeds on various important crops.

The first comprehensive work from India on this family was done by Hampson (1892). This family is most diverse in the tropics. It is represented by 1,700 species reported worldwide (Kitching *et al*., 2021), out of which, about 204 species are distributed in India (Bell & Scott, 1937; D' Abrera, 1986; Sambath, 2011). Looking at some historical resume from Maharashtra on this family, Gurule and Nikam (2013) reported 23 species of hawkmoths from 67 nights' sampling covering north Maharashtra (Nashik, Dhule, Jalgaon and Nandurbar) out of which 10 species are reported from Nandurbar district; 45 species from northern Western Ghats, Maharashtra by Shubhalaxmi *et al*., (2011) from surveys during the years 2004–2008; 07 species from the surveys during 2014–2017 from northern Western Ghats, Maharashtra (Kalawate, 2018).

Nandurbar is an administrative district in the northwest corner (Khandesh Region) of Maharashtra. Generally, the climate of this district is hot and dry. Toranmal is a famous Hills station in the district located in the Satpura hill ranges in Akrani Taluka. It is a small plateau with soccer like shape from which a stream flows across the plateau from south to north. From the literature survey, it was noted that just one paper accounting 10 species of hawkmoths from Nandurbar has been documented. Hence, in the present study, an attempt has been made to document the preliminary collected data, their distribution and larval host plant. The species reported here are collected from Nandurbar district and also from the literature (Gurule and Nikam, 2013).

Material and Methods

A preliminary study was undertaken with an objective to study the diversity of hawkmoth fauna from Nandurbar. The survey was undertaken from June 2019 to November 2019 from two regions of the Nandurbar district i.e. Dudhale shivar and Toranmal for 20 nights. The moths were collected by installing light traps consisting of a 160W mercury vapour bulb hung in front of white cotton sheet stretched between two trees in the said locations. The collected specimens were euthanized with ethyl acetate vapours and brought to the laboratory for further studies. Then, it was relaxed, pinned, and dry preserved in the laboratory. Leica EZ4E stereozoom microscope with photographic facility was used to identify the specimen. The identification, classification and distribution followed as per available literature (Bell and Scott, 1937; Sambath, 2011; Shubhalaxmi *et al*., 2011; Gurule and Nikam, 2013; Mitra *et al*., 2019). After identification, the specimens were duly registered and deposited in the National Zoological Collection, Zoological Survey of India, Western Regional Centre, Pune, Maharashtra, India (ZSI–WRC). The common name along with the larval host plant has also been provided in this study. The common name "Spotted Agnosia hawkmoth" for the species *Agnosia microta* (Hampson, 1907) has been coined in this study, as the common name was not found.

The details of collection locality are provided in material examined section and also shown in Figure 1. The map of the collection locality was prepared using the open, free access QGIS software. The images of the moths are provided in Figure 2.

Results and Discussion

The present work is based on the current field studies carried out from this district and review of literature. The study resulted in the record of 20 species in 13 genera and 03 subfamilies of hawkmoths from Nandurbar. The dominant subfamily reported is Macroglossinae (10 species) followed by Smerinthinae (06 species) and Sphinginae (04 species) from this region. This is a preliminary report and extensive survey is required to properly document the diversity of hawkmoths from Nandurbar. In all total 10 species of moths namely, *Agrius convolvuli* (Linnaeus, 1758); *Psilogramma increta* (Walker, [1865]); *Agnosia microta* (Hampson, 1907); *Marumba indicus* (Walker, 1856); *Marumba spectabilis* (Butler, 1875); *Clanis phalaris* (Cramer, 1777); *Daphnis nerii* (Linnaeus, 1758); *Hyles livornica* (Esper, 1780); *Hippotion rosetta* (Swinhoe, 1892) and *Hippotion rafflesii* (Moore, 1858) are recorded new for this region.

Subfamily SPHINGINAE Latreille, [1802]

Tribe SPHINGINI Latreille, [1802]

Subtribe ACHERONTIINA Boisduval, [1875]

1. *Agrius convolvuli* (Linnaeus, 1758) (Fig. 2a)

1758. *Sphinx convolvuli* Linnaeus, *Syst. Nat.* edn. **10**: 490.

Material examined/source: 02 ex., Dudhale shivar (21.3477 N, 74.2414 E), 25.xi.2019, Shital N. Pawara (ZSI-WRC, L-2273).

Distribution: India: Andaman and Nicobar Islands, Arunachal Pradesh, Assam, Gujarat, Himachal Pradesh, Jammu & Kashmir, Maharashtra (Mumbai, Pune, Satara, Raigarh, Nagpur, Nashik, Dhule, Jalgaon, Nandurbar (present study)), Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, South India, Uttarakhand, Western and Eastern Himalayas. Other countries: Africa, Australia, China, Europe, Indonesia, Japan, Malaysia, Myanmar, Nepal, Pakistan, Siberia, Sri Lanka, Thailand.

Common name: Convolvulus hawkmoth (Pittaway and Kitching, 2021).

Larval Host Plant: *Phaseolus* sp. (Fabaceae) (Pittaway and Kitching, 2021); *Alocasia*, *Colocasia* (Araceae); *Helianthus* (Compositae); *Calytegia, Ipomoea, Merremia* (Convolvulaceae); *Arachis, Dolichos, Vigna* (Leguminosae); *Abutilon*, *Hibiscus* (Malvaceae); *Nicotiana* (Solanaceae); *Tetragonia* (Tetragoniaceae) (Bell and Scott, 1937; Sambath, 2011; Holloway, 1987).

2. *Acherontia lachesis* (Fabricius, 1798)

1798. *Sphinx lachesis* Fabricius, *Syst. Ent. Suppl*.:434.

Material examined/source: Recorded from literature (Gurule and Nikam, 2013).

Distribution: India: Andaman and Nicobar Islands, Maharashtra (Mumbai, Pune, Satara, Raigarh, Nashik, Dhule, Jalgaon, Nandurbar), Odisha.

Other countries: Bangladesh, China, Indonesia, Iraq, Iran, Myanmar, Nepal, Pakistan, Saudi Arabia, Sri Lanka.

Common name: Greater death's head hawkmoth (Pittaway and Kitching, 2021).

Larval Host Plant: Solanaceae, Verbenaceae, Leguminosae, Oleaceae, Bignoniaceae, Labiatae (Bell and Scott, 1937).

3. *Acherontia styx styx* (Westwood,1848) (Fig. 2b)

1848. *Sphinx* (*Acherontia*) *styx* Westwood, *Cab. Orient. Ent.* : **88**, t. 42. f. 3.

Material examined/source: 01 ex., Dudhale shivar (21.3477 N, 74.2414 E), 30.vi.2019, Shital N. Pawara (ZSI-WRC, L-1997).

Distribution: India: Throughout India including Maharashtra (Mumbai, Pune, Satara, Nashik, Dhule, Jalgaon and Nandurbar).

Other countries: Arabia, Bangladesh, Bhutan, China, Iraq, Iran, Japan, Malaysia, Nepal, Pakistan, Sri Lanka, Thailand, Vietnam.

Common name: Eastern Death's Head hawkmoth (Pittaway and Kitching, 2021).

Larval Host Plant: *Sesamum indicum* (Pedaliaceae) (Bell and Scott, 1937).

Subtribe "PSILOGRAMMA genus-group"

4. *Psilogramma increta* (Walker, [1865]) (Fig. 2c)

[1865]. *Anceryx increta* Walker, *List Spec. Lepid. Insects Colln Br. Mus.* **31**: 36.

Material examined/source: 08 ex., Dudhale shivar (21.3477 N, 74.2414 E), 07.ix.2019, Shital N. Pawara (ZSI-WRC, L-2232).

Distribution: India: Jammu & Kashmir, Maharashtra (Mumbai, Pune, Nashik, Dhule, Nandurbar (present study)), Uttarakhand.

Other countries: China, Japan, Korea, Malaysia, Myanmar, Nepal, Sri Lanka, Taiwan, Thailand, Vietnam.

Common name: Plain grey hawkmoth (Kitching *et al*., 2021).

Larval Host Plant: *Millingtonia hortensis* (Bignoniaceae); *Tectona grandis* (Lamiaceae) (Namee, 2017).

Subfamily SMERINTHINAE Grote & Robinson, 1865

Tribe SMERINTHINI Grote & Robinson, 1865

5. *Agnosia microta* (Hampson, 1907) (Fig. 2d)

1907. *Marumba microta* Hampson, *Nov. Zool.*, **14**: 327.

Material examined/source: 12 ex., Dudhale shivar (21.3477 N, 74.2414 E), 30.vi.2019, Shital N. Pawara (ZSI-WRC, L-2491).

Distribution: India: Andhra Pradesh, Maharashtra (Mumbai, Satara, Nashik, Nandurbar (present study)).

Other countries: Sri Lanka.

Common name: Spotted Agnosia hawkmoth (name given in the present study).

Larval Host Plant: Not known.

Tribe SICHIINI Tutt, 1902

6. *Marumba indicus* (Walker, 1856) (Fig. 2e)

1856. *Smerinthus indicus* Walker, *List. Lep. Ins. Brit. Mus.*, **8**: 254.

Material examined/source: 04 ex., Toranmal (21.8685 N, 74.4819 E), 01.vii.2019, Shital N. Pawara (ZSI-WRC, L-2255). 01 ex., Toranmal (21.8685 N, 74.4819 E), 03.vii. 2019, Shital N. Pawara (ZSI-WRC L-2487).

Distribution: India: Maharashtra (Mumbai, Pune, Satara, Nashik, Dhule, Nandurbar (present study)).

Other countries: Sri Lanka.

Common name: Lesser Swirled Hawkmoth (Kitching *et al*., 2021).

Larval Host Plant: *Sterculia villosa. Bombax malabaricum* (Malvaceae); *Helicteres isora* (Sterculiaceae); *Grewia tiliaefolia* (Tiliaceae) (Bell and Scott, 1937).

7. *Marumba dyras* (Walker, 1856) (Fig. 2f)

1856. *Smerinthus dyras* Walker, *List Spec. Lep. Ins. Coll. Brit. Mus.*, **8**: 25.

Material examined/source: 01 ex. Toranmal (21.8685 N, 74.4819 E), 02.vii.2019, Shital N. Pawara (ZSI-WRC, L-2256).

Distribution: India: Andaman and Nicobar Islands, Eastern Himalayas, Maharashtra (Mumbai, Pune, Satara, Nashik, Nandurbar), Southern India, Uttarakhand, Western Himalayas.

Other countries: Bangladesh, Bhutan, China, Indonesia, Malaysia, Myanmar, Nepal, Philippines, Sri Lanka, Taiwan, Thailand.

Common name: Dull Swirled hawkmoth (Kitching *et al*., 2021).

Larval Host Plant: *Bombax* sp. (Malvaceae); *Sterculia* sp. (Sterculiaceae), *Grewia* sp. (Tiliaceae), *Bridelia* sp. (Euphorbiaceae) and *Schleichera trijuga* (Sapindaceae) (Bell and Scott, 1937).

8. *Marumba spectabilis* (Butler, 1875) (Fig. 2g)

   1875. *Triptogon spectabilis* Butler, *Proc. Zool. Soc. London,* **1875**: 256.

   Material examined/source: 01 ex. Toranmal (21.8685 N, 74.4819 E), 02.vii.2019, Shital N. Pawara (ZSI-WRC, L-2489).

   Distribution: India: Maharashtra (Mumbai, Pune, Dhule, Nandurbar (present study)).

   Other countries: China, Indonesia, Laos, Malaysia, Nepal, Thailand, Vietnam.

   Common name: Rosey swirled hawkmoth (Pittaway and Kitching, 2021).

   Larval Host Plant: *Meliosma* sp. (Meliosmaceae) (Bell and Scott, 1937).

Tribe "POLYPTYCHUS genus-group"

9. *Polyptychus dentatus* (Cramer, 1777) (Fig. 2h)

   1777. *Sphinx dentatus* Cramer, *Uitl. Kap.*, **2**(9-16): 42.

   Material examined/source: 01 ex., Dudhale shivar (21.3477 N, 74.2414 E), 20.vi.2019, Shital. N. Pawara (ZSI-WRC, L-2428).

   Distribution: India: Maharashtra (Mumbai, Nashik, Nandurbar), Uttarakhand, Uttar Pradesh, Southern India.

   Other countries: Bhutan, Pakistan, Sri Lanka.

   Common name: Straight-lined crenulate hawkmoth (Pittaway and Kitching, 2021).

   Larval Host Plant: *Cordia dichotoma*; *C. sebestena*; *Ehretia laevis* (Boraginaceae) (Bell and Scott, 1937).

Tribe LEUCOPHLEBIINI Boisduval, [1875]

10. *Clanis phalaris* (Cramer, 1777) (Fig. 2i)

   1777. *Sphinx phalaris* Cramer, *Uitl. Kap.*, **2**(9-16): 83.

   Material examined/source: 01 ex., Dudhale shivar (21.3477 N, 74.2414 E), 20.vi.2019, Shital N. Pawara (ZSI-WRC, L-2497). 01 ex. Dudhale shivar (21.3477 N, 74.2414 E), 23.vi.2019, Shital N. Pawara (ZSI-WRC, L-2498).

   Distribution: India: Andaman and Nicobar Islands, Maharashtra (Mumbai, Pune, Nandurbar (present study)).

   Other countries: Myanmar, Sri Lanka.

   Common name: Common Velvet hawkmoth (Kitching *et al*., 2021).

   Larval Host Plant: *Xylia xylocarpa* (Mimosaceae); *Pongamia glabra* (Leguminosae); *Pterocarpus marsupium* (Fabaceae) (Bell and Scott, 1937).

Subfamily MACROGLOSSINAE Harris, 1839

Tribe MACROGLOSSINI Harris, 1839

Subtribe MACROGLOSSINA Harris, 1839

11. *Daphnis nerii* (Linnaeus, 1758) (Fig. 2j)

1758. *Sphinx nerii* Linnaeus, *Syst. Nat. ed*. **10**: 490.

Material examined/source: 05 ex., Dudhale shivar (21.3477 N, 74.2414 E), 07.vii.2019, Shital N. Pawara (ZSI-WRC, L-2307).

Distribution: India: Throughout India including Maharashtra (Mumbai, Nashik, Dhule, Jalgaon, Nandurbar (present study)).

Other countries: Afghanistan, Africa, Bhutan, China, Europe, Japan, Malaysia, Mauritius, Myanmar, Pakistan, Saudi Arabia, Sri Lanka, Taiwan, Thailand, Yemen.

Common name: Oleander hawkmoth (Pittaway and Kitching, 2021).

Larval Host Plant: *Nerium odorum*; *Holarrhena antidysenterica*; *Ervatamia heyneana*; *Vinca rosea*; *Tabernaemontana coronaria* (Apocynaceae) (Bell and Scott, 1937).

12. *Nephele hespera* (Fabricius, 1775) (Fig. 2k)

1775. *Sphinx hespera* Fabricius, *Syst. Ent.*: 546.

Material examined/source: 01 ex., Toranmal (21.8685 N, 74.4819 E), 25.viii.2019, Shital. N. Pawara (ZSI-WRC, L-2427).

Distribution: India: Maharashtra (Mumbai, Pune, Satara, Raigarh, Nashik, Jalgaon, Nandurbar).

Other countries: Bhutan, China, Indonesia, Malaysia, Nepal, Pakistan, Sri Lanka, Thailand, Vietnam.

Common name: Crepuscular hawkmoth (Pittaway and Kitching, 2021).

Larval Host Plant: *Carissa carandas* (Apocynaceae) (Bell and Scott, 1937).

Subtribe CHOEROCAMPINA Grote & Robinson, 1865

13. *Hyles livornica* (Esper, 1780) (Fig. 2l)

1780. *Sphinx livornica* Esper, *Die. Schmett. Th.*, **II** (13): 88.

Material examined/source: 01 ex., Dudhale shivar (21.3477 N, 74.2414 E), 25.viii.2019, Shital. N. Pawara (ZSI WRC, L-2018).

Distribution: India: Maharashtra (Mumbai, Pune, Nashik, Dhule, Nandurbar (present study)), Southern and Western Himalayas.

Other countries: Africa, China, Europe, Pakistan.

Common name: Striped hawkmoth (Pittaway and Kitching, 2021).

Larval Host Plant: *Vitis* sp. (Ampelideae); *Galium* sp. (Rubiaceae); *Rumex* sp. (*Polygonaceae*) (Bell and Scott, 1937).

14. *Hippotion rosetta* (Swinhoe, 1892) (Fig. 2m)

1892. *Choerocampa rosetta* Swinhoe, *Cat. Lep. Het. Mus. Oxon.,* p. 16.

Material examined/source: 01 ex., Dudhale shivar (21.3477 N, 74.2414 E), 25.viii.2019, Shital. N. Pawara (ZSI-WRC, L-2240).

Distribution: India: Andhra Pradesh, Andaman and Nicobar Islands, Arunachal Pradesh, Assam, Bihar, Goa, Gujarat, Haryana, Himachal Pradesh, Karnataka, Lakshadweep Island, Maharashtra (Mumbai, Pune, Nagpur, Nashik, Nandurbar (present study)), Odisha, Sikkim, Tamil Nadu, Uttar Pradseh, Uttarakhand.

Other countries: Bhutan, China, Hawaii, Indonesia, Japan, Malaysia, Maldives, Nepal, New Guinea, Pakistan, Philippines, Solomon Islands, Sri Lanka, Taiwan, Thailand.

Common name: Swinhoe's striated hawkmoth (Kitching *et al*., 2021).

Larval Host Plant: *Borreria*, *Morinda citrifolia* and *Morinda umbellata* (Rubiaceae) (Pittaway and Kitching, 2021).

15. *Hippotion celerio* (Linnaeus, 1758) (Fig. 2n)

1758. *Sphinx celerio* Linnaeus, *Syst. Nat. Ed.* **X**.: 491.

Material examined/source: 02 ex., Dudhale shivar (21.3477 N, 74.2414 E), 11.x.2019, Shital. N. Pawara (ZSI- WRC, L-2364).

Distribution: India: Madhya Pradesh, Maharashtra (Mumbai, Pune, Nagpur, Nashik, Jalgaon, Nandurbar), Western and Eastern Himalayas, South India, Rajasthan, Sikkim, Uttarakhand, West Bengal.

Other countries: Africa, Arabia, Australia, Bhutan, Borneo, Europe, Fiji, Indonesia, Nepal, Pakistan, Sri Lanka, Timor.

Common name: Common striated hawkmoth (Kitching *et al*., 2021).

Larval Host Plant: *Vitis* sp. (Ampelideae); *Spermacoce hispida* (Rubiaceae); *Boerhavia* sp. (Nyctaginaceae); *Rumex* sp. (Polygonaceae); *Caladium* sp. (Aroideae) (Bell and Scott, 1937).

16. *Hippotion rafflesii* (Moore, 1858) (Fig. 2o)

1877. *Choerocampa rafflesii* Butler, *Trans. Zool. Soc. London*, **9**(19): 556.

Material examined/source: 01 ex., Toranmal (21.8685 N, 74.4819 E), 08.x.2019, Shital. N. Pawara (ZSI-WRC, L-2430).

Distribution: India: Eastern Himalayas, Maharashtra (Mumbai, Nandurbar (present study)), Southern India.

Other countries: China, Indonesia, Malaysia, Myanmar, Sri Lanka, Taiwan.

Common name: Raffles' striated hawkmoth (Pittaway and Kitching, 2021).

Larval Host Plant: *Impatiens* sp. (Balsaminaceae) (Pittaway and Kitching, 2021).

17. *Theretra alecto* (Linnaeus, 1758)

1758. *Sphinx alecto* Linnaeus, Syst. Nat. (Ed. X), **1**: 492.

Material examined/source: Recorded from literature (Gurule and Nikam, 2013).

