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***Cover Page: *Homoeocerus* nymph (Coreidae)**

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Insect Environment

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

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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.

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Editorial

It was indeed a floody quarter- floods across India, Europe, China, etc. Countering this was the blistering heat from across Europe to Canada. Certainly, one has to attribute these to 'climate changes'. That at best is a cliché these days, but no one reasons the *why* of these. Caught in the crossfires of extremes in climate, biota, especially insects pays the price. We've never studied, what happens to insects during floods. Soil-dwelling insects, soak and sink to death in submerged water, which withdraws only when riverine run-off ceases. In the interim period, Collembolans to dung rollers, a host of myriad insects are washed off or drowned. These are hardly enumerated or documented. Ditto for high heat waves for low-temperature adapted insects perhaps heat may not take that much a toll, as insects being poikilotherms, may loop up some rapid physiological survival- perhaps! If deforestation, urbanization, environmental pollution, etc. were the past and present masters of insects' extinction, climate is the new monster on the anvil.

In an interesting paper on the fruit fly, "Effect of climate change on biology of Oriental fruit fly, *Bactrocera dorsalis* Hendel (Diptera: Tephritidae)" published in *Current Science,* that if temperature across India, increases by a few degrees, *B. dorsalis* would shift its base to east and north-east of India! Of course this is mathematical derivative projection, and may not follow the model. My presumption is that this being a gradual upheaval, the fly would concomitantly evolve to adjust to the ambient climate, (if not adapt!) rather than move.

This issue has an excellent mix of insect information. Kituta and Berkmans bring to fore the *Bactrocera latifrons* in Congo, while Sahoo and Tripathy bring out the record of a fruit fly *Gastrozona fasciventris* from Odisha, India. Reddy, Chitra Shankar and Rana record the predator *Conocephalus* on leaf folder larvae in rice ecosystem. There are many interesting short notes of value. I congratulate all the authors for their contributions in digitally disseminating insect information through the pages of *Insect Environment*.

Our regular blogs have really endeared to thousands of students and lay people. It is our endeavour to give space to busy entomologists on the move to take one hour off and blog an

insect theme, for the readers at large. We publish a list of blogs in the last quarter. Our website deserves a leisurely browsing –the back volumes, current column, photographs-"LENS" (an IE unique speciality) and blogs.

The era of professional photographs have not dimmed. Nevertheless, amateurs with mobile gadgets have captures of insects, which cannot but be acclaimed. This changing digital upgrades, in several phones give users mega pixels and picture experience, and have brought photography to a level that hardly distinguish between professional and amateurism! That is why IE has been encouraging all and sunder to eye and shoot pictorial stories of the arthropods, which we banner under LENS. IE appreciates Master Gautham Gavas' (11 years old) insect pictures- a child photographer prodigy indeed. Only IE LENS gives space to such talents.

We of course have professional lensers in Dr. D.N. Nagaraju and Dr. Sevagan Subramanian whose pictures appear on our cover and I at times wrap them with some prose for our blog.

In this issue we have an excellent book reviewed whose author, Dr. Ramesh Arora is an international entomologist of repute. His book is a synthesis of sheer knowledge and experience that translates into very efficacious pest management protocols in the field. Kudos to our Professor.

My obituary on Dr. R.J. Rabindra is an attempt to project him deservingly as a new era biocontrol strategist, who proved invasive insects can be bio-controlled, before they naturalize into unbearable pests and intruders into our biodiversity space. His research bearings saw that papaya mealybug, eucalyptus gall, etc. could not notch a slot like that of serpentine leaf miner, for example, which has come to stay, as though they were non-exotic!

Those who have supported us with 'Announcement' pages deserve our special thanks. As our subscription is free, it is the largesse of you people, which is keeping IE moving. IE rating is under review by NAAS, and our special thanks to CABI, Indian Abstracts, FAO, Zoo Bank for being our partners in disseminating digitally the IE contents.

Wishing our readers a safe quarter ahead.

Dr. Abraham Verghese
Editor-in-Chief

Research Articles

Current status of the Solanum fruit fly *Bactrocera latifrons* (Hendel) in the eastern part of Democratic Republic of Congo

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Abstract

Fruit flies (Diptera: Tephritidae) are well-known for their invasiveness and propagation through the movement of infested products. Also, they constitute the limiting factor for fruit and vegetable exploitation. *Bactrocera latifrons* Hendel is present throughout the Kabare area in the South Kivu province of eastern Democratic Republic of Congo in *Solanum aethiopicum* and *Capsicum frutescens.* It is a species of Asian origin. It is a major destructive pest of fruits and vegetables of the family of Solanaceae and, to a lesser extent, Cucurbitaceae. It displays a rapid progression given that it invaded other territories even entire eastern part of Democratic Republic of Congo.