Distribution: India: Maharashtra (Mumbai, Pune, Nashik, Dhule, Jalgaon, Nandurbar). Other countries: Afghanistan, Bulgaria, Egypt, Greece, Iran, Iraq, Israel, Kyrgyzstan, Lebanon, Pakistan, Turkey, Turkmenistan, Uzbekistan.

Common name: Levant Hunter hawkmoth (Kitching *et al*., 2021).

Larval Host Plant: *Dillenia indica* (Dilleniaceae); *Saurauja nepalensis* (Ternstroemiaceae); *Vitis* sp. *Leea* sp. (Ampelideae); *Psychotria* sp., *Rubia cordifolia* (Rubiaceae) (Bell and Scott, 1937).

18. *Theretra clotho* (Drury, 1773)

1773. *Sphinx clotho* Drury, Ill. *Nat. Hist. Exot. Ins*., **2**: 48.

Material examined/source: Recorded from from literature (Gurule and Nikam, 2013).

Distribution: India: Andaman and Nicobar Islands, Maharashtra (Mumbai, Pune, Satara, Raigarh, Sindhudurg, Nashik, Jalgaon, Nandurbar), Odisha.

Other countries: China, Indonesia, Myanmar, Nepal, Sri Lanka.

Common name: Common hunter hawkmoth (Pittaway and Kitching, 2021).

Larval Host Plant: *Dillenia pentagyna*, *D. indica* (Dilleniaceae); *Hibiscus mutabilis* (Malvaceae); *Vitis* sp., (Ampelideae); *Fuchsia* sp., (Onagraceae); *Amorphophallus* sp., (Aroideae) (Bell and Scott, 1937).

19. *Theretra nessus* (Drury, 1773)

1773. *Sphinx nessus* Drury, Ill. *Nat. Hist. Exot. Ins*., **2**: 46.

Material examined/source: Recorded from from literature (Gurule and Nikam, 2013).

Distribution: India: Andaman and Nicobar Islands, Eastern and Western Himalayas, Southern India, Maharashtra (Mumbai, Pune, Satara, Nashik, Dhule, Jalgaon, Nandurbar), Meghalaya.

Other countries: Bhutan, China, Myanmar, Nepal, Sri Lanka, Thailand.

Common name: Yam hawkmoth (Pittaway and Kitching, 2021).

Larval Host Plant: *Pongamia glabra* (Leguminoseae); *Barringtonia* sp. (Myrtaceae); *Convolvulus* sp. (Convolvulaceae); *Dioscorea* sp. (Dioscoreaceae); *Amorphophallus* sp. (Aroideae) (Bell and Scott, 1937).

Tribe HEMARINI Tutt, 1902

20. *Cephonodes hylas* (Linnaeus, 1771)

1771. *Sphinx hylas* Linnaeus, *Mantissa Plant*., **2**: 539.

Material examined/source: Recorded from from literature (Gurule and Nikam, 2013).

Distribution: India: Maharashtra (Nashik, Jalgaon, Nandurbar).

Other countries: China.

Common name: Coffee bee hawkmoth (Pittaway and Kitching, 2021).

Larval Host Plant: *Wendlandia* sp., *Randia dumetorum*, *Gardenia* sp.; *lxora brachiata*, *Pavetta indica*, *Coffea bengalensis, Adina cordifolia*, *Hymenodictyon excelsum* (Rubiaceae) (Bell and Scott, 1937).

Conclusion

Studying hawkmoths are important as they perform pollination in some night blooming plants and their larvae are pest on many economic important crops. In this study, a total of 20 species of hawkmoths are reported from Nandurbar, a dry and hot place of which 10 species namely, *Agrius convolvuli* (Linnaeus, 1758); *Psilogramma increta* (Walker, [1865]); *Agnosia* *microta* (Hampson, 1907); *Marumba indicus* (Walker, 1856); *Marumba spectabilis* (Butler, 1875); *Clanis phalaris* (Cramer, 1777); *Daphnis nerii* (Linnaeus, 1758); *Hyles livornica* (Esper, 1780); *Hippotion rosetta* (Swinhoe, 1892) and *Hippotion rafflesii* (Moore, 1858) are reported for the first time from Nandurbar. In future, detailed survey covering the entire district would be taken up to properly document the hawkmoth diversity of the studied region.

Acknowledgement

The authors are grateful to the Director, Zoological Survey of India, Kolkata & Officer-in-Charge, ZSI, WRC, Pune for providing necessary facilities and encouragement.

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

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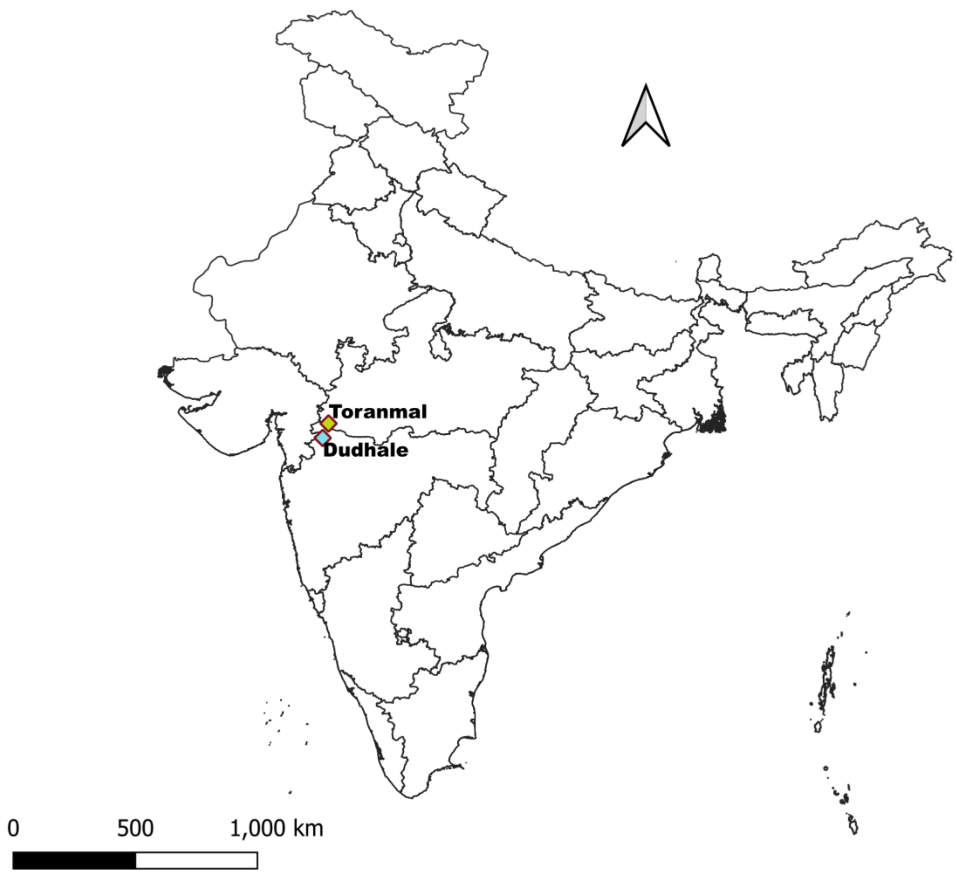
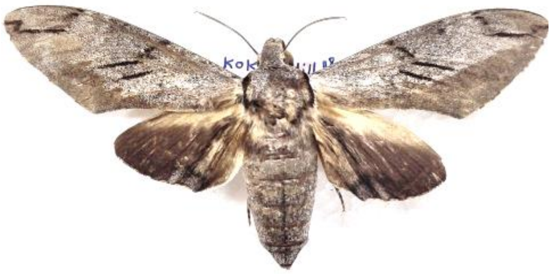


Figure 1. Collection localities of the hawkmoths studied in the present study.

a. *Agrius convolvuli* b. *Acherontia styx styx*



c. *Psilogramma increta* d. *Agnosia microta*

e. Marumba indicus f. *Marumba dyras*

g. Marumba spectabilis h. *Polyptychus dentatus*

Figure 2: Hawkmoths of Nandurbar, Maharashtra, India.

i. Clanis phalaris

j. *Daphnis nerii*

k. Nephele hespera

l. *Hyles livornica*

m. Hippotion rosetta

n. *Hippotion celerio*

o. *Hippotion rafflesii* (museum specimen damaged)

Figure 2. Hawkmoths of Nandurbar, Maharashtra, India.

Incidence of *Nanaguna* sp. and *Perixera* sp. on cashew flowers – Emerging potential menaces in cashew production

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Cashew (*Anacardium occidentale* L.) is a tree nut crop grown in many parts of the world, having good export potential due to its multiple uses in bakery, confectionery, cosmetics, and varied industrial use of the by-products especially cashewnut shell liquid. In India, it is grown in an area of 11.05 lakh hectares. The annual production of cashewnuts in 2018-19 was 7.43 lakh tonnes of cashew (DCCD, 2019). Among the biological constraints, pests are important yield limiting factors in cashew. Tea mosquito bugs and cashew stem and root borers are the two important pests causing significant yield loss in many cashew growing countries. Apart from these two pests, there are few occasional and region-specific secondary pests. Information on the pest species complex, their relative abundance and damage potential is important in the changing pest scenario to understand the pest status of cashew and devise plant protection activities.

Recent studies conducted at ICAR-Directorate of Cashew Research, Puttur (12.45°N latitude, 75.15°E longitude and 90 m above MSL) indicated that different inflorescence pests cause considerable flower damage leading to lower nut set. The inflorescence caterpillars recorded hitherto include, *Lamida moncusalis* W., *Archips* sp., *Dudua aprobola* M., *Hypatima haligramma* M., *Euproctis* spp. *Thylacoptila paurosema* M., *Bombotelia jocosatrix* Guen., *Oenospila flavifusata* W., *Pingasa ruginaria* Guen., *Aetholix flavibasalis* Guen., *Orthaga* sp. and *Hyposidra* spp. feed on the developing inflorescences (Sundararaju, 1993; Sundararaju, 2009). Apart from these, *Perixera* sp. (Geometridae) and *Nanaguna* sp. (Nolidae) are the two emerging new pest species noticed in the last few years. The incidence of *Perixera* sp. and *Nanaguna* sp. was recorded on the inflorescences of cashew during random surveys taken up in the cashew plantations of ICAR-DCR, Puttur between November 2017 and February 2021. Incidence of these two inflorescence pests were noticed from initial flowering *i.e.,* from second fortnight of November or early December till February - March.

The infestation percentage was noticed in 10-15 % of the cashew trees. Larvae of *Perixera* sp. damage the flower buds and flower by chewing the floral parts with slight webbings. In a single inflorescence, a maximum of five larvae have been noticed. Larvae are loopers having band like patterns over the body (Fig.1) express typical wriggling movements. Pupation took place in shoots itself (Fig.2) and the adult moths emerged in 6-7 days. Up to 15% parasitism has been observed in the field collected pupae. The damaged flowers and buds dried away and drastic reduction in nuts set (0-2 /inflorescence) was noticed compared to uninfested ones (3-5/inflorescences) (Fig.3). However, the pest incidence was scattered and in general, a clump of inflorescences got damaged by this pest.

The larvae of *Nanaguna* sp. (Fig.4) webbed the flowers as well as buds into tight clumps and remained inside the webbings. Dried flowers in tight webbings can be seen in the infested inflorescences, which are indicative of presence of larva of *Nanaguna* spor its damage. Wherever the webs were in contact with developing nuts, bored holes inside the nuts were also noticed. Number of *Nanaguna* sp. per inflorescence ranged between 1 and 3 per inflorescence. Apart from cashew, severe incidence of *Perixera* sp. has been noticed in mango orchards located in Doddaballapur taluk of Bengaluru during February 2021. *Nanaguna* sp. has been recorded as a pest of mango (Soumya, *et al*., 2017) which also belongs to Anacardiaceae family. Sudden upsurge in population of *Perixera* sp. has been earlier reported on litchi plants (Kumar *et al*., 2014).

Whenever the damage by inflorescence pests are prominent, timely spraying is very much essential, since yield loss to the tune of 30-40 % has been recorded in unsprayed plots having flower caterpillars compared to pesticide sprayed plots.

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Fig. 1. Larva

Fig. 2. Pupae

Fig. 3. Damaged inflorescences

Fig. 4. *Nanaguna* sp.

Insectivorous birds in and around Regional Central Integrated Pest Management Centre, Bengaluru

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Birds are one of the most fascinating creatures in this world contributing to the Agriculture by consuming insect pests thereby managing pest population (Eilers and Klein, 2009). Bengaluru known for its gardens and lakes harbors diverse avian species (Rajasekhara and Venkatesha, 2014). An attempt was made to observe the insectivorous birds in the premises of Regional Central Integrated Pest Management Centre (RCIPMC), Kadugodi, Bengaluru from July 2020 – May 2021, considering the floral diversity (more than fifteen tree species) within the campus. The different bird species observed at RCIPMC, Bengaluru are listed in Table 1.

These birds have an important role in pest management in the farm lands at Seegahalli and Kadugodi villages near Whitefield, Bengaluru as these villages practicing peri-urban agriculture. The main crops grown in these villages are paddy, maize, vegetables and fruits and the observed bird species (Table 2.) were found feeding on beetles, bugs, caterpillars, grasshoppers and rats. The present observations helped in finding various avian species involved in pest management in these areas thus aiding the farmers in minimizing the use of pesticides.

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Table 1. Insectivorous bird species documented in and around the premises of RCIPMC- Bengaluru

S. No	Common Name	Scientific Name	Family	Prey	Image No.
		Order- Passeriformes			
1.	Red Whiskered Bulbul	*Pycnonotus jocosus*	Pycnonotidae	Caterpillars & small insects	1
2.	Common Myna	*Acridotheres tristis*	Sturnidae SSturnidae Sturnidae	Small insects, beetles & ticks	
3.	Jungle Myna	*Acridotheres fuscus*	Sturnidae	Caterpillars, ticks & other insects	2
4.	Crow	*Corvus splendens*	Corvidae	Grubs, bugs, beetles & other small insects	
5.	Jungle Crow	*Corvus culminatus*	Corvidae	Scarabaeids, cutworms, crickets, bugs & mice	3
6.	Purple rumped sunbird	*Leptocoma zeylonica*	Nectariniidae	Beetles and bugs	4
7.	The Black Drongo	*Dicrurus macrocercus*	Dicruridae	Grasshoppers, cicadas, ants, moths & beetles	5
		Order- Piciformes			
8.	White Cheeked Barbet	*Psilopogon viridis*	Megalaimidae	Caterpillars, winged termites & small insects	6
		Order- Accipitriformes			
9.	Brahminy Kite	*Haliastur indus*	Accipitridae	Beetles, bugs, moths, large insects & rats	7
		Order- Cuculiformes			
10.	Greater Coucal	*Centropus sinensis*	Cuculidae	Large insects, caterpillars & snails	8

Table 2. Pictorial representation of insectivorous bird species found at the premises of RCIPMC- Bengaluru

Image 1- Red whiskered Bulbul *Pycnonotus jocosus*

Image 2- Jungle Myna *Acridotheres fuscus*

Image 3- Jungle Crow *Corvus culminatus*

Image 4- Purple rumped sunbird, *Leptocoma zeylonica*

Image 5- The Black Drongo *Dicrurus macrocercus*

Image 6- White Cheeked Barbet- *Psilopogon viridis*

Image 7- Brahminy Kite *Haliastur indus*

Image 8- Greater Coucal *Centropus sinensis*

Report of *Luthrodes pandava* Horsfield (formerly *Chilades pandava* Horsfield (Lepidoptera: Lycaenidae) infesting *Cycas revoluta* Thunb. in Kerala

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Cycas revoluta is an evergreen tree used for the production of sago as well as commercially cultivated as a landscape plant in almost all botanical gardens. It is a dioecious plant with semi glossy green leaves and the basal leaflets are more like spines. The plant relies on both wind (anemophily) and insect pollination (entomophily), although such anemophily is restricted to female trees growing within a 2-m radius of male trees (Kono and Tobe, 2007). During the months of January to April of 2021, the cycas plants grown in the instructional farm of College of Agriculture, Vellayani was observed with leaflets eaten away. The emerging leaf buds were found completely eaten up and the leaf tips were turned brown and dead (Fig.1). On close and regular examination, purple and green coloured elongate flattened larvae were found hiding on the underside of leaflets (Fig.2). Several lycaenid butterflies were found fluttering and ovipositing on growing leaf buds. The eggs were ornamented and shining white (Fig. 3). The larvae were collected and reared by giving cycas leaflets under laboratory conditions. The larvae were voracious feeders and transformed into pupal stage in 12-14 days. The pupal instars lasted for about a week and later shining blue and dull grey butterflies emerged. This butterfly was identified as *Luthrodes pandava* Horsfield (Lepidoptera: Lycaenidae) (Fig. 4). Marler *et al*. (2012) recorded 85 hosts of this insect belonging to family Cycadaceae. This lycaenid butterfly is a new report from Kerala.

Figure 1. Emerging leaf buds completely eaten up and the leaf tips turned brown and dead

Figure 2. Larvae

Figure 3. Egg

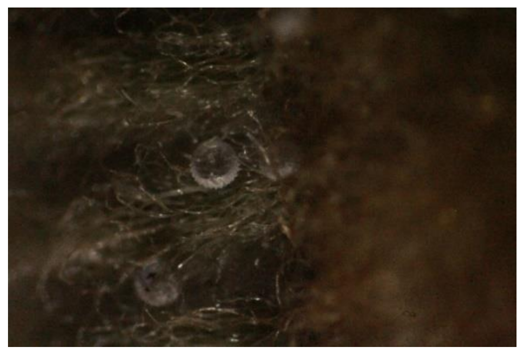

Figure 4. Adults

Acknowledgments

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New record of rice horned caterpillar, *Melanitis leda* (L.) larvae (Lepidoptera : Nymphalidae) parasitized by *Cotesia ruficrus* (Haliday)(Hymenoptera: Braconidae) from rice ecosystem of Assam, India

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Rice is the staple food of Assam comprising about 24.3 million ha cultivated area with a productivity of 52 lakhs metric ton (Anonymous 2017). In Assam, rice is cultivated mainly as winter or *Sali* (June- July to November- December), autumn or *Ahu* (March – April to June-July) and as summer or *Boro* rice (November- December to May – June). The insect pests are more predominant during *Sali* and *Ahu* season infesting different growing stages of rice. Among these, the rice horned caterpillar, *Melanitis leda* L. (Lepidoptera: Nymphalidae: Satyrinae) is presently observed causing a significant damage at different growing stages of the crop. Recently this pest has been recorded from different rice growing regions of Assam whose population has been increasing over a period of time causing considerable loss to the crop. Considering the severity of infestation caused by this pest, presently considered as a minor pest, and might attain the major pest status in near future if not managed effectively. The change in climatic conditions and agricultural practices are reasons where insect pest status has been changing from minor to major or secondary to primary pest. *Melanitis leda* feeds on different plants under the family Poaceae. Literature shows that besides rice, the caterpillar feeds on different host plants such as *Axonopus compressus, Bambusa arundinacea, Brachiaria mutica, Cyanodon dactylon, Eleusine indica, Paspalidium germinatum, Pennisetum setaceum* and *Sorghum halepense* (Saji *et al.*, 1758).

The insect pests were collected by hand picking and sweeping netting from the Instructional Cum Research (ICR) farm of Jorhat, Assam (26.44′ N and 94°10′ E) on regular basis during *Sali* season, 2019. The first, second and third instars of larvae *M. leda* (Figure 1) were collected at different growing stages of the crop. After field collection, the different instar larvae were reared separately in rearing cages (96 x 26 x 24 cm) and were provided rice seedlings as food material. The rearing cages were maintained at temperature 28 ± 1°C, and 80 to 90% (RH) under laboratory conditions. The observations on emergence of parasitoid from the larvae were taken regularly. After 2-3 days of rearing, the parasitoids emerged (Figure 2) from already laid cocoons on the body of the caterpillar which fed on the internal body contents of the host larvae. Each parasitoid spins a spindle shaped whitish cocoon outside the host body after emergence. The cocoons, in general were observed adhering on the host larvae and the adult wasps emerged by cutting a circular lid at one end of the cocoon. The adult wasps emerged were later preserved in 70% alcohol for further taxonomic and molecular identification. The insect samples were sent to Dr. Ankita Gupta, Senior Scientist, ICAR-National Bureau of Agricultural Insect Resources (NBAIR) for identification and it was identified as *Cotesia ruficrus* (Haliday) (Hymenoptera: Braconidae) (Figure 3).

The genus *Cotesia* was first described by Cameron in 1891 which belongs to the sub family Microgastrinae and tribe Cotesiini. *Cotesia* is an economically important larval parasitoid of many of the notorious lepidopterous pests. The range of hosts and distribution pattern of *Cotesia* species can be found in Yu *et al.* (2013). The present study is the first report of rice horn caterpillar (*M. leda*) (Lepidoptera: Nymphalidae) parasitized by *C. ruficrus* from Assam.

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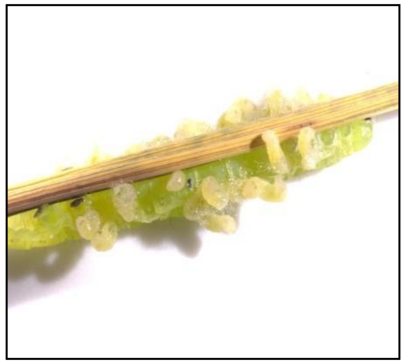

1. Larvae of rice horned caterpillar **2.** Emergence of parasitoids **3.** Adult wasp

Estimation of the duration of Indian bee (*Apis cerana indica* Fab.) venom collection

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Abstract

Honeybee venom is a well-known pharmacologically active product from hive. Electrical stimulation was found to be effective in the bee venom collection where the bees do not lose their sting. The present study on estimation of bee venom collection was conducted at the Indian bee apiaries of College of Agriculture, Vellayani. Studies on the peak venom yielding hour of the day revealed that maximum quantity of bee venom (52.00 g) was obtained in the collections made between 2 pm and 3 pm while least quantity of bee venom was obtained at 7 am to 8 am. The ideal duration to collect optimum venom quantity (25.12 mg) is 30 minutes.

Key words: *Apis cerana indica,* bee venom

Introduction

Honeybees, the hymenopteran insect, possess sting which is the modified ovipositor through which the bee venom is delivered. Venom is produced in the epidermal glands and is stored in a venom sac till its release (Bridges and Owen, 1984). Recently bee venom has evoked interest among researchers to study about its composition and biological activities due to it rising medical benefits and importance. Various methods have been identified for the extraction of venom by stimulating bees with an electrical current (Benton *et al*., 1963; Nobre, 1990). Most of the modern devices for bee venom collection employ the same principle, where the bees do not lose their sting and stay live, hence identified as a safe and efficient method of collection (Schmidt and Buchmann, 1999), both for the bees and the beekeepers. Detailed studies related to the peak venom yielding hour (time of the day during which maximum bee venom can be collected) is scanty and hence this study was conducted.

Materials and Methods

The present study was conducted in the Indian bee apiaries maintained at College of Agriculture, Vellayani (8°25′53.8″N 76°59′09.6″E), Kerala. During the brood rearing season, September- December, 2020. Thirty six hives of almost uniform bee strength (5.5 to 6.0) was selected and labelled. A bee venom collector possessing an automatic cut off mechanism after 40 minutes was used. The collector was carefully taken out after 40 minutes and the glass plate was then placed in a dark ventilated area for drying. A few light strokes with a camel brush were made over the glass plate to remove any pollen or dust, if present. Dried venom was then carefully scraped from the glass surface and weighed. The hives were not fed for at least two days before the collection was made, to avoid undesirable moisture and to enable easy drying of the venom. Bee venom collections were made on an hourly basis from 6 am to 6 pm. Each hour was considered a treatment, therefore a total of 12 treatments. These hourly collections was repeated for three days from 12 hives making 3 replications for a treatment, in total making 36 readings. The scraped bee venom after weighing was kept at 5 °C in amber coloured bottles to prevent oxidation. The optimum duration for which the collector has to be placed in the hive so that maximum bee venom can be collected with minimum damage to the bees (least mortality) was also assessed. The collector was placed in hives for three different durations 30 min, 40 min and 60 min at the peak venom yielding hour. The 60 min collection was performed by first keeping the collector in the hive for 40 min, then subsequently switching on the collector again for 20 min after the device was off from the first 40 min set. Five replications were maintained for each treatment. Venom was scraped, weighed and stored. The data were subjected to Completely Randomized Design analysis.

Results and Discussion

Studies on the peak venom yielding hour of the day revealed that maximum quantity of bee venom (52.00 g) was obtained in the collections made between 2 pm and 3 pm (Table 1.) which was on par with 11 am – 12 noon, 12 noon – 1 pm and 1 pm – 2 pm. 2 pm – 3 pm was selected as it yielded higher venom. The higher venom quantity obtained could be attributed to the peak hive activity and the number of bees in the hives after the foraging activities. Least venom quantity was obtained when collection was made at 7 am to 8 am.

Table 1: Quantity of venom collected (mg) at different hours of the day

Time	Quantity of venom* (mg)
6am – 7am	24.80
7am – 8am	13.50
8am – 9am	35.25
9am – 10am	27.50
10am – 11am	20.90
11am – 12pm	36.00
12pm – 1 pm	33.00
1pm -2pm	48.25
2pm – 3pm	52.00
3pm – 4pm	30.25
4pm – 5 pm	17.25
5pm – 6pm	27.00
CV	29.30

*Mean of three values (replications)

Maximum bee venom (55.34 mg) was collected at 60 minutes duration (Table 2.), but the mean mortality was very high (5.20 bees). Least mortality was recorded at 30 minutes duration (0.8 bees), bee venom collected during this duration was on par with that of 40 minutes. Hence 30 minutes was selected as the ideal duration to collect optimum venom quantity (25.12 mg). This was in accordance with de Graaf *et al*. (2021) where they reported that the bee venom collected for a period of few hours of uninterrupted stimulation is less than the amount collected for the same time, but with breaks included. Electro-stimulation tests conducted for a four-hour period with one minute break at every 30 minutes resulted in exponential bee venom secretion drops with the peak being in the first 30 minutes.

Table 2: Quantity of venom (mg) collected at different durations

Duration (minutes)	Quantity of venom * (mg)	Mortality (No. of bees)
30	25.12	0.8
40	34.14	2
60	55.34	5.2
CV	23.70	

*mean of five values (replications)

Conclusion

There is a rising interest among beekeepers and researchers to study bee venom due to its health as well as economic benefits. An important aspect is to collect maximum venom without damaging the bees and not affecting other foraging or storage activities of the hive. Bee venom can definitely be a source of income to the farmers thus improving their financial stability. The bee venom collector has paved way for collecting venom without damaging the bees, in addition to that, the above studies on ideal duration and peak venom yielding hours can help farmers in collecting maximum venom without compromising honey or pollen yield.

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Sweet shop: An emerging threat of honeybee decline

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Pollination is one of the most important (yet most underrated) ecosystem services, but often taken for granted. It is estimated that one-third of the world's crops require pollination to set seeds and fruits; also one out of every three bites of food we eat is only because of pollinators (Jivan, 2013; Said *et al*., 2015). Besides this the sustainability of wild floral diversity is also greatly influenced by the service of pollinators (Ollerton *et al*., 2011). Insects hold a superior position among different pollinators in which only bees contribute to more than 80% share of pollination services (Robinson and Morse, 1989). Honeybees are the members of genus *Apis* and live in perennial colony and can be domesticated. Only two bee species namely, the European bee, *Apis mellifera* and Asian bee, *Apis cerana* can be domesticated and their use in planned crop pollination is of great economic importance. Over the past decades, decline of pollinators specially the honeybee (*Apis mellifera*), is getting its deserved attention worldwide. The major reasons for the decline of these pollinators are documented as habitat destruction, agricultural chemicals, pests and diseases etc (Potts *et al*., 2010). Recently new dimension of studies registering various inconceivable causes of honeybee population declines have been analysed, and one among these is the disposable paper cups in tea and/or coffee stalls, where the sugary residue left behind in the abandoned beverage cups attracts the honeybees on a large scale and result in death (Chandrasekaran *et al*., 2011; Sandilyan, 2014**).**

Random surveys were conducted at different places of West-Bengal (Table 1) in the same lines to search new drivers of bees decline for a period of three months between January and March, 2021. Based on primary observations, sweet shops had been selected for the study, as honeybees had been found to frequently visit the juicy sugar syrup of sweet shops. The observations were recorded twice in a month and the values were presented as mean and standard deviation.

The foraging worker bees easily get attracted to the juicy sugar syrup of sweets. But when they visit for collection, unwillingly fall into the syrup and were unable to fly, which leads to death of the bees. Thus, the sugary syrup of sweets appears as death trap for the visiting bees (Figure 1). In present study it had been found that an average of 158.35 ± 4.96 (ranging from 128-184) honeybees die in a single sweet shop per day. The mean number of dead bees' increases in the consecutive months from January (153.25 ± 14.76), February (158.63 ± 15.48) and March (163.17 ± 12.86); which also denotes the non-availability of food sources in nature (as in Bengal the honey flow period starts from November-December and continues up to April-May). Apart from this, the foraging visitors cause annoying problem to the shop keepers, as they sting frequently while handling the sweets for selling. Thus, the shop keepers also used to kill the bees manually by beating with the mosquito killing electric nets.

Interestingly, only the honeybees were found to visit the sweet shops, and not other bees namely the solitary leaf cutter bees, sweat bees, carpenter bees etc. The reason may be due to the fact that the honeybees used to collect ample amount of nectar for honey production, as their colony food for dearth, while the other solitary bees not do so (Abrol, 2012). Thus, the honeybees tend to visit the sweet shops to get easy availability of sugar syrup than the natural floral sources, which basically act as an alternative food resource for them.

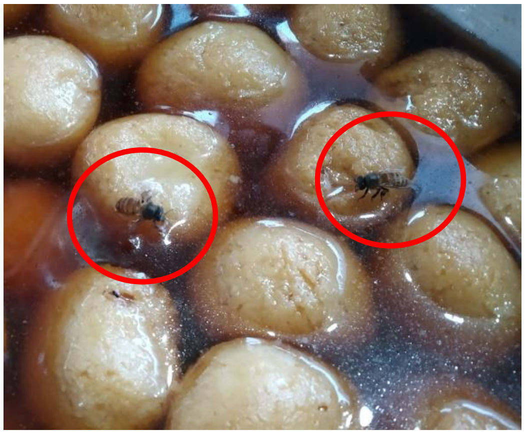
This neglected threat of honeybee decline should be managed with measures like proper covering of sweets with insect net or any other similar means. Educating common people through awareness programme would also help in curbing the decline of pollinators, as it brings up the issues of vulnerability of agricultural production system and sustainability of ecosystem globally.

Table 1: Location of surveyed places

Area	District	Location
Bagnan (Bus stand bazar)	Howrah	22.463146 N; 87.97141 E
Mecheda (Rail Station road)	Purba Medinipur	22.413769 N; 87.85911 E
Sikira (Awalsiddhi more)	North 24 Parganas	22.865614 N; 88.50984 E
Bethuadahari (Rail Station bazar)	Nadia	23.611244 N; 88.384575 E

a.

b.



c.

d.

Figure 1: a, b, and c, Honeybee foragers visiting and collecting sugar from the sweets and syrup; d, Mass of dead honeybees.

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Popularization of beetle fry dish in Majuli river island of Assam

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The white grub beetle, *Lepidiota mansueta* Burmeister (Coleoptera: Scarabaeidae) had appeared as a severe key pest of many field crops in Majuli (N27°0'5.8212", E94°13'27.4728"), the largest mid-river deltaic island of the world. The most severely affected crops were potato, sugarcane, taro and green gram and the extent of damage varied from 42-48, 15-20, 35-40 and 30-35%, respectively. *Lepidiota mansueta* is a unique biennial species, which is the first of its kind from North East India. This species is the first Indian phytophagous white grub with non-feeding adults (Bhattacharyya *et al*., 2015). The species spends its entire life cycle under the ground except for a very short period (two-three weeks) during which adults come out of the ground for mating and oviposition.

Lepidiota mansueta are effectively captured during their pre-mating flights (6.15-7.15 pm) using light traps or by scouting/hand-picking the mated pairs found on the sheltering plants. To combat the beetle menace, a massive mass campaigning was conducted in the island embracing social engineering approaches exploring light traps and scouting by deploying 400 farmers at 40 beetle endemic villages during 2010-2019 leading to massive collection and killing of approximately 11.33 lakhs beetles.

Efforts were made to analyse the nutritional profiling of the beetles for their further exploration as human food/animal feed (Bhattacharyya *et al*., 2018). The proximate analysis of the beetles revealed a higher amount of crude protein content (76.42%) along with other proximate parameters like crude fat (4.10%), crude fibre (5.16%), total mineral (2.98%), carbohydrate (9.18%) and moisture (2.16%). The energy content was 379.29 kcal/100g of sample. Elemental analysis revealed the presence of seven minerals *viz.*, Na (27.76), K (14.20), Ca (33.33), Fe (1.64), Cu (6.52), Zn (15.55) and Mn (1.30) mg/100 g of sample. As antioxidant properties, the phenol and flavonoid content was found to be 4.00 mg catechol equivalent/g and

1.59 mg quercetin equivalent/g, respectively. The DPPH (2,2-diphenyl-1-picryl-hydrazyl-hydrate) was registered 22.60% whereas tannin (3.24 mg/g) as antinutritional compound was recorded at acceptable level. Fatty acid profiling showed maximum amount of saturated fatty acid (2.24%) followed by mono unsaturated fatty acid (0.57%) and polyunsaturated fatty acid (0.49%). Altogether ten fatty acids were estimated, of which palmitic acid content was maximum (0.28%). Amino acid profiling registered 17 amino acids, of which eight were found essential. Considering the immense nutritional value of the beetles, beetle fry dish (Figure 1) was developed and popularized through community feast.

Figure 1: Popularized beetle fry dish in Majuli river island

Conclusion: Initially, the tribal populace relished the cooked/fried adults of *L. mansueta* as protein rich food as part of their traditional belief and wisdom. However, of late, nontribal people of Majuli are also showing their interest to use the beetles as human food/animal feed after knowing the nutritional advantages of the beetles. This effort had tremendous impact in reducing beetle load in Majuli island in terms of protecting the crops, enhancing crop productivity as well as improving both livelihood and nutritional security.

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Anther spur determines the orientation of *Apis florea* prior to the flower entry in *Thunbergia coccinea*

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Introduction

The stability of any species in its natural habitat is dependent on its successful reproduction (Shivanna and Tandon, 2014). Flowers and their visitors have had an intricate relationship from long ago, for many things ranging from food to brood sites. These close-knit interactions tell us about their interdependence. Pollination is one such ecosystem service that indirectly supports the entire living by virtue of producing fruits and seeds which serves as an important food source for many organisms, flower visitors that bring about this is termed pollinators. On the other hand, those just benefitting from the rewards without bringing about pollination are nectar or pollen robbers. Nonetheless, the flower architects itself in a way to limit these illegitimate visitors, thereby rendering reward to the perfect match. Anther appendages play a crucial role in dispersing pollen grains for certain flowers. In *Torenia*, lever actions of the anthers result in pollen shedding (Armstrong, 1992). Flower visitors have the arduous task of finding the troves meant for them.

Flower Morphology and Reproductive organ Architecture

The flower of *Thunbergia coccinea* Wall 1826 (Acanthaceae) is tubular, gamopetalous with a red exterior and yellow inner throat. The calyces are reduced and bracteoles are wine red in color and give out a luster under the sunlight. The male reproductive organ of *T. coccinea* has a good architecture. The stamens are didynamous, the shorter pair of stamens are seen in front of the flower entrance. The orientation of the anthers seems to be tilted inwards thereby clearly distinguishing the outer theca and inner theca. Their outer theca has a long anther spur that is branched unequally. These branching tips have 6-8 pointed endings. The inner theca of the shorter stamen has a shorter spur half the size of the long spur. This spur is unbranched, yet possesses 2-4 pointed endings (Plate 5 and Plate 6).

The theca of the longer stamen with the same tilted orientation possesses a small spur on its outer theca which is also opposing the inner theca of the short stamen. This spur is unbranched yet makes a forked appearance at the tip. Apart from this, all four anthers have dense anther hairs. This explains the detailed morphology of one of the stamens per pair of the didynamous androecium in the study plant. The same explanation holds good for the other stamen of the same pair. The two long anther spurs of outer theca present on the shorter anthers of the didynamous stamen make up a gateway for entry towards the nectar source, the space between them is termed as inter anther spur space. This further leads to the inter-filament space which is the area between the 4 filaments, further down is a tight constriction that seals the whole of the ovary from the rest of the flower. However, there is a tiny odd space hole that oozes nectar, which is one of the major sites of attraction for the flower visitors, the other being the anthers for pollen consumption. The gamopetalous flower of the study plant has five upper corolla lobes and the lower part of each lobe coalesces to form a long floral cup within which the above-mentioned reproductive system is seen.

***Apis florea* behaves as both legitimate and illegitimate nectar visitor:**

Out of 50 randomly sampled flowers five of them were observed to have lateral perforations (LP) which are illegitimate openings created by nectar robbers to rob nectar without bringing about pollination. It is observed that the Indian palm squirrel *Funambulus palmarum* makes these LP's by gnawing the base of the tube and licking off the nectar.

Apis florea bee was found to enter the flower in two ways. One being illegitimate, where the bee does not contact the reproductive organs but through, lateral perforations. If entered so, it feeds on the nectar alone, confirmed by the Proboscis extension reflex. The other legitimate entry is where the bee contacts the reproductive whorls through the flower entrance. The bee has two food sources in this mode of entry, one being the pollen for which it never entered the tube but, was seen around the tube entrance. Another food source is nectar for which the bee enters the floral tube. How is the author sure about the latter scenario among the two? Careless entry into the flower tube can cause spur-gaster/ spur-wing/ spur leg jamming with the anther spur on the way out to the bee, which can further yield costly ramifications (Plate 11 and Plate 12) (personal observations)

Parallelly oriented entry into the flower by *Apis florea* causes easy access to nectar source:

Before the legitimate entry of the bee into the flower it aligns its body and wings parallel to the corolla tube. It carefully moves its head in between the Inter Anther Spur Space (IASS), thus widening the gap between the anther spur, resulting in pollen shedding. It moves further down into the Inter-Filamental Space (IFS) in the same orientation and spends an average of 70 secs (∓5 sec) feeding on the nectar (personal observation).

There are two ways in which they exit the flower. In the first type, the abdomen of the bee is seen out, prior to this the hind legs of the bee are placed on the anther spurs which pressurizes the spur and the IASS increases causing the bee to exit freely with its head moving out last. In some cases, few inexperienced bees do not apply pressure on the anther spur which leads to spur-gaster/ spur-wing/ spur-leg jamming. The latter type of bees spends more time (+30 secs) to move out of the flowers. In the second type of exit, the head is seen out first. After nectar consumption, the bee makes a 180-degree turn, in doing so the head appears on top that is opposite to its entered direction. The bee moves out in the same orientation.

Alightment on the lateral petals ensures parallel orientation in *Apis florea*

The flower has five corolla lobes: the upper head pair, the lateral pair, and the lower lobe. For convention, let us name the lobes numerically starting from the right pair of the upper head in a clockwise manner. This numbering yields ‘2’ and ‘4’ for the lateral lobe pair respectively making them even-numbered petals (Figure1). The bee always alights on one of the lateral lobes making them an entry point to the flower. In some cases, bees alight on the odd-numbered lobes. In such scenarios, it moves and orients its body towards the lateral lobes.