Keywords: *Solanum aethiopicum*, *Capsicum frutescens*, incubation, invasive species, Solanum fruit fly, tephritid

Introduction

The Solanum fruit fly *Bactrocera latifrons* (Hendel) is among the economically most important insect pest, belonging to the Dacinae subfamily of tephritid fruit flies (Vargas *et al.,* 2015). *Bactrocera latifrons* is of Asian origin (Carroll *et al.,* 2002). Its range has however expanded through introductions into Hawaii (Vargas and Nishida, 1985), Japan (Ishida *et al.,* 2005), Tanzania (Mwatawala *et al.,* 2010), Kenya (De Meyer *et al.,* 2011), Burundi (Ndayizeye *et al.,* 2019) and Congo (Ndayizeye and Kataraka, 2021). McQuate and Liquido (2013), based on reported field infestation data, show that a total of 59 plant species from 14 plant families are identified as hosts of *B. latifrons*. However, Yong *et al.* (2013) and Vargas *et al.* (2015) attested

in their study, *B. latifrons* infests mainly solanaceous fruits. It has caused serious damage to solanaceous crops such as chili pepper, tomato, and eggplant (Vijaysegran and Osman 1991, Liquido *et al.*, 1994).

The study of Ndayizeye and Kataraka (2021) focused on African eggplant in the farms in low land Uvira territory of South Kivu province at Kavimvira. However, they were chosen this region because it borders Burundi to the west and there is a lot of movement of people and goods across the border. In addition, the agriculture sector is quite well developed in this low land area. Moreover, because it might be that retail trader people traveled to purchase solanaceous crops such as chili pepper, tomato, and eggplant to Rwanda and Burundi.

There is further expansion of the species throughout the province South Kivu province, eastern part of Democratic Republic of Congo, and the whole area of Kabare territory by bringing in host fruits and /or by the movement of adult flies.

This paper outlines the current status of the Solanum fruit fly in the area of Kabare territory at the South Kivu province in the eastern part of Democratic Republic of Congo.

Materials and Methods

The frequency of sampling is invariable, but depends on the time of year. An incubation study was carried out over a two-months period from 10 February to 10 March 2020 and 2021 on *Solanum aethiopicum, Lycopersicon esculentum, Capsicum* spp. collected in the field at Lwiro, Ciranga, Kamakombe, Kashenyi, Bishibiru, Kamakombe, Cegera and Buhandahanda localities, Kabare territory. For each fruit species, 12 fruits were sampled and incubated at periods of up to four or five weeks, depending on the stage of infestation of the fruits. Convenience sampling was used to select the fruits collected. It is a non-probability sampling plan where the sampling units are selected on purpose. The basis of selection was the presence of visual fruit fly puncture marks on the surface of the fruit. The infested fruits collected are placed in incubation units and provided with labels, following the method described by Ekesi and Billah (2007). The incubation units consist of two plastic tubs of different diameters, depending on the size of the fruits. All fruits collected were washed, weighed, placed and incubated (four fruits per box individually). The bins are respectively 30 cm and 20 cm in diameter. The trays are superimposed, a layer of

fine sand 2 to 3 cm thick at the bottom of the large tray, on which is placed the second small tray containing the infested fruit (s) to be incubated. The trays are then covered with a fine cloth or muslin cloth, to ensure good ventilation of the medium and prevent secondary infestations during incubation. Then, the boxes with the fruits are placed in the laboratory to allow the flies to form pupae. The pupae are removed from the sand by sieving from the first 10 days of incubation. The sand is sieved at intervals of 3 to 4 days. The pupae are counted and placed in Petri dishes and / or in a transparent box with a perforated lid, lined with toilet paper and kept in cages until adults emerge. The sieving is continued until the fruit has completely rotten. They are then dissected to collect any residual pupae or larvae. The methods of breeding fruit flies are described by Ekesi *et al.* (2007) were used. The pupae are separated and then counted. After emergence of adult flies, Tephritidae are placed in tubes filled with ≥ 90% ethanol for storage. Several types of determination keys are used: the recent systematic review of tephritidae including that of White and Elson-Harris (1994), CABI (2005), White (2006), De Meyer *et al.* (2008).

The DTMs are derived by using different interpolation methods. Indeed, the applied interpolation methods can be changed depending on the structure of the surface and the number of control points (Yilmaz, 2007). In this study, a different interpolation method is interpreted to define a surface. Measured points are transferred to Surfer 17.1 software and the volume of the object is calculated by using the previously mentioned interpolation methods. So, the better the surface is described, the closer the amount of volume is to the real value. Accordingly the results closest to the real value of the volume are obtained from the following methods: kriging (90.00%) and inverse distance to a power (95.00%). The most suitable contour map of the object is obtained from the triangulation with linear interpolation and inverse distance to a power method. The most suitable 3D model of the object is obtained from triangulation with inverse distance to a power method.

Software R was used to analyze paired t-Test, one-way ANOVA and linear model regression of flies and making boxplot of fruit flies observed during incubation of Solanaceous. T-test was done for examining the difference in means of solanaceous fruits weight bags from Rwanda and eastern of DRC, South Kivu province. The parametric methods (t-Test) appropriate for examining the difference in means that is paired or dependent on one another. Tukey

multiple comparisons of means at 95% family-wise confidence level was done and mean ± standard deviation was calculated too.