Anther spur serves as an entry signal and maintains preferred orientation into the flower for *Apis florea*

It was observed that 23 out of the 30 flowers with their lateral petals alone dissected out had insect visitations; these insects alight on the lower petal and orient their body in accordance with the anther spur so as to facilitate easy entry into the flower. However, in another experimental setup, only 5 out of the 30 flowers with the anther spur alone dissected had insect visitation rate, these insects move in a haphazard manner in the corolla tube and very limited pollen shedding takes place in this case.

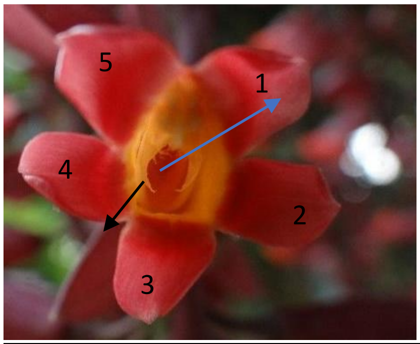

Plate.1: Flower of *Thunbergia coccinea* showing Anther spur (Black arrow) and IASS (Blue arrow). The numbering depicts corolla lobes

Plate.2: The reproductive organ showing a stamen each from the Didynamous stamen.

Plate.3: A flower with exposed style due to Lateral perforation (Black arrow)

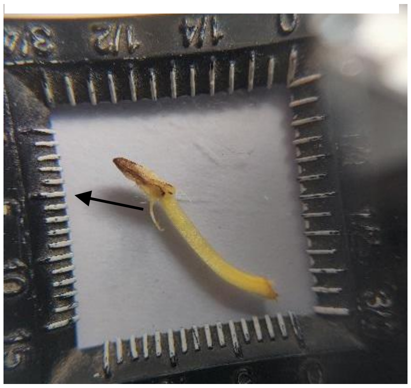

Plate. 4: A hand lens picture of stamen showing anther spur (Black arrow)

Plate.5: A hand lens picture showing branching tip of the short spur

Plate.6: A hand lens picture showing one of the branching tip of the long spur

Plate.7: Top view of the reproductive organ showing the style (Black arrow) within the Intra filamental space

Plate.8: *Apis florea* with filled corbicula.

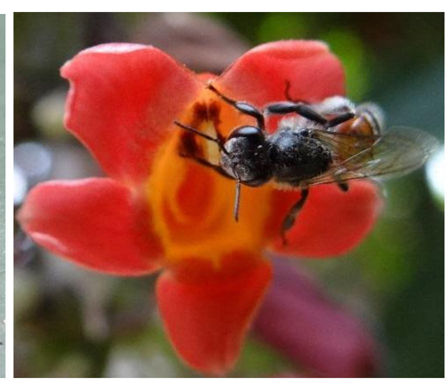

Plate.9: *Apis florea* feeding on the pollen from the anther.

Plate.10: *Apis florea* tunneling through the flower.

Plate.11: Anther spur jamming the gaster of *Apis florea* (Black arrow)

Plate.12: Anther spur jamming the right wing of *Apis florea* (Black arrow)

Plate.13: *Apis florea* (Black arrow) inside the floral tube against an artificial light background.

Plate.14: A flower with anther spurs removed exposing the filaments (Black arrow) directly

Plate.15: Black tip (Black arrow) marked at the base of the flower denotes the final point up to which *Apis florea* can reach.

From the study, it is clearly observed that proper flower architecture is necessary for successful interactions between the plant and the animal. The Anther spur is a floral architecture devised by *Thunbergia coccinea* to ward off unnecessary large flower visitors, this structure also checks the pollen shedding rates on its visitors thereby serving as a pollen-dispersal trigger mechanism (Yang *et al, 2008)*. This parallel orientation of the bee results in copious pollen load on the head region of the bee, any other orientation could lead to unsuccessful visitation for the flower, which can be costly for the plant.

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Diversity of insect orders from two botanical gardens of Bengaluru, Karnataka, India

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Abstract

Diversity forms an important foundation of an ecosystem. To understand the diversity of insect orders, two botanical gardens were selected from Bengaluru, Karnataka. A total of 1,759 and 4622 insects were collected during the study period from the University of Agricultural Science botanical garden (Garden A) and Lalbagh botanical garden (Garden B) respectively. Diversity indices reveal that botanical garden A was diverse when compared to botanical garden B indicating abundance and richness contributes to diversity of the ecosystem.

Introduction

Botanical gardens form an important man-made ecosystem, where varieties of plants are collectively cultivated, preserved and maintained in one area (Kevin and Langellotto, 2011). The plants can be of different collections/ varieties *viz*., succulents, flowering plants, woody trees and even exotic plants. With these varieties botanical gardens act as an excellent resource for insects, birds, reptiles etc. and are considered a good location to carry out various research activities (Jaganmohan *et al*., 2013).

Of the various organisms, insects constitute more than 70% of the animal kingdom. They contribute to important ecosystem services like pollination, predation, nutrient cycling, organic matter decomposition and soil aeration and minor percentage are considered pests (Verghese, 2015). It has been reported that although multiple insects have not been identified there seems to be a decline in the diversity due to various anthropogenic reasons. Therefore, conducting studies in order to identify insects before their decline is highly commended (Didham *et al*., 2020).

Hence, it was decided that the botanical gardens would be a suitable place to understand the diversity of insect orders and the present study was carried out.

Materials and Methods

To understand the diversity of insect orders, two botanical gardens were selected based on human interferences (Figure 1). Botanical garden A (University of Agricultural Sciences Botanical Garden) (13.0822 N; 77.5763 E) spanning an area of about 50 hectares where human interference is minimal was selected as one of the sampling site. The second sampling site was Botanical garden B (Lalbagh Botanical Garden) (12.9507 N; 77.5842 E) spanning an area of about 97 hectares and is considered as one of heritage gardens of Bangalore where the human interference is high.

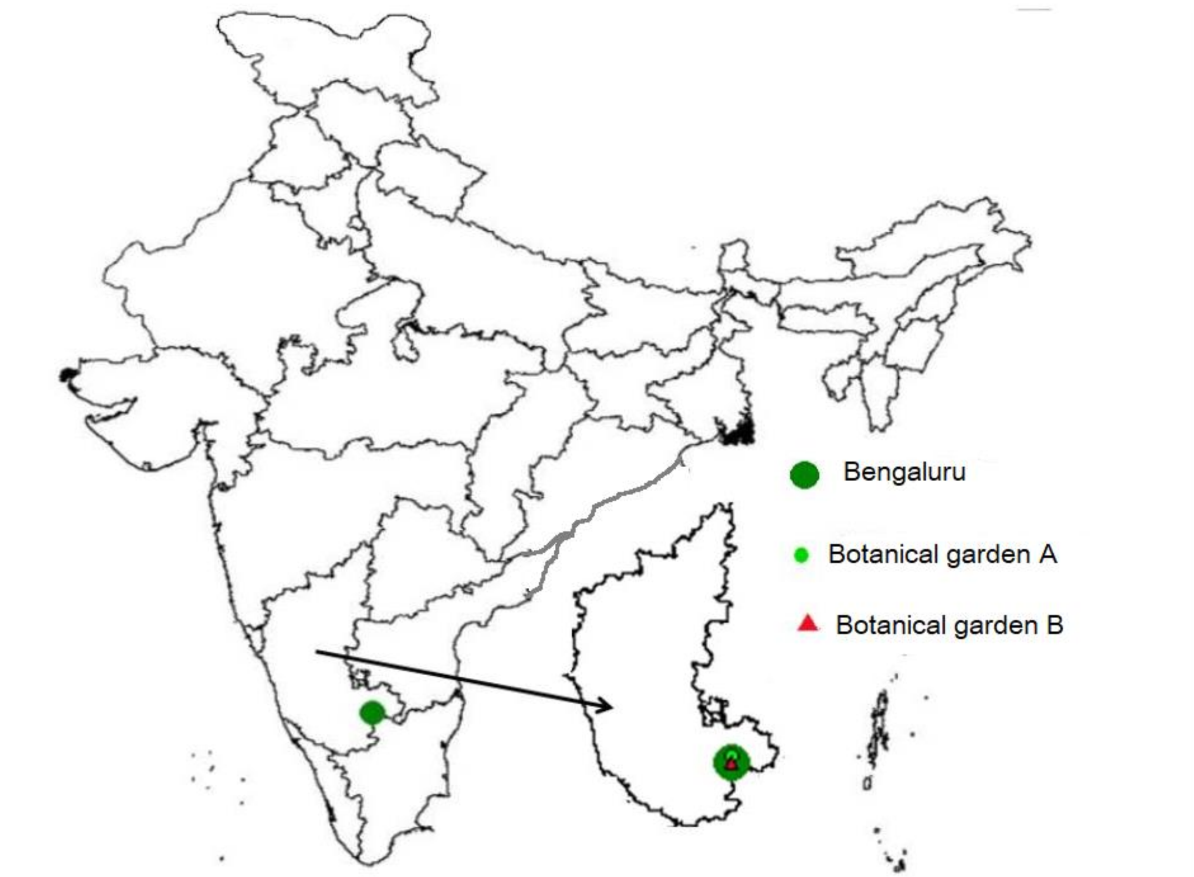

Figure 1. Map created using DIVA GIS version 7.5 showing the sampling locations

From these two botanical gardens, sampling by sweep method using sweep net was carried out. As the area of the gardens selected was not uniform, constant time was maintained. It was carried by two separate batches of students who simultaneously swept both the gardens in the morning from 8.00am to 10.00am under constant supervision. Collections were done once in two weeks for a period of five months from December 2018 to April 2019. Collections from the sweeps were brought to the laboratory; separated, and insects were sorted according to the orders, curated and tabulated. The count obtained from both the gardens was subjected to assess diversity indices (Shannon-Weiner Index, Simpson Index of Diversity and Evenness).

Results

From this study, a total of 1,759 from Garden A and 4,622 insects from Garden B were collected during the sampling period. The collected insects belong to ten insect orders and Arachnida (ticks, mites and spiders) Figure 2 (a and b).

Following are the insect orders identified:

1. Blattodea
2. Coleoptera
3. Diptera
4. Dictyoptera/Mantodea
5. Hemiptera
6. Hymenoptera
7. Lepidoptera
8. Orthoptera
9. Odonata
10. Thysanoptera

Arachnida (Spiders and mites)

Diversity indices (Table 1) reveal that the botanical garden A was more diverse with species richness S of 11 (insect orders and Arachnida), this was supported by Shannon-Weiner Index showing high diversity during most of the sampling dates. The probability of getting similar counts in the insect orders in the next sampling is low as indicated by Simpson Index (values closer to 1) when compared to botanical garden B, where the species richness S was eight and the Shannon –Weiner index showed less diversity for majority of the sampling dates and the probability of getting similar counts in the orders was higher as evidenced by Simpson

Index for most sampling dates. Evenness of insect counts of different orders in botanical garden A was almost uniform for majority of the sampling dates unlike botanical garden B where the counts in insect orders were not uniformly distributed.

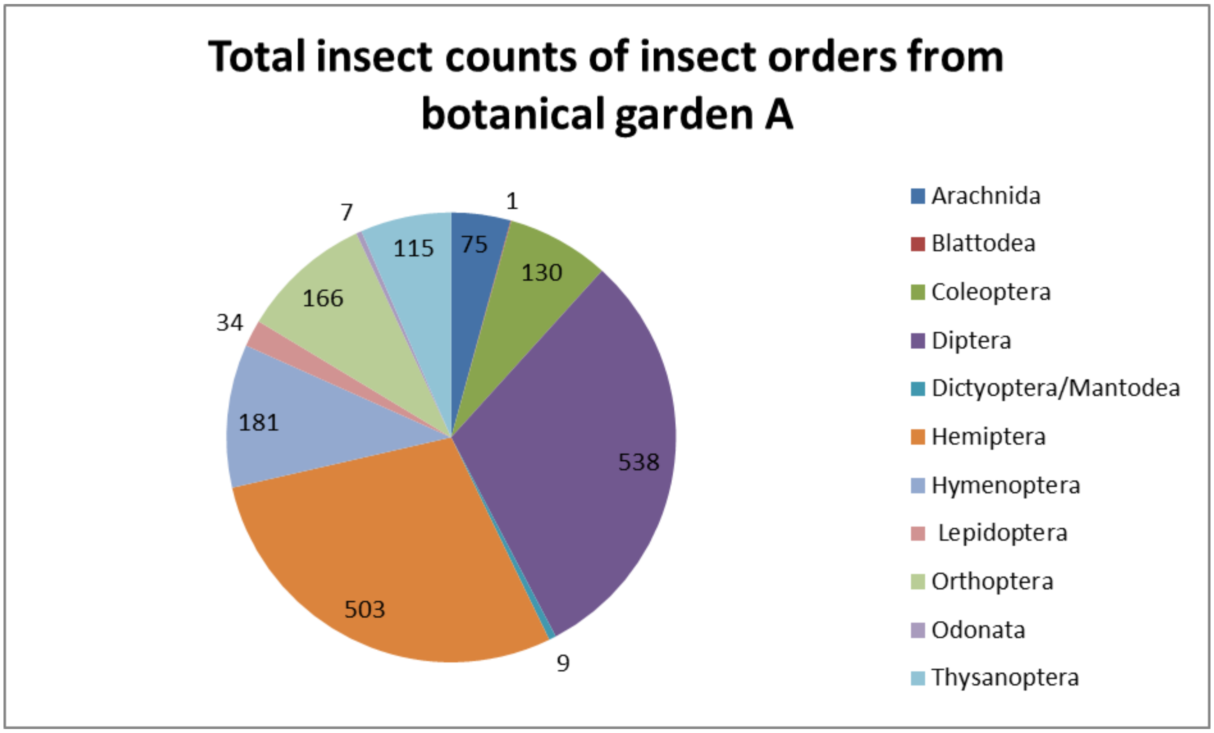

Figure 2 (a). Insect orders with their respective counts from Botanical Garden A

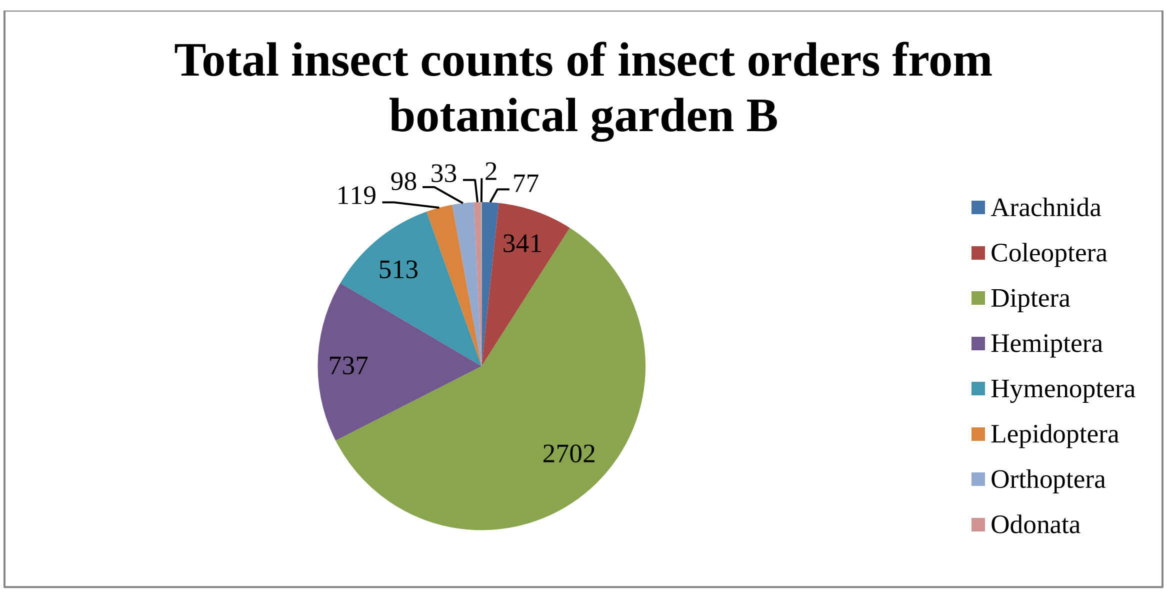

Figure 2 (b). Insect orders with their respective counts from Botanical garden B

Table 1. Diversity indices of insect orders for sampling dates

Species richness S		Shannon-Weiner H		Simpson Index 1-D		Evenness EH	
Bot. Gar A	**Bot. Gar B**	**Bot. Gar A**	**Bot. Gar B**	**Bot. Gar A**	**Bot. Gar B**	**Bot. Gar A**	**Bot. Gar B**
7	7	1.53	0.70	0.74	0.30	0.66	0.29
8	8	1.80	1.24	0.80	0.56	076	0.43
10	7	1.85	1.5	0.81	0.70	0.63	0.63
11	8	1.30	0.89	0.58	0.41	0.33	0.30
8	6	1.74	0.63	0.80	0.30	0.71	0.31
8	8	1.59	1.19	0.74	0.54	0.61	0.41
8	8	1.11	1.31	0.49	0.66	0.38	0.46
6	7	1.22	1.26	0.59	0.60	0.56	0.50
9	7	2.01	1.16	0.84	0.61	0.83	0.46
6	8	1.06	1.21	0.50	0.55	0.48	0.42

Bot.Gar- Botanical Garden

Discussion

The basis of any ecosystem is the uniqueness and diversity of organisms. From the present study it is evident that Botanical garden A was comparatively diverse, though the abundance of insect count are two and half times less than B. This clearly shows that diversity of an ecosystem depends on the richness as well as abundance (Southwood and Henderson, 2000).

The botanical garden A is mainly used for research activities hence human interference like spraying of pesticides/insecticides will be minimal. This could have led to the occurrence of more insect orders than botanical garden B which is a heritage garden hence to maintain, more human interferences like sprays, regular pruning will be involved.

The orders Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Orthoptera are more commonly found insect orders. Presence of Dictyoptera/ Mantodea (nine) mostly predators present in Garden A might be due to less usage of pesticides could be a possible reason because the abiotic factors was common for both the gardens as they were sampled simultaneously. The Hymenopteran (513) and Lepidopteran (n=119) mostly pollinators are more in botanical garden B might indicate more flowering plants than the botanical garden A. Dipteran mostly pests, were highest in both the gardens may be are uncontrollable with the measures adopted or mild/ minimal usage of pesticides in order to save the hymenopterans and lepidopterans and for the health benefit of human visitors/spectators. In the present study, the difference in the counts might vary and this may be due various factors like presence, availability of host plants and agronomic practices involved.

This study though carried out for a shorter duration enabled us to identify the above mentioned orders. More such studies should be encouraged to assess the taxonomic assessment upto species level and if carried out for longer duration will definitely help to identify the diversity of several other insects and their importance in an ecosystem and might also lead in identification of new species.

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Review Articles/ Short Notes/Essays

The dwarf/little honeybee, *Apis florea* Fabricius.

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The dwarf/little honeybee *Apis florea* Fabricius is one of the two species of wild honeybees found in Kerala, the other species being the rock bee *Apis dorsata* F. As its name implies, the dwarf honeybee is the smallest species of true honeybee, both in the body size 7-10 mm body length of its workers and in the size of its nest. It is an important pollinator of crops in hot and dry agricultural plains.

Dwarf bees are found in plains up to an altitude of 300–500 m above sea level. (Rarely found at altitudes above 1500 m, being in absent in northern Himalayas.) They nest in dense bushes, hedge plants, small trees, corners of hay stalks, generally preferring shaded sites. It is also seen in corners of buildings, wells and on rock cliffs. A colony usually builds a single, exposed comb in the open on tree branches or shrubs (Figure 1). Most nests are hung from slender branches of trees or shrubs covered with relatively dense foliage, usually from 1 to 8 m above the ground level.

Figure 1 *Apis florea* colony with single exposed comb in the open on a tree branches

Apis florae, first identified in the late eighteenth century is unique for its morphology, foraging behaviour and defensive mechanisms such as making a piping noise which makes them more susceptible to predation than cavity nesters with large numbers of defensive workers. Apart from its small size, simple exposed nests and simplified dance language, the life cycle and behaviour of this species are fairly similar to other species of *Apis*.