Results

The results from the current study indicated that Solanum fruit fly *Bactrocera latifrons* (Hendel) observed after incubation in those fruits *Solanum aethiopicum* and *Capsicum frutescens* but not in *Lycopersicon esculentum* and *Capsicum annuum* in the area of Kabare territory at the South Kivu province in the eastern part of Democratic Republic of Congo. The figure shows the visually maps of irregularly spaced *B. latifrons* in surface of this area. Additionally, *B. latifrons* set has a stationary variance but also a non-stationary mean value within the search radius (Figure 1). Calculated value of ‘‘t’’ comes to -3.185 at df 3 on 0.01 level, p-value is 0.050. Thus, the calculated value is less. Therefore, the difference between solanaceous fruit weight bags from Rwanda and DR Congo is significant. Thus, small traders and peoples often bring a greater quantity of solanaceous from Rwanda country to DR. Congo. Table 1 shows the difference in mean of whole origin of the solanaceous fruits. In the table 2 of one-way anova, it shows the significant difference of fruits weight bag in different sites of South Kivu province i.e. Walungu_Kamanyola has a greater solanaceous fruits weight bag than Kabare and Kalehe, so Kabare has a greater fruits weight bag than Kalehe too (table 3). The boxplot and the linear model regression show tendency of fruit flies observed during incubation of Solanaceous fruits (Figure 2 and 3). The average at eggplant was of 69 ± 41.78 for *Bactrocera dorsalis,* of *2* ± 0.97 for *Zeugodacus cucurbitae*, of 2 ± 0.89 for *Dacus bivittatus* and of 1 ± 1.13 for *Bactrocera latifrons.* According chili pepper, the average was of 44 ± 33.70 for *Bactrocera dorsalis* and of 1 ± 0.58 for *Bactrocera latifrons*. Additionally, the average of *Bactrocera dorsalis* on tomato was of 57 ± 39.59 and of 3 ± 1.53 *Ceratitis capitata* on pepper.

Discussion

In view of the results, Solanum fruit fly *Bactrocera latifrons* (Hendel) is detected for the first time at the South Kivu province in the eastern part of Democratic Republic of Congo. Near border and trade can explain this presence of Solanum fruit fly. This is the reason of *Bactrocera latrifons* migration and other fruit flies.

This result confirms the observations of Mziray *et al.* (2010 a, b) indicating that *B. latifrons* attacks mature ripe eggplant. Ndayizeye (2019) shows that it displays a rapid progression given that it invaded the entire country within one year of first detection, with potential to invade neighboring countries in the region of Great Lake of central Africa. The results of the study of Ndayizeye and Kataraka (2021) showed that *Bactrocera latifrons* on African eggplant (*Solanum aethiopicum*) in Kavimvira, Uvira territoty of South Kivu province.

Conclusion

Bactrocera latifrons is present throughout Kabare area at the South Kivu province in *Solanum aethiopicum* and *Capsicum frutescens.* It displays a rapid progression given that it invaded other territories even entire eastern and western part of Democratic Republic of Congo.

Acknowledgments

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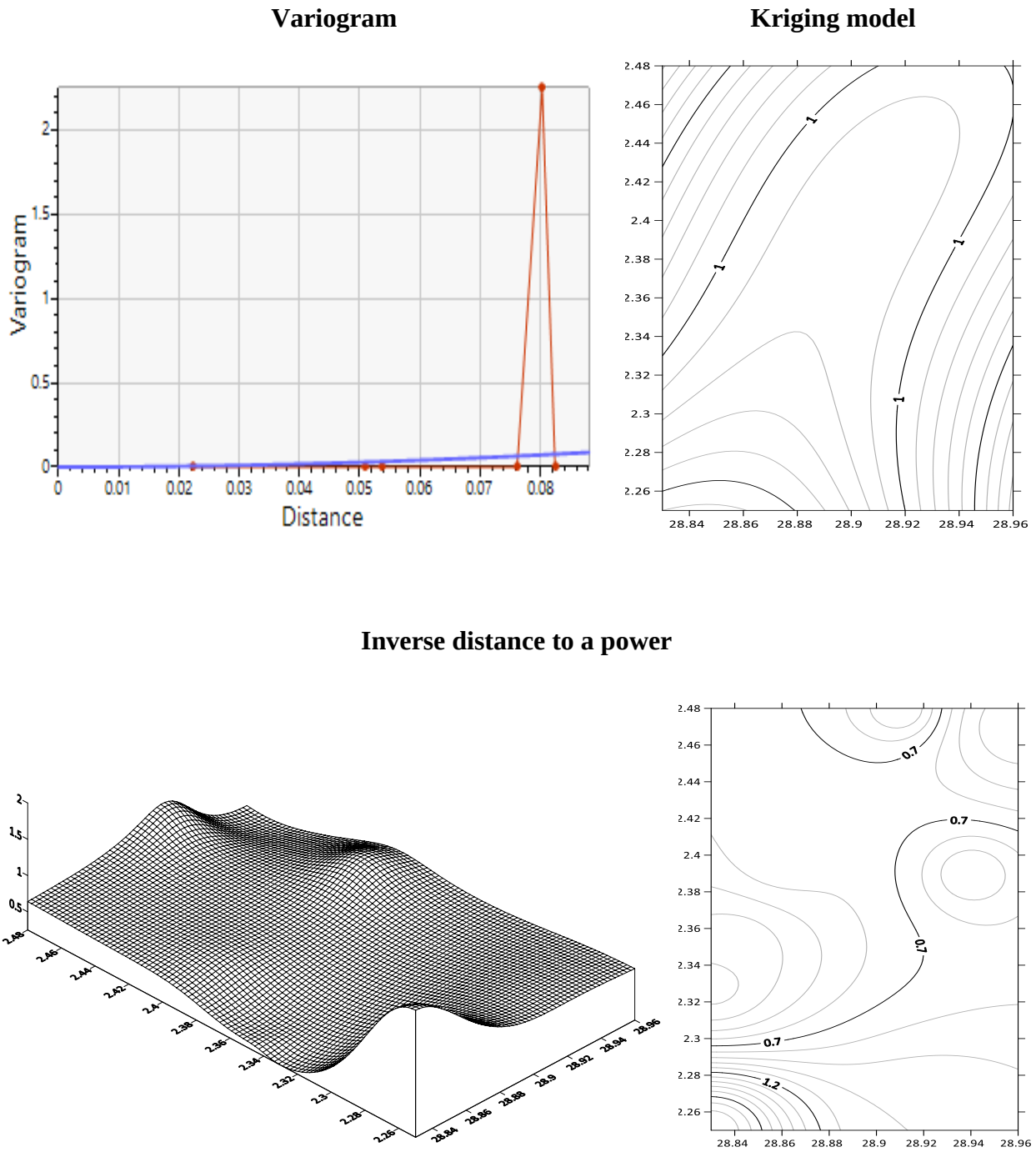


Figure 1. Solanum fruit fly *Bactrocera latifrons* (Hendel) in study area

Table 1. Solanaceous crops (Tomato, eggplant, pepper, chili pepper) weight bag of South Kivu province

Area	Tomato	Eggplant	Pepper	Chilli pepper
Kabare	1440	5550	2250	2000
Walungu_Kamanyola	7000	6500	3050	3000
Kalehe	4080	0	0	0
Mean ± Standard deviation	4173.33 ± 2781.17	6025 ± 671.75	2650 ± 565.68	2500 ± 707.1

Table 2. One-way ANOVA of solanaceous fruits weight bag of South Kivu province

Source of variance	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Area	2	29970217	14985108	3.661	0.0687
Residuals	9	36840875	4093431		

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table 3. Tukey multiple comparisons of means

Area	Diff	lower	upper	p adj
Kalehe-Kabare	-1790.0	-5784.3398	2204.34	0.4551230
Walungu_Kamanyola-Kabare	2077.5	-1916.8398	6071.84	0.3569167
Walungu_Kamanyola-Kalehe	3867.5	-126.8398	7861.84	0.0574106

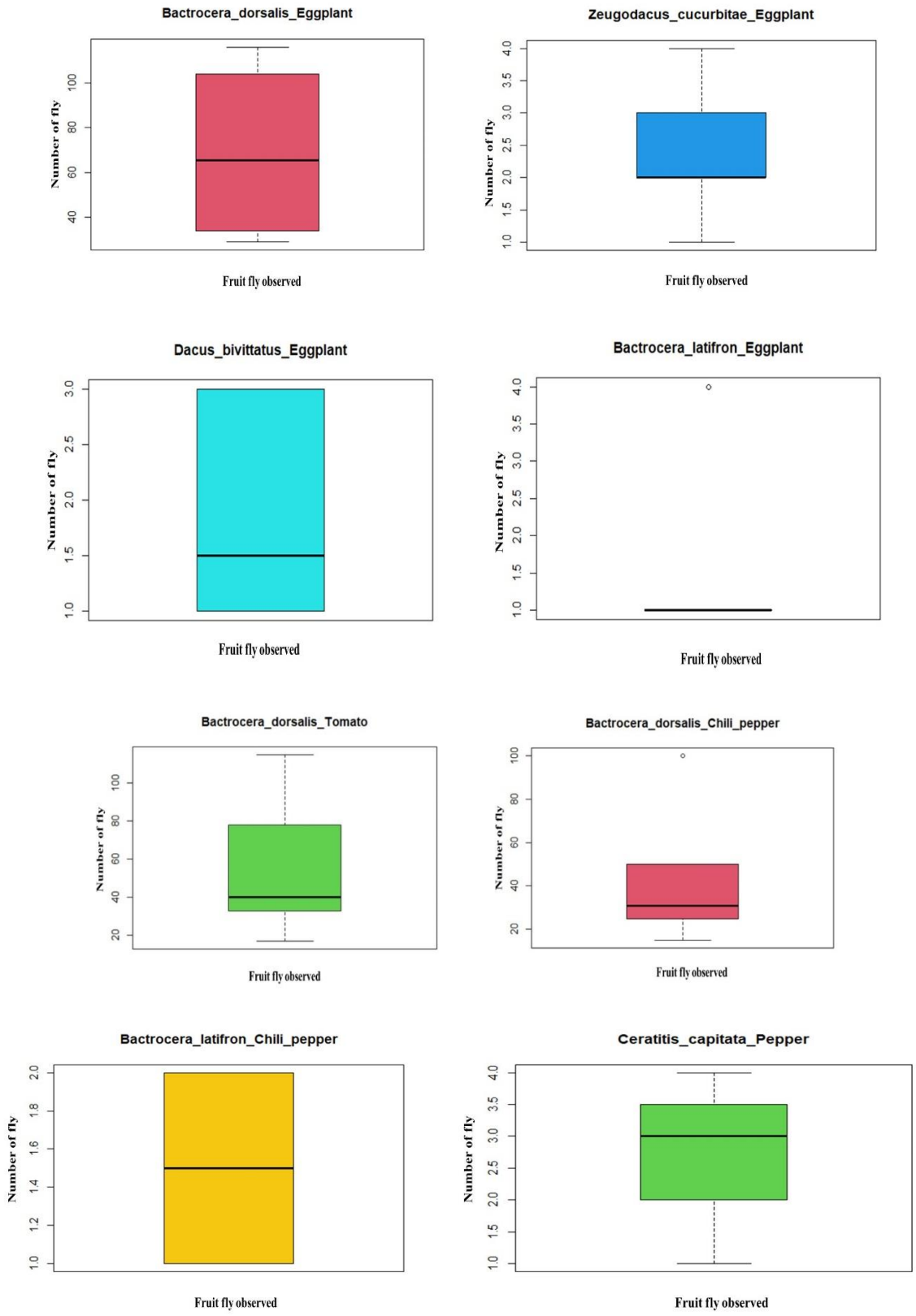
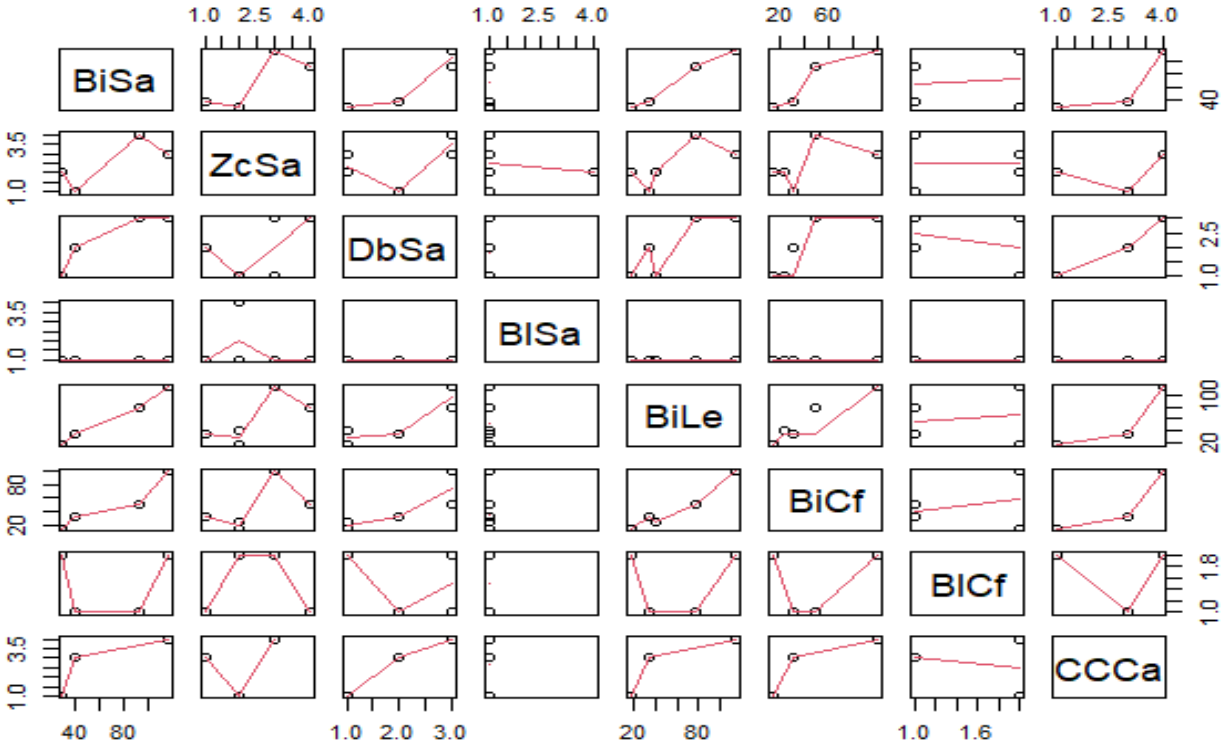


Figure 2. Boxplot of fruit flies observed during incubation of Solanaceous



Legend

Bi:Bactrocera dorsalis, Bl: Bactrocera latifrons , Db: Dacus bivittatus , CC: Ceratitis capitata, Zc: Zeugodacus cucurbitae , Sa: Solanum aethiopicum, Le: Lycopersicon esculentum, Cf: Capsicum frutescens, Ca : Capsicum annuum

Figure 3. Linear model regression of flies observed

Record of *Conocephalus longipennis* de Haan (Orthoptera: Tettigonidae) predating on rice leaf folder larvae