Characteristics

The honeybees are migratory in nature and frequently change their place whenever the colony is disturbed. They often migrate between plains and nearby low hills depending on the availability of a food source. If they are building a new nest near the old one, they salvage the wax from the old nest. Other species of honeybee do not return to the old nest to recoup wax. This behaviour is observed only in this species.

Distribution and Habitat

Apis florea is found in southeastern Asian countries, especially in Thailand, Iran, Oman, India, Myanmar, and some parts of China, Cambodia, Vietnam and Sudan. The comb is always covered by a curtain of worker bees clinging to each other. About three-quarters of the colony's worker population are employed in forming this living protective curtain of bees. A comb has 13.2 cells per cm^2, and the nest is 20 cm in diameter and contains approximately 3600 cells on each side. The upper part of the comb expands by adjoining honey storage cells to form a crest that surrounds the branch or other object from which the comb is suspended. Adjacent to the rows of honey storage cells is the section of comb, which the workers use for storing pollen. Beneath this band of pollen storage cells is the area where the worker brood is reared and queen cells in the bottom during brood rearing season. (Figure 2).

Figure 2 The comb with honey storage cells, brood and queen cell

Castes and Life Cycle

An *A. florea* colony consists of three castes, *viz*., a queen, hundreds of workers and few drones as in other honeybees. The queen bee lays eggs singly in a cell in a wax honeycomb, produced and shaped by the worker bees. She can lay both fertilized and unfertilized eggs. Drones develop from unfertilized eggs, while females (queens and worker bees) develop from fertilized eggs. Larvae are initially fed with royal jelly produced by worker bees, later switching to honey and pollen. The exception is the larva fed solely on royal jelly and reared in larger cells that will develop into a queen bee. (Figure3 & 4)

Figure 3. *Apis florea*- drone bee

Figure 4. *Apis florea*- queen bee

The larva undergoes several instars before pupating. Brood cells for workers and storage cells for honey or pollen are alike, hexagonal; brood cells for males are similar but larger.

Queen-producing cells tend to hang individually from brood combs of worker cells. Development from egg to emerging bee varies among queens, workers and drones. Queens emerge from their cells in 15–16 days, workers in 21 days and drones in 24 days. (Figure5)

Breeding and Lifespan

The average lifespan of a drone is 15.6 days, ranging from 6 to 41 days and that of worker bees ranged from 48 to 56 days. The queen has a much longer lifespan consistent with the longevity of the colony. When a queen mates, the sperm is transferred into the spermatheca directly. The queens typically mate with 3–4 males and hence use the more energetically efficient method of sperm transfer.

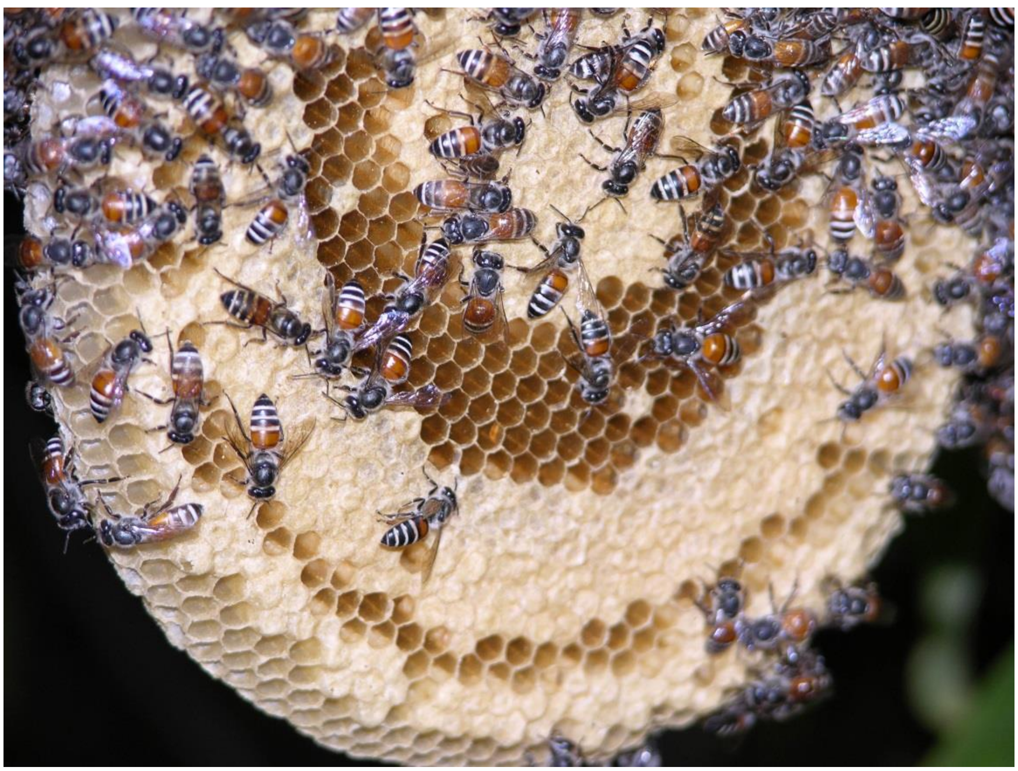

Figure 5 Development of *Apis florea* in the comb

Worker Policing

In the presence of a multiple mated queen eggs laid by workers are removed in a process called worker policing. With worker policing, workers control the production of males by other workers in favour of reproduction by the queen.

Genetic Diversity and Division of Labour

Even in a single nest, there is high genetic diversity among the *A. florea* bees. Since honeybee queens are polygamous, strong genetic variability exists. The tendency of this species to perform certain tasks is dependent on this variation. Among the members of the colony there is division of labour and specialization in the performance of biological functions. The younger individuals work within the nests by performing maintenance while older individuals are responsible for protection and foraging.

Migration and Swarming

The annual colony cycle of honeybees involves migration, swarming and absconding. Disturbances cause the colonies to desert the comb, leaving behind honey, brood and pollen stores. The honeybees are gentle in temperament; however, they do sting when disturbed showing a 'shimmering' movement, with the individual bees shaking their abdomens from side to side in a synchronous manner; at the same time, a hissing sound is released. If the colony is further disturbed, the worker bees raise their abdomens and take off from the curtain to attack the intruder. *Apis florea* swarms travel to the new site as a group and leave to a new site if it is later discovered to be unsuitable. This makes searching for new sites a much faster process but not necessarily more accurate.

Communication and Recruitment to Crops

The mechanism of communication through a dance 'language', which has two important basic forms: the "round dance" and the "tail-wagging dance". The round dance indicates that food is near the hive and the tail-wagging dance gives more details. The distance is indicated by the speed while the direction by the bee's abdomen while in movement. In waggle dance, shaking the abdomen from side to side indicates the distance to a site. The longer the waggle phases, the longer the distance to a site and vice versa. In order to indicate direction workers orient the waggle phase in the direction of the site.

Foraging

They mainly forage for pollen and nectar as food sources as well as water and safety from predators. Their frequent foraging and long migration range display their high degree of mobility. They tend to build combs at lower elevations, away from direct sunlight and on the peripheral side of plant branches.

Conclusion

Apis florea provides source of livelihood in mountainous areas and marginal farmers. It is an excellent pollinator of tropical and subtropical crops, fruits, vegetables etc less prone to diseases and enemies. Due to urbanization, interference of the public destroying the natural domicile and other ecological factors, there has been a decline in the dwarf bee population. Conservation and augmentation of the species should be ensured by creating awareness among the public about the benefit of this species for pollination support and yield enhancement. Destruction of the species by honey hunters and irrational use of pesticides should be prevented by law. As *A. florea* is contributing a major share in the pollination of many agricultural and horticultural crops and forest ecosystem, it should be protected from extinction so as to achieve biodiversity conservation and ecological stability and food security.

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Photography: Dr. Stephen Devanesan

Insects and extra floral nectaries: Sugar-coated strategy more than anatomical anomaly

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Introduction

Flowers, also known as "blooms" or "blossoms," are the female reproductive structures of angiosperm plants. They are colorful, attractive, scented, and used for diverse occasions, from gifts, decorations and to convey emotions. A flower's primary goal is to ensure reproduction through pollination. Insects are responsible for 90 percent of the pollination that happens, and these are mainly from the members belonging to the orders Diptera, Coleoptera, Hymenoptera, and Lepidoptera (Nicoleson, 2007). Such entomophilous insects are attracted to the sweet sugary-rich secretion produced by plants as they serve as a primary source of carbohydrates. The secretion is called "nectar" and is produced by special glands known as nectary or nectarines. The term "nectary" was first coined by Carl Linnaeus, which paved the way for numerous studies till date. Studies were conducted in the early 1820s and 1830s to understand the function of nectar, and in 1833 a study from (Anthony, 2017) suggested that they might assist towards attracting animals in pollination. Nectary can occur anywhere on the plant except the roots and are broadly classified into two types; floral nectary (FN), associated with flowers, and the Extrafloral nectaries (EFN) associated with vegetative parts (Figure 1 and 2).

Figure 1: Extrafloral nectaries on stems of young *Elderberry* plants (Source: Mizell, 2001)

Figure 2: Extrafloral nectaries on the leaf (Source: Mizell, 2001)

EFN have not received due attention to be studied in the research arena dominated by dynamics associated with floral nectaries. EFN are nectar-producing glands on the vegetative parts like petioles, stipules, bracts, pedicels, leaf laminae, fruits, etc. and their sizes can vary depending on the plant species. They can be of different types, namely, extra nuptial nectaries, post floral nectaries, circum floral nectaries, and foliar nectaries. The nectar secreted is primarily 95 per cent sugar, and the rest containing amino acids, lipids, enzymes, and other nutrients.

Phylogeny

The EFNs were first evolved in the pteridophytes and occurred on their fronds, due to the absence of flowers known as "foliar nectaries" (Koptur, 2013). Generally, the EFN origin is thought to be an evolutionary trait in order to form a mutualistic relationship with insects like ants. The ants originated late, around the cretaceous period, which led the researchers to believe that the nectary's initial function did not involve the ants or insects. According to the leaky phloem hypothesis, these secretions resulted from leakage in the phloem sap in the plants' weak anatomical points due to the high phloem pressure (Ward, 2007). In the present geological timeline, the diversity, structures, phenology of the EFN are much greater among the angiosperms compared to pteridophytes and even their interactions with other organisms. The presence of nectar in gymnosperms however, has been debated for a while; their pollination drops (sugary secretions by ovules) were often confused with nectar by earlier workers (Weber, *et al*., 2013; Nepi, 2017)

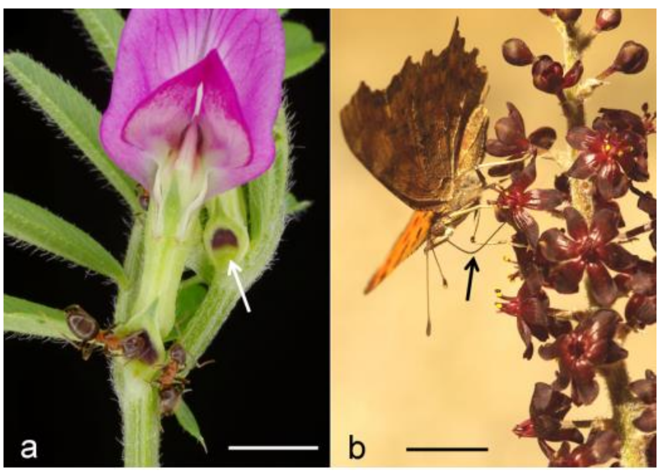

Figure 3: Foraging of the extrafoliar nectar from *Vicia sativa* (a) *and Veratrum nigrum* (b)
Source: Nepi (2017)

Prevalence

There are currently 4017 species of plants, belonging to 110 families that are identified with EFNs. They are more prevalent in families Passifloraceae (11.2%), Malvaceae (7.7%), Malpighiaceae (4.6%), Orchidaceae (2.2%), Rosaceae (1.7%), Salicaceae (1.4%), Lamiaceae (1.1%), Oleaceae (0.8%), Gentianaceae (0.8%), Poaceae (0.7%) (*World List of Plants with Extrafloral Nectaries*). The occurrence of EFN's on the vegetative parts vary in different plant species; it occurs on the leaf margins (*Ailanthus*), leaf axils (*Allamanda*), adaxial surface (*Callicarpa*), petiole (*Cassia*), stipules (*Vicia*), midvein (*Hibiscus*), petiole (*Passiflora*), leaf and inflorescence (*Ricinus*), etc., (Mizell, 2001)

Physiology vs Protection

Researchers have long explored the functioning of this EFN. From the early 1870s to 1970s, various arguments were put forth among the protectionists and physiologists. The physiologists suggested that these secretions prevent the accumulation of excess carbohydrates. "Protectionists hypothesis" is a widely accepted theory according to which the EFN secretions attract ants, parasitoids, and wasps to protect them from other herbivores. However, some obligate and myrmecophytic interactions are formed due to EFN secretions, which also defends the plants from pathogenic attacks. Studies have shown that the plants without EFN's were more prone to herbivore attacks than plants with EFN's (Pereira, 2020). The EFN's can be seen mostly on the valuable part of plants like young leaves or developing fruits and the intensity of the secretion increased depending on the herbivore-inflicted damage. Also, according to the distraction hypothesis, in many species of angiosperms, conflicts arise with insects like ants and other pollinators for the consumption of the sweet nectar. The EFN acts as a distraction by providing nectar in the vegetative parts, preventing these insects from entering the floral parts. In some species of plants, the EFN secretion is at its peak only during the flowering period. When the nectar is already available for the crawling insects, below the flower or near stem, they do not prefer to enter the flower; instead, they remain content with the nectar, which is being offered first. This reduces conflict with the pollinators crucial for plant reproduction (Villamil *et al.*, 2019). Due presence of EFN's near the plant's most viable organs, EFN feeders like ants' patrol around these organs and also act as a natural defender from herbivore attacks.

Synthesis

The nectar production in FN and EFN is produced in similar mechanisms. Cell Wall Invertase (CWIN), a key enzyme stimulates secretion. Higher CWIN activity resulted in higher levels of EFN secretion (Millan-Canongo, 2014). The CWIN responds with herbivory damage, increasing EFN secretion in plants that experience physical harm. Other enzymes that influence the secretion are sucrose phosphate synthase and sugar transporter SWEET9. The unloading of sucrose occurs *via* the CWIN, while the synthesis of the nectar occurs in the nectary parenchyma with the help of sucrose phosphate synthase and sucrose synthase. Nectar is further secreted into the extra-cellular spaces with the help of SWEET9. Before its secretion as liquid nectar, it is further hydrolyzed by apoplastic invertase. Factors that affect the secretion of EFN are blocking sunlight, which can reduce the secretion of EFN and pruning or burning of plants. Apart from these factors, higher EFN has been reported in the youngest part of the plant and among the invasive species of plants (Heil, 2015)

Discussion

Evolution has paved the way for brilliant adaptations and mutualistic relationships, also involving in multi-trophic interactions involving- Ants-Plants-Herbivores (Koptur *et al*., 2018). The EFN's are one such trait that cannot be ignored and whose functioning and evolution have been under debate. They assist in pollination by being the perfect distraction for reducing conflict with the pollinating and non-pollinating insects, forming a natural defense mechanism by mutualistic relationships. These tiny nectary glands are indeed a natural bio-control agent. However, environmental pollution and climate can affect EFN production. Elevated levels of carbon dioxide can increase the number of leaves producing EFN but reduce the volume of nectar production per leaf, and higher levels of temperature can increase the leaf maturation process resulting in ceasing of EFN production. Also, stressful environments like drought can reduce the amount of sugar secreted in the EFN (Holopainen *et al*., 2020).

Types of EFNs include extranuptial nectaries, circumfloral nectaries, postfloral nectaries and foliar nectaries can be located on every plant organ except roots

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Eco-physiology of mud puddling in insects

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Puddling is basically a behavioural trait in which the insects aggregate on wet soil or dung either to obtain moisture or nutrients. Mostly in butterflies, large gatherings in hundreds assemble on the edges of puddles, on moist soil, on dung or on salts (Figure 1). Some other insects such as leafhoppers e.g. Potato leafhopper, *Empoasca fabae* (Harris), locusts and different bee species also exhibit this type of behaviour. For instance, honeybees and stingless bees are known to puddle on sweat and tears (, Banziger *et al.*, 2009). It is believed that the insects puddle for sodium and nitrogen and such nutrients enhance neuromuscular activity and reproductive success. In order Lepidoptera, both butterflies and moths exhibit diverse strategies to gather liquid nutrients. Puddling generally takes place on wet soil but even reported on sweat, human skin, blood and tears. It plays a significant role in lepidopteran nutritional and mating ecology. Puddling is rare or usually absent in immature stages. Molleman (2009) remarked about the strong evidence for the widely cited hypothesis that sodium from puddles is used to enhance neuromuscular activity is still lacking. He further added that the high mobility and long life spans could be associated with puddling behavior, whereas insects such as beetles that are concealed or well defended are less likely to puddle.

The butterflies are behaviourally active only when sunlight and air temperature allow them to achieve their preferred body temperature. Butterflies keep their body temperature upto or close to 98°F by exposing themselves to warming rays of the sun as they are ectothermic (do not create their own body heat). At low temperature, the butterflies move slowly and cannot fly whereas at higher temperature they cannot survive due to heat shock. Therefore, adult Lepidopterans puddle in sunlight to maintain body temperature and get nutrients from wet soil, dung and carrion (Norris, 1936; Downes, 1973 and Adler, 1982). Puddles also contain substances other than sodium that are nutritionally important to puddling insects. Such behaviour i.e., aggregations of individuals for sunlight and feeding is termed as Puddling (Fig 2). The participants in such aggregations are usually young males (Collenette, 1934; Adler, 1982; Adler and Pearson, 1982). The females show this behaviour singly and only females in few noctuid species are found at perspiration or wet sand. Scarcity in sodium in adult's diet triggers puddling behaviour. The association between sex of an individual and puddling is explained by two sets of hypothesis on sodium limitation. Arms *etal.* (1974) suggested that males require more sodium for their neuromuscular activities because males spend larger time in flight than females.

Figure 1. Mud puddling by butterflies on Kollar migratory path in Coimbatore. (Photo Credit: Hand out Email).

The males transfer the sodium and other nutrients collected from puddles to females at the time of mating. This transfer enhances the survival rate of eggs. Puddling is the result of competitive exclusion of males or young individuals from a richer source (e.g. flowers) by females or older individuals. This behaviour is an integral part of the foraging repertoire. The puddling phenomenon is also exhibited by butterflies in their post reproductive period and more than 75% of butterflies which do puddling in post-reproductive period are females. The older ones exhibit this behavioural aspect in order to enhance the declining concentration of sodium and calcium phosphate in their bodies (Adler and Pearson, 1982; Boggs and Dau, 2004).

Few species of butterflies attracted to dung or carrion prefer ammonium rather than sodium. The brush-footed Nymphalids such as *Charaxes bernardus* Fabricius and *Charaxes durnfordi* Distant have the ability to perceive smell and home in rotting meat over a distance of hundred meters. The attraction of yellow-spined bamboo locust, *Ceracris kiangsu* Tsai to human urine is specifically due to presence of sodium and ammonium ions in it (Shu *et al.*, 2014). In few species where both sexes puddle for sodium, male spermatophores have been shown to contain little sodium (Molleman *et al.*, 2005). Feeding sodium to previously mated males increases the spermatophore size, mass of accessory gland substance and number of sperms, relative to those of virgin males (Nihiara and Watanbe, 2009). It is noteworthy that the direct benefits and neuromuscular activities are not mutually exclusive. The males of many lepidopteran species perform intricate aerial courtship displays (Rutowski *et al.*, 2010). The flight performance of males during courtship serves as an honest signal to the females about male ability to provide sodium as a nuptial gift to potential mates. The males with low body sodium are unable to produce quality flight signal due to low neuromuscular activity.