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Orthopteran predators in rice fields are a lesser researched area. Chitra *et al.*, (2000) have recorded *Conocephalus longipennis* (de Haan), *Conocephalus maculatus* Le Guillou, *Anaxipha longipennis* Servo and *Metioche vittaticollis* (Stal) as the commonly encountered orthopteran predators in the rice fields. *Conocephalus longipennis* is widespread in all rice growing regions. It is considered as a minor pest in Africa, where it is widely distributed in the lowland rice ecosystems and have a wide host range *viz.,* maize, wheat, sorghum, millets etc., (Abo *et al.,* 2002). The eggs are laid on leaf sheaths with the help of long sickle shaped ovipositor. The newly emerged nymphs complete its life cycle in 142 to 182 days (Rubia *et al.,* 1990). *Conocephalus longipennis* is a generalist predator in early growing season of rice, feeding on egg masses of yellow stem borer, leaf folder and rice ear head bugs (Nozato and Kiritani 1976; Ito *et al.,* 1995). They also feed on nymphs and adults of brown planthopper, green leafhopper and adults of leaf folders, stem borers, whorl maggot and ear-head bug (Rubia *et al.,* 1990). It had a greater preference for eggs of the ear-head bug than leaf folder eggs (Kraker *et al.,* 1996). Manley (1985) reported that, *C. longipennis* was an opportunistic predator, which breaks open the stem borer egg masses and other strong cases of eggs of rice pests, which were later accessed by smaller parasitoids and predators. He also reported that, when nymphs of *C. longipennis* were forced to feed on leaves alone, it showed abnormal development. Chitra *et al.,* (2002) reported that, *C. longipennis* fed on an average of 17.5 leaf folder eggs per day. The field predation range of 17 to 65% on yellow stem borer egg masses was recorded by Pantua *et al.,* (1984).

In our study, conducted for evaluating the impact of bio-intensive pest management (BIPM) practices on natural enemy abundance and diversity in rice in a farmer's field in Nalgonda district (16° 46′ 45″ N, 79° 28′ 39.5″ E) of Telangana state, *C. longipennis* was

observed at a mean population of 1 per 10 hills. Rice leaf folder was the dominant pest with mean population of 8.50 to 14.75 larvae per 10 hills during *kharif*-2020. Along with other mortality factors such as predators, parasitoids and granulosis virus and entomopathogenic fungi, *C. longipennis* was found predating on leaf folder larvae (Fig 1). While earlier workers have recorded feeding of eggs, nymphs and adults of rice insect pests, this behaviour was recorded for the first time and detailed study in regard is required in the future.

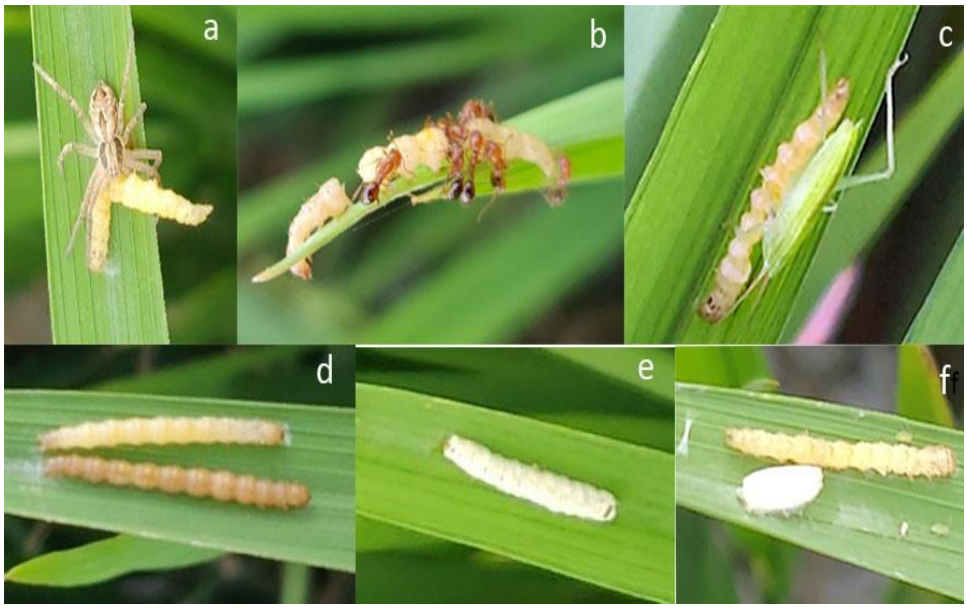

Figure 1. Mortality factors of leaf folder in the field (a) Wolf spider, *Lycosa* sp. (b) Ant, *Solenopis* sp. (c) *Conocephalus longipennis* (d) Granulosis virus (e) *Beauveria bassiana* (f) *Apanteles* sp. (Images were captured by the first author during the study)

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Comparative biology and predatory potential of *Scymnus coccivora* on mealybugs

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Abstract

Potential predator, *Scymnus coccivora* Ayyar is against several species of mealybugs, but awareness of their comparative biology and feeding potential in diverse mealy bug species is not yet explored. In this regard, a comparative study on the biology and feeding potential of *Scymnus coccivora* on two prominent mealybug pests, *Maconellicocuus hirsutus* and *Planococcus citri* were studied. The results on the biology of *S. coccivora* on *M. hirsutus* and *P. citri* revealed the beetle had completed its life cycle successfully on both species with the total developmental period (egg to pupa) of 18.1 ± 1.0 days on *M. hirsutus* and 21.1 ± 0.8 days on *P. citri*. The adults beetles developed on *M. hirsutus* had high fecundity 36.6 ± 0.9 eggs / female and longevity 59.8 ± 1.2 days than those developed on *P. citri*. Analysis on the growth indices of *S. coccivora* portrayed more preference on *M. hirsutus* with high suitability index of 2.54 than *P. citri* (1.99). Among the two life stages, adults of *S. coccivora* was more voracious and each adult consumed an average number of 1301.64, 151.08 and 24.53 on *M. hirsutus* eggs, nymphs and adults respectively while it was 1229.06, 139.4 and 19.6 for *P. citri*, respectively. The grubs required 277.46, 54.87 and 8.66 numbers of *M. hirsutus* and 136.92, 44.0 and 4.8 number of eggs, nymphs and adults for *P. citri*, respectively to complete life stages. Out of different instars of *S. coccivora*, third and fourth instars consumed around 68.8, 77.3 and 64.5 per cent eggs, nymphs and adults of *M. hirsutus* and it was 77.0, 82.7 and 58.3 per cent for *P. citri*, respectively. Though predatory *Scymnus coccivora* displayed good development and feeding potential with both the mealybugs, *Maconellicoccus hirsutus* as the feed expressed more gains in terms of short development period of the beetle, higher fecundity and consumption rate.