The moths are rarely recorded at puddling sites due to their nocturnal behaviour, although dead moth specimens of families Geometridae, Noctuidae and Crambidae are found in water or stuck in mud at mud puddling sites indicating their active mud puddling behaviour. Gorbunov (2015) noticed mud puddling behaviour in Clearwing moths of family Sessiidae, and observed large congregations of these moths in Laos. The individuals demonstrated aggressive behaviour often bashing other insects from puddles. Showkron *et al.* (2015) described and illustrated the mud puddling behaviour of clearwing moth species namely *Heterosphecia pahangenses* Showkron *et al.,* 2015.

During puddling, the role for puddling nutrients in the overall nutrient budget of insects is species or family specific. Boggs and Dau (2004) demonstrated that butterflies referable to family Nymphalidae feed to a greater extent on dung and have different preferences or detection abilities for ammonium than pierid butterflies which prefer mud. Even marine puddling i.e., seawater puddling is known to occur among 21 species of butterflies referable to families Papilionidae, Nymphalidae, Pieridae, Lycaenidae and Hesperiidae (Pola and Garcia Paris 2005; John and Tennet 2012; John and Dennis 2019). Hewavitharana *et al.* (2013) recorded twenty six species belonging to five families Lycaenidae (9 species); Pieridae (7 species); Nymphalidae (4 species); Papilionidae (4 species) and Hesperiidae (2 species) puddling on bear faeces in Wasgamuwa National Park, Sri Lanka. All these species mainly feed on nectar. The most frequently observed species are Common Hedge Blue, *Acytolepis puspa* (Horsfield) and Lesser Grass Blue, *Zizina otis* (Fabricius) of family Lycaenidae. Phon *et al.* (2017) noticed large aggregations of males of *Trogonoptera brookiana* (Wallace) puddling on a hot spring in Malaysia. Such geothermal sources attract butterflies due to higher levels of ammonia emission and ammonium concentration as compared with those in surrounding waterbodies. Patwardhan (2019) recorded 128 species of butterflies puddling in and around Mumbai. The butterflies of family Riodinidae are the dominant ones, followed by Nymphalidae and Papilionidae. Kolosava *et al*. (2020) reported five species of butterflies namely *Papilio bianor* Cramer (Papilionidae), *P. machaon* Linnaeus (Papilionidae), *Trogonoptera brookiana* (Wallace) (Papilionidae), *Pieris napi* (Linnaeus) (Pieridae) and *Carterocephalus silvicola* (Meigen) (Hesperiidae).

Table 1. Recent records of mud puddling in Lepidoptera

FAMILY	SPECIES	SEX	REGION	REFERENCE
Sesiidae	*Heterosphecia pahangenses* Showkron *et al.*	Male	Laos	Showkron *et al.*, 2015
Papilionidae	*Trogonoptera brookiana* (Wallace)	Male	Ulu Geroh Perak, Malaysia	Phon *et al.*, 2017
Riodinidae	*Abisara echerius* (Moore)	Male	Sanjay Gandhi National Park, Mumbai (India)	Patwardhan, 2019
Nymphalidae	*Danaus chryssipus* (Linnaeus) & *Danaus genutia* (Cramer)	Male	Tungareshwar Wildlife Sanctuary Mumbai (India)	Patwardhan, 2019
Papilionidae	*Papillo demoleus* (Linnaeus) & *Papillo polytes*	Male	Karnala Sanctuary Mumbai (India)	Patwardhan, 2019
Pieridae	*Appias lyncida* (Cramer)	Male	Indonesia	Suwarno *et al*., 2019
Papilionidae	*Graphium sarpedon* (Linnaeus)	Male	Indonesia	Suwarno *et al*., 2019
Hesperridae	*Carterocephalus silvicola* (Meigen)	Male	Kamchatka Russia	Kolosava *et al*., 2020
Papilionidae	*Papilo bianor* Cramer	Male	Kunashir Island Russia	Kolosava *et al*., 2020
Papilionidae	*Papilo machaon* Linnaeus	Male	Kamchatka Russia	Kolosava *et al*., 2020

Conclusions: Mud puddling is certainly not a simple behavourial process. The insects, particularly the Lepidopterans acquire a limited amount of minerals during the herbivorous caterpillar stage which is being sequestered in subsequent life stages. Behavioural adaptations such as puddling enable these organisms to obtain a balanced mineral uptake and overcome the shortfalls in larval nutrition. It is basically the result of competitive exclusion of males or young individuals from a richer source (e.g. flowers) by females or older individuals. The insects adopt the puddling behavoiur due to the requirement of nutrients (especially sodium) and moisture for their survivals and regulated by various abiotic factors such as wind, type and texture of soil, temperature, humidity etc of the ecosystem. It further leads to uptake of other minerals as well as nitrogenous nutrients rather than simply a means of acquisition of sodium. The nutritional needs vary among different taxa (butterflies and moths). Thus, the study of puddling showered more light on nutrient enrichment in insects. Apart from the physiological factors, ecological costs of puddling are potentially important.

Figure 2 Puddling Photo: Krista Melville CWF Photo club

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Pheromone based mating disruption technology- A new era in management of insects

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Introduction

The injudicious use of pesticides has created many problems like insect resistance to insecticides, secondary pest outbreak, killing of non-target organism and environmental pollution etc. So, more attention is given to non-chemical insect control methods in Integrated Pest Management (IPM) programme. Among various methods of non-chemical insect control, pheromone based mating disruption techniques is one of the effective tools in IPM strategies.

Mating disruption is a pest management technique designed to control certain insect pests by introducing artificial stimuli that confuse the individuals and disrupt mate localization and/or courtship, thus preventing mating and blocking the reproductive cycle. It usually involves the use of synthetic sex pheromones, although other approaches, such as interfering with vibrational communication, are also being developed.

Pheromone

Pheromone is derived from Greek word *Pherein*- to transport and *hormone*- to stimulate. Pheromone is exocrine secretions of insects which are used for communication among different individuals of the same species.

Sex pheromone

Sex pheromone is a substance generally produced by the female to attract male for the purpose of mating. It was first discovered by A. A. Butenandt in 1959 from silkworm moths *i.e.* Bombykol.

Majority of sex pheromones are released by female species except cotton boll weevil, cabbage looper and Mediterranean fruit fly where males produce sex pheromone.

Important sex pheromones which have a potential in pest management are dispalure (gypsy moth), gossy lure (pink bollworm), grand lure (cotton grey weevil), loop lure (cabbage looper), heli lure (American bollworm), lit lure (*Spodoptera*) etc.

Table 1: Sex pheromone produce by insects

Insects	Pheromones
American bollworm	(*Z*)-11- hexadecenal and (*Z*)-9-hexadecenal
Codling moth	(*E*,*E*)-8,10-dodecadien-l-ol
Pink bollworm	(*Z*,*Z*) and (*Z*,*E*)7,11-hexadecadienyl acetate (1: 1)
Tobacco cutworm	(*Z*,*E*)-9,11-tetradecadienyl acetate and (*Z*,*E*)-9,12-tetradecadienyl acetate (10:1)
Diamondback moth	(*Z*)- 11-hexadecenal, 11-hexadecanyl acetate and (*Z*)-11-hexadecenol (5:5:5)
Oriental fruit fly	4-allyl-1,2-dimethoxybenzone
Melon fly	4 (p-hydroxy phenyl) 2-butanone acetate

(Source: Jacobson M., 1974)

Use of sex pheromone

- ✓ Monitoring and survey
- ✓ Mass trapping
- ✓ Mating disruption

Mating disruption

Control of insect pests by mating disruption technique is achieved by widespread application of synthetic pheromones over the treated crop.

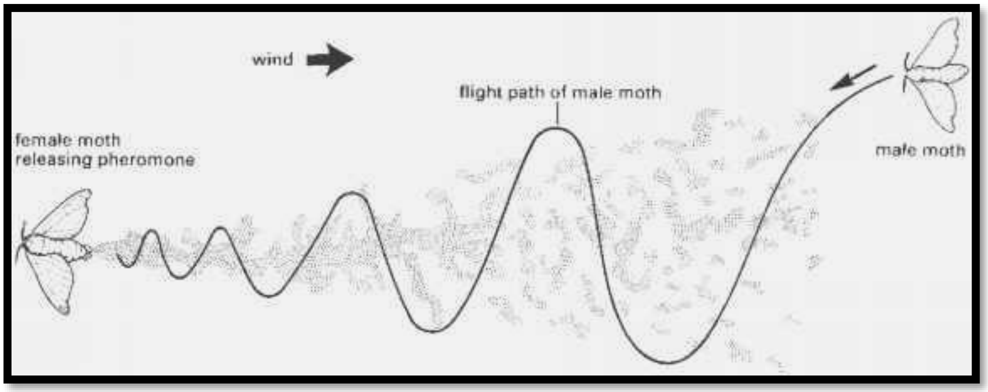
Various slow release pheromone formulations have been developed which either permeate the air with relatively high level of pheromone so as to achieve sensory adaption or provide numerous discrete point sources so as to mask trait following or to create false trail.

Mating disruption is to release sufficient sex pheromone over large enough area so that males cannot find and fertilize females.

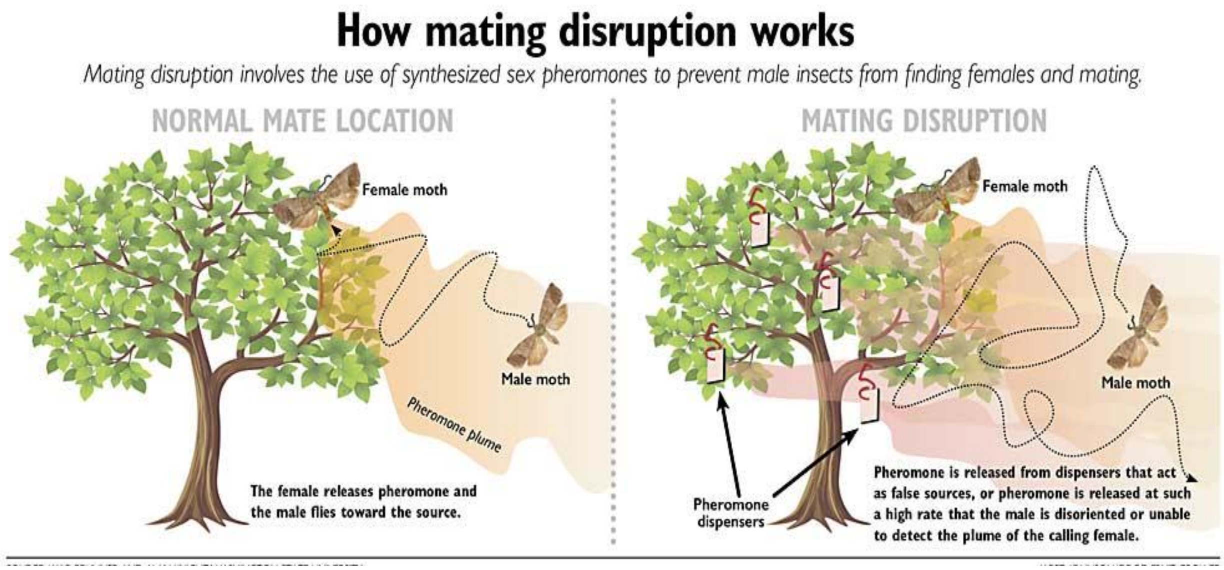
Mating commences with the release of a specific pheromone by the female. When received by the male, this pheromone causes the male to move in a zig-zag flight against the wind towards the source of the pheromone.

Mechanism of mating disturbance

- ✓ Central nervous system effects
- ✓ False trails
- ✓ Masking



Source: Insectomania, 2021



Source: Brunner J. F.

Illustration: Jared Johnson/Good Fruit Grower

Table 2: Successful cases of mating disruption in IPM

Pest	Crop	Reference
Pink Bollworm	Cotton	Doane *et al.* (1983)
Oriential Fruit moth	Stone fruit	Stelinski *et al.* (2007)
Leaf roller	Pome fruit	Pfeiffer *et al.* (1993)
Grapevine Moth	Grape	Schmitz *et al.* (1997)
Tomato pinworm	Tomato	Trumble and Alvarado-Rodriguez (1993)

Table 3: Advantages and disadvantages of mating disruption

Advantages of mating disruption	Disadvantages of mating disruption
• Safety to applicator	• Species specific
• No residues at harvest	• High cost of pheromone dispensers
• Harmless to beneficial species	• Dispenser longevity critical
• No secondary pest outbreaks	• Uniform and large blocks recommended
• Applied less often than insecticides	• May need to place in top of trees
• Resistance less likely	• Immigration of mated female pests
• No specialized equipment needed	• Female pests may mate outside of MD blocks, enter the blocks and lay fertile eggs.
• Prevents pesticide resistance	• Areas with consistent high winds are not suitable for MD because wind will move the pheromones away from the crop.

Research Recommendations for Farmers Community by Department of Entomology, College of Agriculture, Junagadh Agricultural University, Junagadh

Year: 2017-18

Evaluation of new pheromone based mating disruption technology for pink bollworm in cotton

The farmers of South Saurashtra Agro-climatic Zone growing Bt cotton are recommended to give three application of Sawaj Pheromone based Mating Disruption Paste

(Sawaj MDP) technology @ 400 g paste per application per hectare (uniformly distributed in 1000 dots between two branches) against pink bollworm, first at initiation of pest infestation (flowering stage) and subsequent two applications at an interval of 30 days for effective, economical and eco friendly management. **(Anonymous, 2017-18)**

Year: 2018-19

Evaluation of new pheromone based mating disruption technology for fruit fly in mango

The farmers of South Saurashtra Agro-climatic Zone (VII) growing mango are advised to give Sawaj MDP technology 400 g paste/ha uniformly distributed in 1000 dots on main and subsidiary branches of each tree against fruit fly, first application in the month of March, when fruit fly catches in the trap and successive two applications at 30 days interval for effective, economical and eco-friendly management. **(Anonymous, 2018-19)**

Year: 2019-20

Evaluation of new pheromone based mating disruption technology for shoot and fruit borer in brinjal

The farmers of South Saurashtra Agro-climatic Zone growing brinjal are advised to give three applications of Gir Sawaj Mating Disruption Paste @ 400 g per application per hectare (uniformly distributed in 1000 dots between two branches), first at initiation of pest infestation and successive two application at an interval of 30 days for effective, economical and eco friendly management of brinjal shoot and fruit borer. (http://www.jau.in/attachments/FarmersRecommendations/3PlantProtection.pdf)

Conclusions

The indiscriminate use of insecticides is not only costly but also has adverse effects on environment, human health; creates problems of secondary pest out breaks; residues and lead to development of resistance. Mating disruption is a proactive way to protect crops by preventing pests from reproducing in the first place. The over abundance of these pheromones in the field confuses males and they can’t find females for mating. The result is the collapse of insect pest populations without a single drop of pesticide. Mating disruption technology has potential to add value in long-term pest management of many economically important pests. Key factors that can contribute to success of pheromone technology includes: low-density, isolated target population; a lure competitive with wild females; high dispenser density relative to pest density. This would help to emphasize that disruption with semio-chemicals is not usually regarded as a single control strategy developed to replace pesticides, but that it can be an integral component of IPM.

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Climate change: A new dimension in insect pests' damage

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At a remote village in Uttar Pradesh (29°66'N, 77°86'E), my grandfather observed that over the years the menace of insect pests has increased significantly and according to him it was all because of climate change. Being an entomologist I have always considered other reasons like monocropping, loss of biodiversity for this shift, but after the last inter-continental locust attack, I think we seriously need to assume climate change as a realistic reason for the escalating insect pests' damage.

Climate change is a worldwide threat now due to gradual increase of the earth's average temperature, leading to a permanent change in its climate. Global temperature has been steadily increasing up to 1°C since 1900. Furthermore, the rate of global warming is increasing; temperature increased with a double rate during the last 50 years as compared to the last 100 years. In India the mean temperature is proposed to increase up to 1.7º C in *kharif* and up to 3.2º C during *rabi* season, the average rainfall is expected to increase by 10 percent before 2070 (Gupta, 2011) affecting all life forms including insects. The rising levels of Carbon dioxide (CO_2) and temperatures have direct effect on pests and diseases in crops. But will the overall effect be negative or positive? This is a question yet to be answered.

Effects of elevated CO_2 on insect pests

Among all the greenhouse gases, level of anthropogenic CO_2 is almost twice as important for the variation in the temperature. The increase in the temperature due to increased anthropogenic CO_2 level affects insects' including their distribution, phenology, nutrition and role as disease vectors. In general, host plants grown under elevated CO_2 typically make leaf material eaten by insects less nutritious, which can affect their behaviour and performance. As a consequence, in order to alleviate the effects of less nutritious food, insects often consume more host plants. Leaf eating insects feeding performance is positively correlated with leaf water and nitrogen content. Under elevated CO_2, decrease in leaf water and nitrogen contents is observed for mustard and collard plants (Zvereva and Kozlov, 2010).

Elevated CO_2 increases trichome densities, leaf thickness/ toughness and specific leaf weight, which in turn increases mechanical defense of the host plant. It results in less herbivory by insects, as levels of mechanical defense are negatively correlated with consumption rates. Zvereva and Kozlov (2010) detected that overall herbivore performance was lower on plants grown under elevated CO_2 *vs.* ambient CO_2. This is partially due to their higher mortality by parasitoids and other natural enemies as their preys are more evident under elevated CO_2.

Effects of elevated temperature on insect pests

Insects are poikolotherms (cold-blooded) i.e. their body temperature changes with that of the environment. Therefore, temperature plays the most important role in influencing insect distribution, development, reproduction, and survival. The correlation of increased temperature with insect performance is significantly positive as they tend to be more active under warmer conditions. The effects of elevated temperature increases the herbivory efficiency causing a decrease in time to pupate, making them less visible to natural enemies.

It has been studied that with a 2^{o} C temperature increase, insects may show additional life cycles (one to five) per season (Yamamura and Kiritani, 1998). Higher temperature increases the gypsy moth (*Lymantria dispar*) performance, by decreasing its development time and increasing its survival rate. However the survival rate of nun moth (*Lymantria monacha*), become more prone under increased temperatures. Though less predominant than CO_2, elevated temperatures can also have direct effects on plant phenotypes like total non-structural carbohydrates-*viz.*, starches, and sugars which ultimately affect insect herbivores. Temperature may change gender ratios of some insects such as thrips thus affecting reproduction rates (Lewis, 1997). We know that species diversity per unit area tends to decrease with increase in latitude and altitude, meaning that rising temperatures could result in lower mortality of insects in temperate climates.

Effect of changes in rainfall pattern on insect pests

Along with temperature, precipitation changes can impact insect pest, parasites, predators and diseases creating a complex dynamics. Under climate change early and timely planting becomes more uncertain. For example, in 2009, delay in onset of monsoons by 45 days resulted in delayed sowing of pigeon pea that led to heavy damage by *Helicoverpa armigera* (Sharma, 2010). However, some insects are killed/ removed from crops by heavy rains and are sensitive to precipitation. One explanation is that entomofungal pathogens are preferred by high humidity thus their incidence would increase by high humidity due to climate changes.

Summary

Insect species respond differently to changes in environments and it is extremely difficult to predict the impact of climate change on insect pests, but we may expect an overall increase of certain primary as well as secondary pests and invasive species in the future. The best strategy for farmers to follow is to use integrated pest management (IPM) tactics emphasising on pest forecasting, biological and cultural control and to closely monitor insect species occurrence that will determine the feasibility of using certain pest management strategies.