Key words: Comparison, biology, predatory potential, *Scymnus coccivora*, mealybugs, *Maconellicoccus hirsutus*, *Planococcus citri*

Introduction

Coccinellids are efficient predators of soft bodied insects such as aphids, mealybugs, whiteflies, leafhoppers, scale insects and mites. They are augmented and conserved as an important bio-control agent to manage several important pest species in the concept of Integrated Pest Management globally (Ali *et al*., 2015). *Scymnus* spp. are well known predators of pests that cause severe economic damage (Ghosh and Chakrabarti, 1984; Saraswati, 1990). *Scymnus coccivora* Ayyar is a promising predator for several species of mealybugs. *Scymnus* coccivora belongs to beetle group of insects in the family Coccinellidae and type genus of the subfamily Scymninae and the tribe Scymnini (Bug Guide, 2006). The adult lady bird beetle is an elongate oval, moderately convex beetle with pale yellow to yellowish brown markings in elytra. Two small circular spots are present in the elytra. The adults lay pale yellow coloured eggs in the colonies of mealybugs. The emerging grub is a compodeiform larva, dorsal surface covered with white waxy filaments, which on hatching, feed on mealybugs. The larval stage lasts for 15 to 20 days. The grubs turn to an exarate pupa, which is oval and light yellowish brown fringed with hairs. The pupa turns to adult in a day or two and starts feeding on mealybugs (Poorani, 2004). Both the grub and adult stages are predacious on mealy bugs, but adults were more potential feeders of mealybug eggs (Padmaja *et al*., 1995). Different workers have studied the biology of a number of *Scymnus* spp. (Kapur, 1942; Johnson, 1972; Tawfik *et al*., 1974; Buntin and Tamaki, 1980; Ramamurthy, 1982; Mani and Thontadarya, 1987). But the information available on the biology and feeding potential of *Scymnus coccivora* on different types of mealy bugs is quite meagre. A comparative study on the biology and feeding potential of *S. coccivora* on two different mealybugs, *Maconellicoccus hirsutus* and *Planococcus citri* was, therefore, carried out at Tamil Nadu Agricultural University.

Materials and Methods

The laboratory studies on biology and feeding potential of S. *coccivora* on *M. hirsutus* and *P. citri* were conducted at the Biocontrol Laboratory, Department of Agricultural Entomology, Tamil Nadu Agricultural University from 2003-2004.

Biology of *S. coccivora* on *M. hirsutus* and *P. citri*: The cultures of *M. hirsutus* and *P. citri* maintained on pumpkin were used for the biology study of *S. coccivora*. Eggs of *S. coccivora*

were allowed to complete one generation on the respective hosts and were used for biological and predatory potential studies. Twenty-five fresh eggs were taken separately from the surface of *M. hirsutus* and *P. citri* infested pumpkin. Egg period was calculated by recording the day of oviposition and day of emergence. After eclosion, first instar grubs started to feed mealybugs and the developmental period for each instar was recorded by observing the moulted exuviae. Pupae of *S. coccivora* were collected and kept in adult emergence cage for the pupal period. Observations on pupal weight, adult emergence and sex ratio were made by the method suggested by Sunil Joshi *et al*. (1999). Various growth indices were calculated based on the data generated on biological parameters of *S. coccivora* on two mealybugs by different formulae.

Predatory potential of *S. coccivora* on *M. hirsutus* and *P. citri:* The predatory potential of the grub and adult of *S. coccivora* was studied on *M. hirsutus* and *P. citri*, according to Radke *et al*. (1977). Experiments were conducted to determine the rate of consumption on different stages of both the mealybugs (eggs, nymphs and adults) by the predatory grubs in two different experiments (After hatching, each grub was confined in a polypot and provided with known number of host insects. Observation was made at 24 h interval and surviving host insects were counted and removed. Fresh hosts were offered to the predatory grub until pupation. Number of host insects consumed by the grub in each instar and the total consumption during grub period were calculated. The feeding potential studies were conducted with ten grubs considering each one as replication. Similarly, to determine the rate of consumption on different stages of mealybugs (eggs, nymphs and adults) by the adults of *S. coccivora*, each adult was confined in a polypot and provided with known number of mealybugs. The number of mealybugs preyed by the adults / day was counted at 24 h interval till the adults were alive.