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Novel insecticides in relation to environmental safety

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Insecticides have become an undeniable part of day to day agricultural practices. The most significant factor disrupting biological control of pests in most cropping systems is the over use of insecticides which has led to negative impacts on natural enemies causing pest resurgence or secondary pest outbreaks (Fernande *et al.,* 2010). Conventional insecticides such as chlorinated hydrocarbons, organophosphates (OPs), carbamates and pyrethroids were successful in controlling insect pests during the past few decades, minimizing losses in agricultural yields. Unfortunately, many of these chemicals are harmful to man and beneficial organisms causing ecological disturbances. Therefore, considerable efforts have been made to minimize the adverse environmental impact of these insecticides. This has led to the development of new compounds or bio-rational insecticides *viz*., neonicotinoids, oxadiazines, diamides, tetramic, phenylpyrazoles, pyridine, avermectins, spinosyns, pyrroles, insect growth regulators (IGRs), etc. replacing many conventional compounds because of their effectiveness at low rates, greater specificity to target pests, safer to non-target organisms and the environment (Kodandaram *et al*., 2010).

Today, there is a great demand for safer and more selective insecticides affecting specifically harmful pests, while sparing beneficial insect and other organisms. Furthermore, increasing cases of insecticide resistance by insect pest to conventional insecticides warrants alternatives and more ecologically acceptable methods of insect control as a part of Integrated Pest Management (IPM) programs. Novel insecticides are known to play a crucial role in the management of insect pests infesting many crops. Excellent efficacy, high selectivity and low mammalian toxicity making them attractive replacements for OPs and carbamates, and are considered by the U.S. Environmental Protection Agency as “reduced risk” insecticides. (Grafton-Cardwell *et al*., 2005).

Accordingly, many conventional pesticides have been replaced by novel insecticides which are more selective than conventional insecticides, hence, safer and fit well in IPM programme. Bioefficacy of Novel insecticides like Emamectin benzoate and Lambda-cyhalothrin were tested by Shalini *et al*. (2021) and they reported that these novel insecticides are effective against *Leucinodes orbonalis* and are safer to natural enemies like coccinellid beetle in brinjal ecosystem. As such, they are less likely to cause outbreaks of secondary pests that are well controlled by natural enemies, and may be used as "clean-up" sprays to manage outbreaks of pests caused by broad-spectrum insecticides. The registration of these insecticides has helped to reduce conventional insecticide use in the world.

New and biorational insecticides are effective against different life stages of important insect pests and are less detrimental to certain natural enemies. It is true that no single pesticide is completely safe to different life stages of all natural enemies. The potential benefits of particular insecticides with respect to an IPM program must be carefully considered in light of the dominant insect pests and predators in the application area. Thus, the biorational nature of pesticides depends upon the time, pest and crop. Therefore, in order to maximize the effectiveness in managing pests and for the environmental safety, it is essential to have a thorough knowledge on the life stages of the pests and natural enemies that are present in a particular agro ecosystem. Also the application schedule, timing and delivery methods are crucial in determining the safe use of the insecticide.

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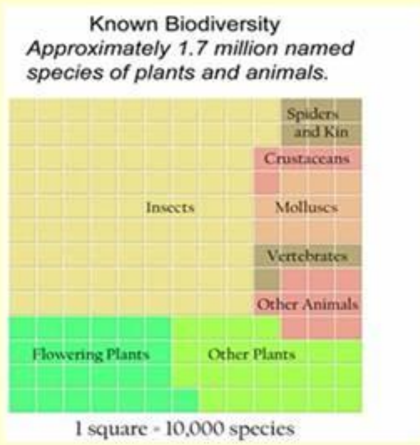
Poster on world biodiversity day

We Insects,
greet you on this
World Biodiversity Day!



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Insects are useful to Man,
So Conserve us !

Give me back my life, I deserve the Earth and its beauty!

Life of bees matter!

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I am a bee. A honeybee!!! I bring this to the notice of mankind…

I was leading a beautiful life with flowers surrounding me. My home was safe and I was busy at my work collecting pollen and nectar, amidst the best of flowers. I cleaned my nest, and fed the brood inside. Some of my enemies in nature attacked my colony for stealing the honey. I was naive and lost. I knew not what I could do. I did not even defend my colony, it all happened suddenly. I was told, if I sting, I die! That's my sacrifice to protect the colony. I would certainly have! Meanwhile the humans interfered in my life, they grabbed my food, destroyed my home, they literally left us dying. Do you know how hard it's for me to build a single comb? We put lot of efforts in building a single colony! You humans will never know!! You destroyed everything of mine.

But, we had to still live, for the remaining few from my hive moved further away from the forest. I shifted my work from forest to farm flowers in search of food. Humans dint allow that either! There they created a nuisance by spraying excessive chemicals, to keep away the pests! Those chemicals made me blank, I lost my vision, and now I'm helpless! I cannot even communicate with my colony members. Pesticide is poison! I want to tell my sisters not to enter the field. But, the pesticides have blocked all my ways of communication; I know I'll die soon because of the poisoning. Now, they even started destroying dear nature, with whom I was closely associated I love to live on this beautiful earth by providing you my pollination services. I request all the humans to bring back my life which I was leading in the past.

Create a habitat for me. Plant more trees, atleast a flowering plant in the balconies of your concrete jungles. Don't kill me when I enter your beautiful homes, open the windows and doors so I may fly out. There are many natural products and biocontrol agents which can replace the poisonous chemicals, use them for pest control and save . People who are rearing me for commercial purpose listen, don't destroy the entire comb to harvest honey instead use honey harvester and replace my comb. No, matter I will provide the honey. During dearth period provide some food for me. Kindly check for the entry of natural enemies in my nest and save us inside the box. Don't burn hives down. Give us a replacement home, we will move after our queen is transferred. Start extending the colonies which have been rearing in the bee boxes, stop destroying the natural colonies. When you eat some fruit preserve the seeds of it and while moving out throw the seeds in the open place, so that during rainy season they sprout out and grow which makes you feel proud that you are contributing to the environment and saving many lives including your life. I will be blessed if humans follow any one of these. I hope I will be safe in human hands in the future don't break my hope.

Lets live together, if I die, you may last for only few years….

BEST WISHES

Regional Central Integrated Pest Management Centre (RCIPMC)

Government of India, Ministry of Agriculture & Farmers Welfare

Department of Agriculture, Cooperation & Farmers Welfare

Directorate of Plant Protection, Quarantine & Storage

Jaivik Bhavan, Kannamangala Post,

Via Kadugodi, Bangalore

Karnataka-560067

The Journey of 'Entomology Certificate Course' in St. Joseph's college (Autonomous), Bengaluru

Emblem of the College
(Worker bees encircled in red)

Entomology certificate course logo
(Birdwing, dung beetle, honeybee and dragonfly designed by Kishan Nag)

"Little Things That Run the World", wrote eminent ecologist E.O. Wilson referring to the importance of conserving invertebrates. Insects constitute a magnificent percentage of these creatures. Around 80 percent of members of Animalia are arthropods, and out of this percentage, 72 percent are insects. They are one of the oldest taxa on Earth, some tracing back to even 350 million years ago. They come in varied colors, shapes, and sizes, ranging from the tiniest of fairyflies and the most colorful of butterflies to the largest of wetas and the most cryptic of moths. With such fascinating diversity, it is a delight learning about them and Entomology is a branch dedicated to study of insects from Ants to **Z**orapterans.

Present

The Entomology certificate course (initially referred to as Honour's programme) conducted in St. Joseph's College, is comprehensive and enlightening, offering valuable insights into the lives and taxonomy of these critters. This is a 90 hours course (currently 60-hours due to the pandemic). Students from all the streams are welcome to join. Presently coordinated by Dr. M. Jayashankar (JS), this program's syllabus delves into the subjects of Taxonomy, Applied Entomology, Insect Ecology and Conservation, and Scientific Writing and Presentation. Theory is complemented with Practical sessions involving collection and curation, minor research projects, Invited talks, and technical visits – notably Centre for Ecology (CES)- IISc, Indian

Institute of Horticultural Research (IIHR), and National Bureau of Agriculturally Important Insects (NBAIR).

Genesis

Entomology was a full-fledged 100-hour honors course, directed by the eminent and venerable Dr. Geetha Viswanathan (GV), former Head of Department of Zoology. Her teaching journey began in 1987. Rev. Father Nelapaty, Principal at that time, encouraged her to start two honor's courses in Entomology and Genetics, which were her areas of expertise. Intended to compensate for the fourth year of under graduation needed to study MS in many countries abroad, these honors courses were of academic demand. GV was entrusted with the curation of the scheme, which she achieved with help from her guide and the IISc researchers. In no time, she became the first female staff to be part of the Department and became the Director of both Entomology and Genetics courses. The strength of students was impressive, with already 70 enrolling for both in the very first year! Registration fees was a nominal amount of Rs. 50, along with other costs (like travel money) borne by the students. Theory classes for Entomology were held during Saturday afternoons. Groups of two to three were formed and accompanied by GV, they would perform small experiments to be submitted as dissertations. Some were published for their meritorious value in journals like 'Insect Environment'. Dr. Abraham Verghese (Former Director, NBAIR) is a long associate of GV and a subject resource scientist for the students of entomology course.

Interesting tasks by (ento) workers!

- *Bee raga:* GV recollects a particularly delightful experiment she conducted with her students on honeybees maintained in bee boxes placed on terraces. They played different kinds of music to the bees and saw the corresponding honey production. She calls it 'Music Therapy'. Following that, they sent their observations for biochemical assays. The quantity and quality of honey made in response to M.S. Subbulakshmi's songs were rather high!.

  The hostel block stone building in SJC (one of the oldest colleges in the state of Karnataka with a history of 139 years) is home to numerous colonies of the stingless bee, an in-house experiment lab to observe colony activity. A bee box will soon be placed in the

Arrupe garden. Envisioned by the French Foreign Missionary Fathers in 1882, the emblem and motto of the college announce the core values of the institution. There are two bees on either side of the lower part of the cross representing hard and persevering work.

- *Blood and sweat:* Students often come to GV for mentorship and projects. She assigns small activities for them to carry out, that prove incredibly helpful for practical experience. Once, they performed an experiment on female mosquitos, procured from the Bangalore university lab. Securing a glass tank, they removed glass from one side and placed sleeves on them. After starving the bloodsuckers for a day, they released them into the glass tank. Four students with different blood groups were then allowed to insert their hands in, through the sleeves. Observations were made on which hand mosquitoes flocked to, i.e., which blood group they preferred most and why.

- *Campus connect:* The ornamental plants in the campus are laboratory to study tritrophic interaction involving plant-mealybug-ant association, ants, moths and butterflies are provide biodiversity inventories, weaver ant and rock bee colonies, pollinators of the campus. Checklists of entomofauna of the campus are prepared and are monitored.

- *Pandemic era:* Fruit trays and mud puddles were used to attract and observe insects. Photography of representatives of different orders of insects, observation of pollinator activity, setting up pitfall traps, and listing of beneficial and harmful insects in and around the residence were some projects assigned during the pandemic to avoid venturing far from residence. Online viva were conducted to assess the review dissertations on various aspects of insect taxonomy, ecology, and behavior.

Bugs on wings: Field and lab visits

Field visits were prevalent to acquaint the students with lab techniques, surveys, and observations. Kavalur, a quaint village in the Jawadhu Hills in Vaniyambadi taluk, Tamil Nadu, hosts a forest and the Vainu Bappu Observatory (VBO). Batches of students would travel there among other locations. They would observe all kinds of species and phenomena, from fireflies at night (bioluminescent flash frequency) to termites (extent of damage on sandal wood trees) in the day. In recent times field visits to A Rocha field study center adjoining the Bannerghatta

National park were organized. Small projects would be undertaken, which often turned into dissertations. These scientific works would then be assessed by external examiners. After spanning 100 hours, an exam was conducted. Dissertations would be submitted for assessment, and *viva* would be held. Ms. Geetha believes in external examinations for quality and unbiased assessment. She would also allot blue books to each student and assign thinking-based questions. JS (former entomology course student) fondly recollects his bluebook assignments on pollinators, making greeting cards highlighting significance of insects. They would again be assessed by external examiners. Dr. K. P. Jayanth (Entomologist) was one of the external examiners for entomology. When the number of science combinations increased, so did the enrollments. Numbers often peaked to a 100 and above. Often, the number of enrolled students from outside the college was more. The end of the course was marked with a short convocation, and certificates with medals would be issued by the college. The external examiners would present them to the students.

'Insect Environment' the online insect journal, has been a forum for entomology course students to publish short research notes and essays. It is a platform to launch young minds aspiring to pursue career in entomology!

Geetha Viswanathan*, Nandita Madhu and M. Jayashankar

*Former Head, Department of Zoology, School of Life Sciences

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Profile

Tribute to the "queen bee"

Prof. Geetha Viswanathan and Dr. M. Jayashankar

Having dedicated 27 years to teach 27 batches of Entomology, GV feels blessed. She is largely, a positive person who ignores the negativities in life. "I only focus on the positive. Whatever happens is for the good." She says, with a smile in her voice. The most important aspect of teaching for her is the impact a teacher has on a student. Many teachers come and go in a student's life, but very few stay on in their mind. Whoever does is "truly blessed with a gift by God". Many students have kept in touch with her, years after learning from her, a true testimony to her teaching. Her faith in God is powerful. She believes that the unseen spiritual energy, the life force that is imbibed in us, is what we call God. The environment is an evergreen source of knowledge to her. "We cannot conquer the world. We can only learn from it, from nature, the environment..." Students were her "DNA", they were the source of her energy and she has volumes to say about her experiences with them. The present coordinator (JS) was GV's student during 2000-03 at SJC and also an entomology honour's student.

This is just an example of what one can study in Entomology, a treasure trove of intriguing topics. Nandita Madhu belongs to the 2020-21 batch of the course and sums the experience - "I have always been intrigued by insects, especially lepidopterans, dung beetles, cicadas, and odonates. The course has enhanced it to a much greater level. By exposing us to different arenas and concepts within the field of entomology, JS and the guest lecturers have illustrated just how the study of insects is diverse and wide-ranging. We learnt not only through these talks, but also assignments, projects, and dissertations. We were encouraged to study and observe these beings on our own. The course is wonderful and all-encompassing, leaving behind a lasting impression on students".

Dr. M Jayashankar

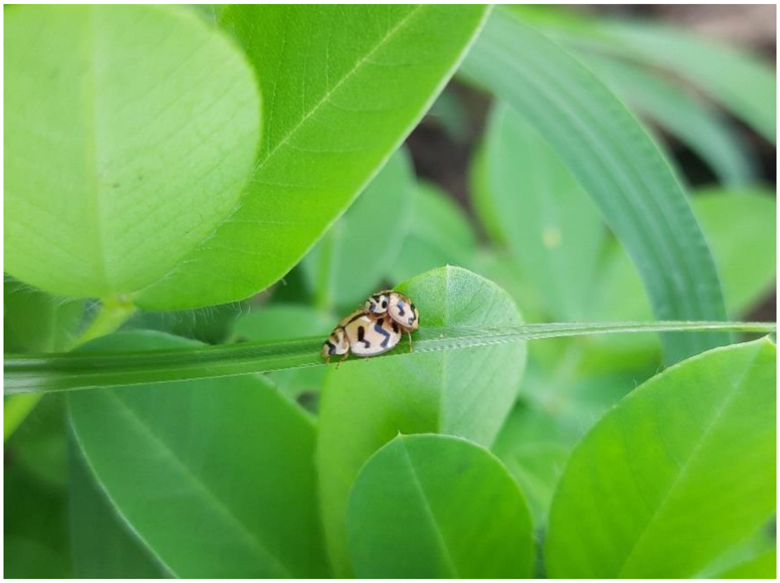
Insect Lens

Rock bee (Apis dorsata) – left side; European honeybee (Apis mellifera) – right side above and Indian honeybee (Apis cerana indica) – right side below, visiting a single sunflower

Author: Rakesh Das, Research Scholar, Department of Agricultural Entomology, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal
Location: BCKV, West Bengal
Email: rdas6907@gmail.com

White grub beetle, Lepidiota mansueta Burmeister

Author: Partha Pratim Gyanudoy Das, Ph. D. Scholar, Department of Entomology, Assam Agricultural University
Location: Majuli river island, Assam, India
Email: parthagyanudoy.das3@gmail.com

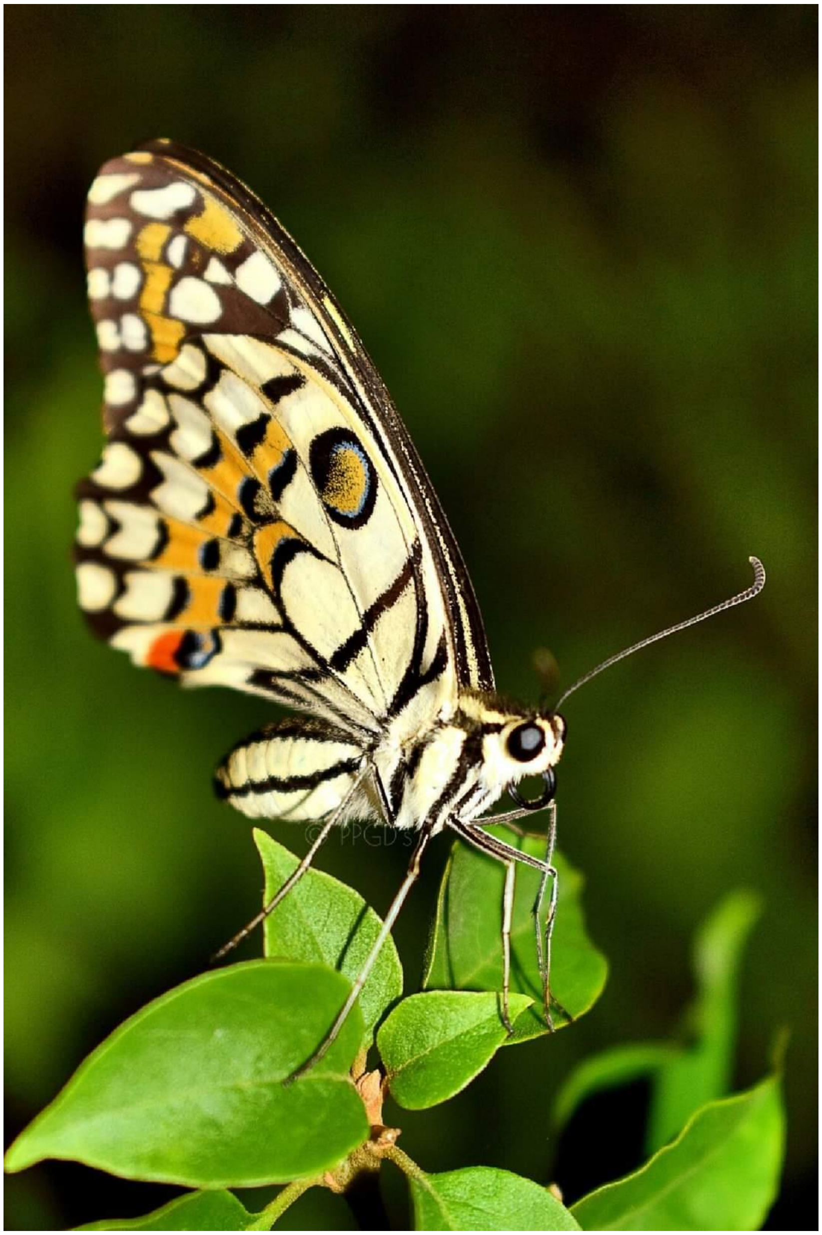


Lady Bird Beetle, Menochilus sexmaculatus

Author: Kotak Jigar Narendrabhai, Technical Assistant, JAU, Junagadh
Location: Groundnut Field, Main Oilseed Research Station, JAU, Junagadh
Email: jigarkotak@yahoo.com

Tawny coster, Acraea terpsicore

Author: Dr. Soumya B R
Location: Anavatti, Shivamogga, Karnataka
Email: soumya.gowdar@gmail.com



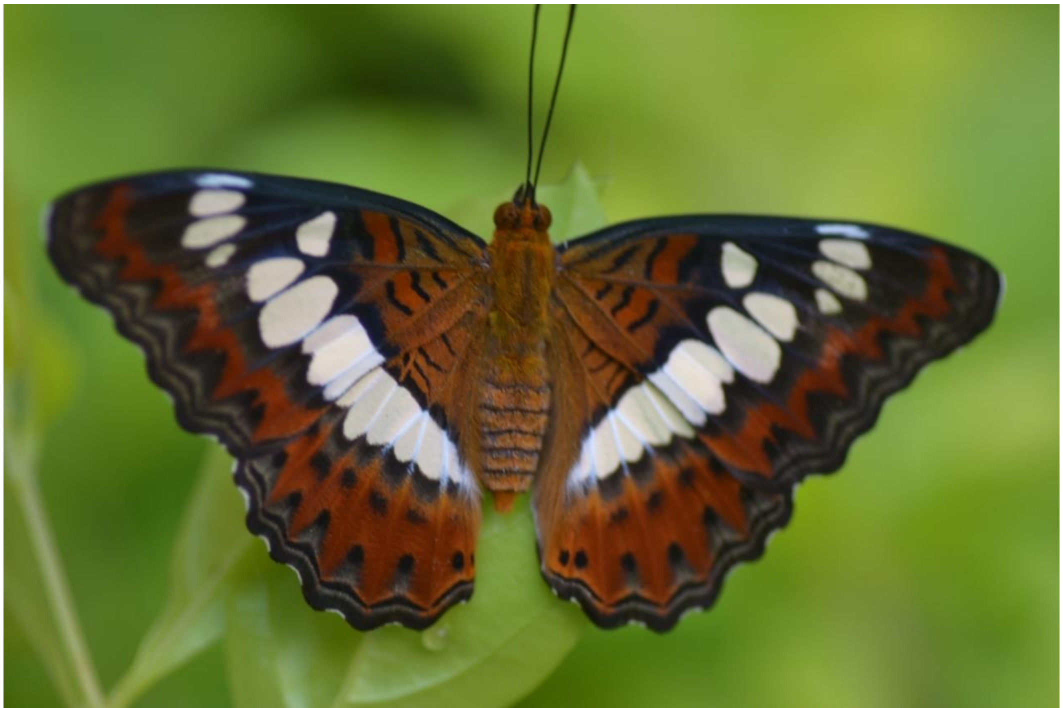
Lime butterfly, Papilio demoleus

Author: Partha Pratim Gyanudoy Das
Location: ICR Farm, Assam Agricultural University, India
Email: parthagyanudoy.das3@gmail.com

Commander butterfly, Moduza procris, The larvae found feeding Mussenda frondosa

Commander butterfly, Moduza procris, Pupa

Author: Kalleshwara swamuy CM, Assistant Professor, Dept of Entomology, UAHS, Shivamogga, Location: Mudbidre, Dakshina Kannada district, India
Email: kalleshwaraswamycm@uahs.edu.in



Commander butterfly, Moduza procris, Adult
Author: Kalleshwara swamuy CM, Assistant Professor, Dept of Entomology, UAHS, Shivamogga
Location: Mudbidre, Dakshina Kannada district, India
Email: kalleshwaraswamycm@uahs.edu.in

Honeybee, Apis mellifera (Apidae: Hymenoptera) pinned to a thorn on Solanum leaf
Author: Dr Sevgan Subramanian, International Centre of Insect Physiology and Ecology, Nairobi, Kenya Location: Nairobi, Kenya,
Email: ssubramania@icipe.org

Rat tailed maggots, Eristalis (Linnaeus)

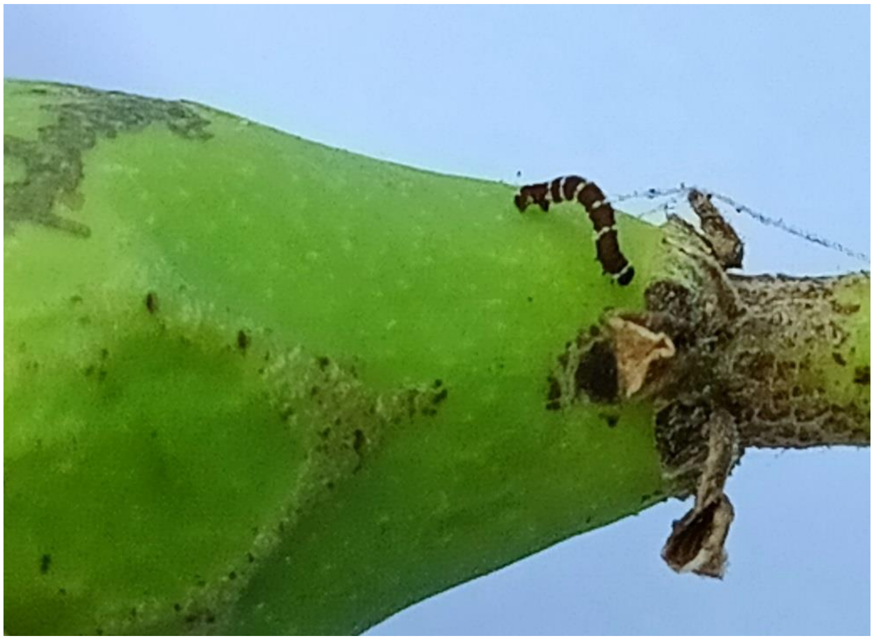
Author: Bharath B, Student at St. Joseph's College (Autonomous), Bengaluru
Location: Doddabanagere, Sira Taluk, Tumkur District, Karnataka, India
Email: bharathb244@gmail.com

Stingless bee, Tetragonula iridipennis colony

Author: Jayashankar, Assistant Professor, Department of Zoology St. Joseph's College (Autonomous), Bengaluru
Location: B.R.Hills, Chamarajanagar Dist., Karnataka, Karnataka, India
Email: jay81zoology@gmail.com

Red Cotton Bug, Dysdercus cingulatus (Fabricius)

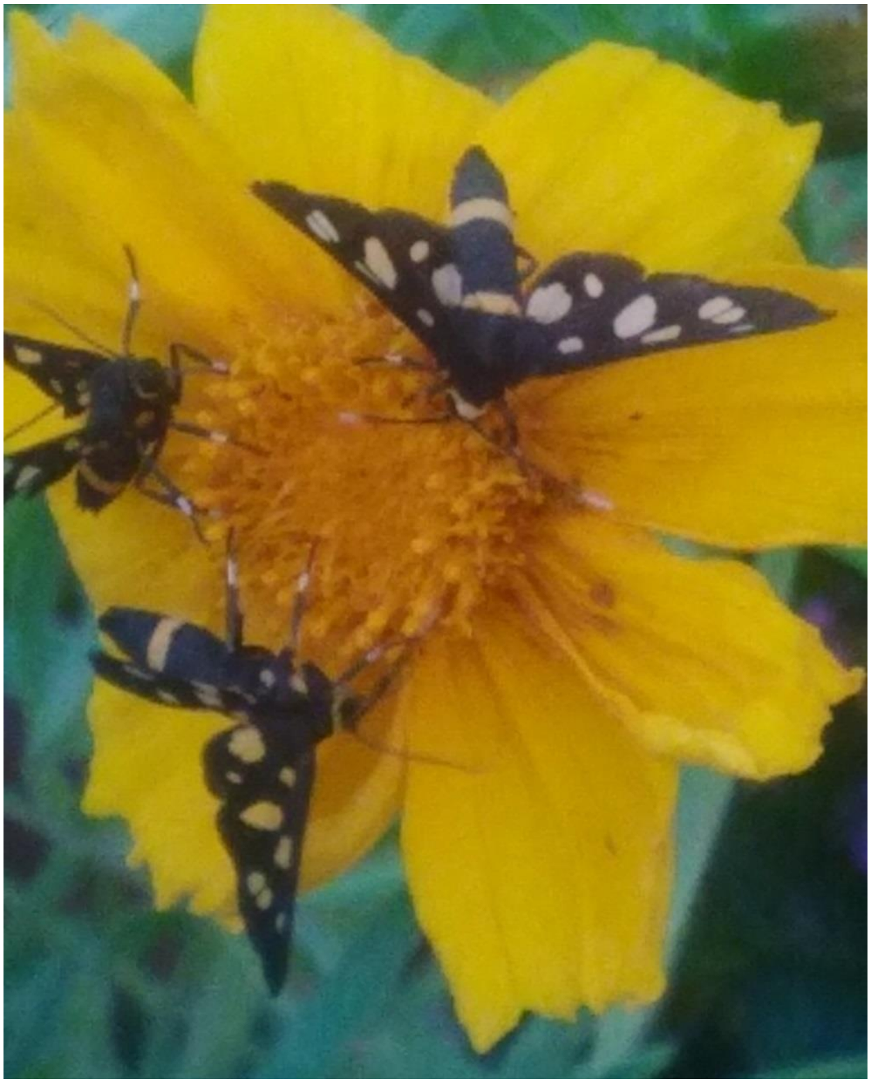
Author: Dr. Sachin Rameshchandra Patel, Assistant Professor, Navsari Agricultural University
Location: Navsari Agricultural University Campus, Navsari (Gujarat)
Email: sachinpatel@nau.in



Mango semilooper, Perixera illepidaria

Author: Viswanadha Raghuteja Puvvala, Ph.D Research Scholar (Entomology), Horticultural Research Station (HRS), Ambajipeta, East Godavari District, Andhra Pradesh.
Location: Mango orchard, Bavajipeta village, East Godavari, Andhra Pradesh., India
Email: Viswanadharaghuteja@gmail.com

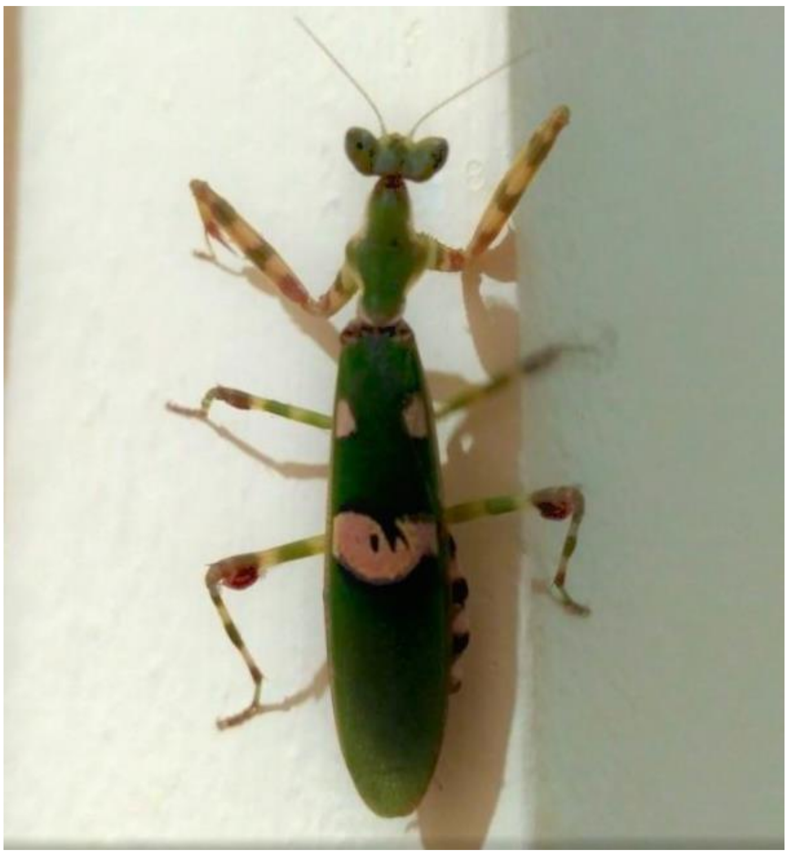
Wasp devouring another wasp's nest
Author: Dr. T. M. Shivalingaswamy, Principal Scientist (Agril. Entomology)
ICAR- National Bureau of Agricultural Insect Resources
Location: ICAR- NBAIR, Yelahanka Campus
Email: Shivalinga.SwamyTM@icar.gov.in



Amata sp.

Author: Anudita Chamoli
Location: Dehradun, Uttarakhand, India.
Email: anuchamoli80@gmail.com

***Clanis bilineata** (Two-lined velvet hawk-moth)*
Author: Rohini Girish
Place: Bangalore University, Bangalore
Email:nithurohini@gmail.com



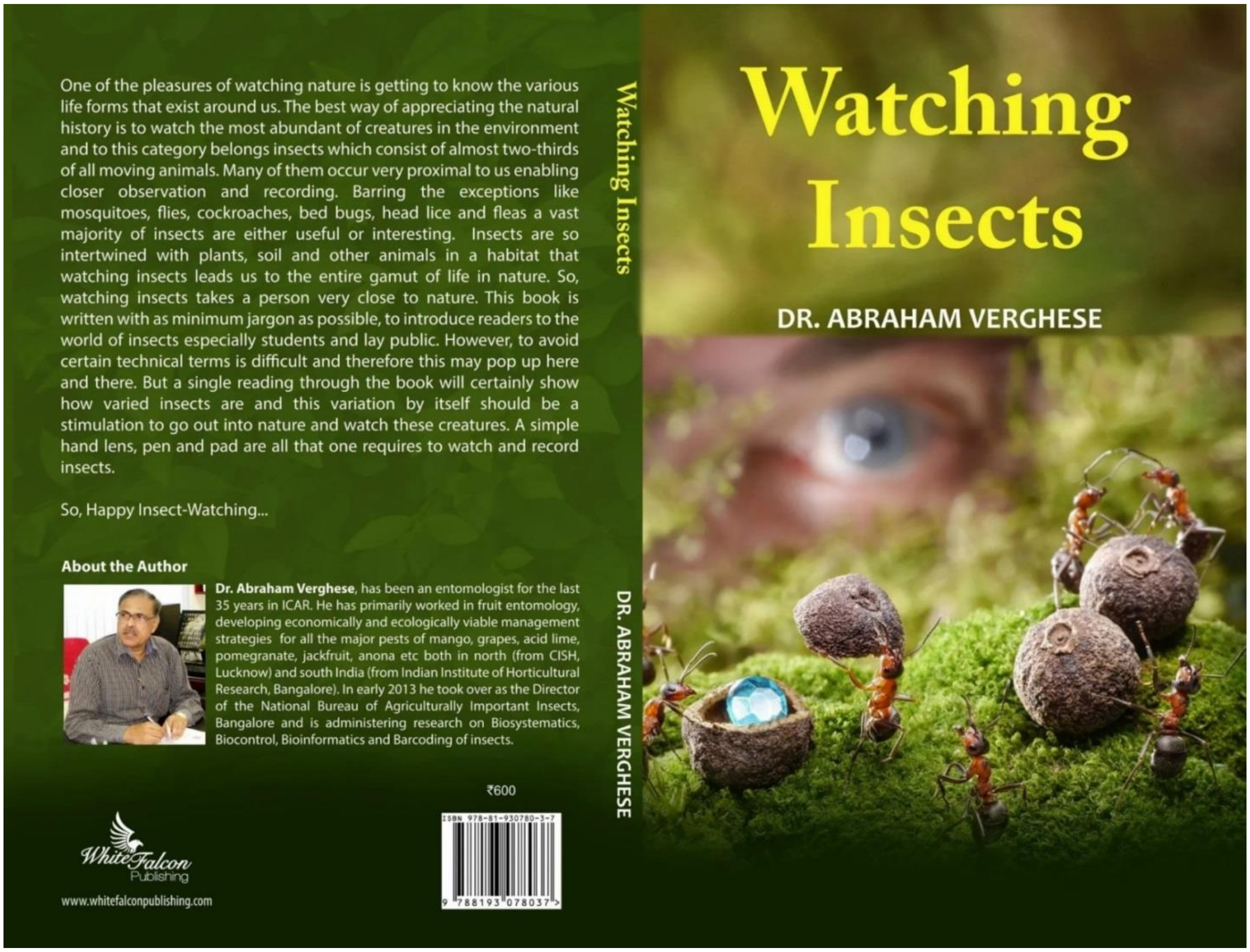
Banded Flower Mantis
Author: Rohini Girish
Place: Vidyaranyapura, Bangalore
Email:nithurohini@gmail.com

Adult White/Root Grub mating on Babul Tree host (Vachellia nilotica)

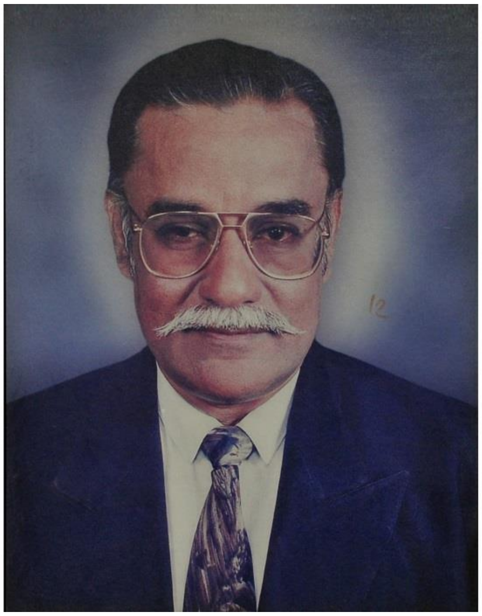
Author: Dr. Narasa Reddy, G. Assistant Professor (Agril. Entomology), College of Sericulture, Chintamani. UAS Bangalore

Location: Pedda Harivanam (Village), Adoni (M), Kurnool (Dist), Andhra Pradesh-518308

Email: narasareddy2009@gmail.com



***** Available on Amazon, Flipcart



Obituary

Prof. P. C. SUNDARA BABU

(25-12-1939 to 07-03-2021)

Dr. P. C. Sundara Babu, an inspiring teacher to hundreds, mentor for many and a benign friend to all, passed away at 9.45 am on 07-03-2021 at his residence in Periyasamy Road, Coimbatore. He is survived by his wife, Dr. Rajeswari Sundara Babu, two sons and grand children.

He led the Department of Agricultural Entomology as the Professor and Head from 1.3.1991 to 6.4.1994. Under his headship he coordinated 67 research projects and 17 schemes. During his tenure the biocontrol works came to limelight and got extra fillip.

Under his able guidance as Director of Plant Protection studies, at the Directorate of Plant Protection education, research and extension activities were streamlined and executed in the most planned and systematic manner.

He served as the Registrar in charge of the University during 1998-1999. As the Registrar in-charge, he actively organized board meetings, convocation, top level management meetings and government meetings. Besides, for a brief period he served as Acting Vice Chancellor of TNAU also.

His pioneering research won him the Nathaniel Memorial Award for his pathbreaking findings on Rhinoceros Beetle in his Doctoral Programme. He carried out research and completed 10 research schemes with national and international collaborations. He was awarded the V.C.V. Vellingiri Gounder Gold Medal for excellence in research in the field of Entomology.

He had guided 16 postgraduate students and six Ph.D. scholars. He has authored 10 books, 15 book chapters and 246 research papers. He was also awarded the Lifetime Achievement Award for the year 2020 by Dr.B. V. Vasantharaj David Foundation, Chennai.

He was active even after his retirement from University service in 1999. He also served as advisor in Nagarjuna Fertilisers, Hyderabad. Post retirement he was an active member of the Rotary Club in Coimbatore to serve the less fortunate in the society; he held many responsible positions in the Rotary Club *viz.*, President, Asst. Governor, District Officer and District General Secretary. He also published Book entitled " ALL ABOUT ROTARY".

As a teacher he was well known for his unique commendable style of teaching and was always admired for his "print"- like neat and legible handwriting by his students. He fondly credited his father's meticulous training for his handwriting.

As a colleague, he stood with his staff through thick and thin and led them in the right direction and as an administrator he was a strict yet a friendly counsellor. He is always fondly remembered by his colleagues for his humane ways.. Even after retirement he never failed to attend any of the meetings hosted in the Department of Agricultural Entomology and adviced all in his own inimitable and jovial style. He was a compassionate human being and in meetings he often would request everyone to observe a prayer for the sick person when an ambulance passed by on the road.

We would dearly miss him for a long long time!.

Dr. N. Sathiah
Professor and Head
Department of Agricultural Entomology
Tamil Nadu Agricultural University
Coimbatore 641 003