Results

Biology of *S. coccivora* on *M. hirsutus* and *P. citri* with its predatory potential: Life cycle of *S. coccivora* had succcessfully completed on *M. hirsutus* and *P. citri* and the lifestages and development periods were listed in Table 1. The mean egg period of *S. coccivora* was 3.6 ± 0.4 days and 4.2 ± 0.3 days when reared on *M. hirsutus* and *P. citri*, respectively. Uniformly four grub instars were observed on both mealybug species with an average duration of 1.9 ± 0.3, 2.1 ± 0.2, 2.6 ± 0.3 and 2.8 ± 0.4 days respectively for first, second, third and fourth instars *M. hirsutus*

and 2.7 ± 0.4, 2.4 ± 0.2, 2.3 ± 0.2 and 3.1 ± 0.2 days on *P. citri*. The mean grub period of *S. coccivora* averaged 9.6 ± 0.4 and 10.7 ± 0.3 days on *M. hirsutus* and *P. citri*, respectively. The prepupal and pupal period of *S. coccivora* lasted 1.2 ± 0.2 and 3.7 ± 0.3 days and 2.2 ± 0.3 and 4.0 ± 0.3 days on *M. hirsutus* and *P. citri*, respectively (Table 1). *S. coccivora* showed more feeding preference on *M. hirsutus* than *P. citri*. *S. coccivora* took 18.1 ± 1.0 days from egg to pupa when reared on *M. hirsutus* , while it was 21.1 ± 0.8 days on *P. citri*. Although there was slight variation in per cent pupation of *S. coccivora* per cent adult emergence was recorded on two prey species studied. *Scymnus coccivora* had a maximum fecundity of 36.6 ± 0.9 eggs/ female on *M. hirsutus* in a oviposition period of 28.6 ± 0.6 days compared to 33.7 ± 0.9 eggs/ female on *P. citri* with a oviposition period of 25.2 ±1.3 days. The sex ratio observed was 1:0.9. The adult of *S. coccivora* survived for 59.8 ± 1.2 days when reared on *M. hirsutus* whereas57.4 ± 0.8 days on *P. citri*. The average pupal and adult weight of *S. coccivora* was 0.4 ± 0.03 and 0.7 ± 0.07 mg on *M. hirsutus* and 0.3 ± 0.04 and 0.3 ± 0.06 mg on *P. citri*. Studies on the growth indices of *S. coccivora* on *M. hirsutus* and *P. citri* by keeping one mealybug species as constant indicated that the predator showed more preference on *M. hirsutus* with high suitability index of 2.54 than for *P. citri* (1.99) (Table 2).

Predatory potential of *S. coccivora* on *M. hirsutus* and *P. citri:* Grubs and adults of *S. coccivora* required a total numbers of 1579.1 ± 552.2, 205.95 ± 62.36 and 33.19 ±10.03 eggs, nymphs and adults of *M. hirsutus* while the requirement *P. citri* was 1365.98 ± 534.74, 183.4 ± 58.11 and 24.4 ± 8.23 to complete their life stages. The adult of *S. coccivora* was able to consume on an average of 1301.64 ± 45.9, 151.08 ± 3.4 and 24.53 ± 0.3 numbers of *M. hirsutus* while it was 1229.06 ± 51.3, 139.4 ± 5.0 and 19.6 ± 0.5 number of eggs, nymphs and adults of and *P. citri*. The grub required 277.46 ± 40.47, 54.87 ± 12.37 and 8.66 ± 0.79 numbers and 136.92 ± 23.70, 44.0 ± 10.29 and 4.8 ± 0.23 number of eggs, nymphs and adults of *M. hirsutus* and *P. citri*, respectively. Among various instars of the predator, third and fourth instar were voracious and consumed 62.62 ± 2.0, 10.46 ± 1.1 and 2.46 ± 0.3 number and 128.47 ± 40.7, 31.98 ± 0.8 and 3.13 ± 0.3 numbers of eggs, nymphs and adults of *M. hirsutus.* whereas, the third and fourth were consumed 40.26 ± 3.9, 10.8 ± 0.9 and 1.4 ± 0.3 numbers and 65.23 ± 10.2, 25.6 ± 2.5 and 1.4 ± 0.5 numbers of eggs, nymphs and adults of *P. citri*, respectively, which were 68.8, 77.3 and 64.5 per cent and 77.0, 82.7 and 58.3 per cent of total eggs, nymphs and adults of

M. hirsutus and *P. citri* consumed, respectively. First and second instars consumed collectively 31.1, 22.6 and 35.4 per cent and 22.9, 17.3 and 41.6 per cent of eggs, nymphs and adults of *M. hirsutus* and *P. citri*, respectively. The consumption of first and second instars were 86.37 ± 2.6, 12.43 ± 1.2 and 3.07 ± 0.7 numbers and 31.43 ± 3.6, 7.6 ± 0.4 and 2.0 ± 0.4 numbers of eggs, nymphs and adults of *M. hirsutus* and *P. citri,* respectively (Table 3).

Table 1. Life stages of *Scymnus coccivora* reared on *Maconellicoccus hirsutus* and *Planococcus citri*

Life stages of *S. coccivora*	Developmental periods* on	
	M. hirsutus	***P. citri***
Egg (days)	3.6 ± 0.4	4.2 ± 0.3
Grub (days)		
I instar	1.9 ± 0.3	2.7 ± 0.4
II instar	2.1 ± 0.2	2.4 ± 0.2
III instar	2.6 ± 0.3	2.3 ± 0.2
IV instar	2.8 ± 0.4	3.1 ± 0.2
Total grub period (days)	**9.6 ± 0.4**	**10.7 ± 0.3**
Prepupal period (days)	1.2 ± 0.2	2.2 ± 0.3
Pupal period (days)	3.7 ± 0.3	4.0 ± 0.3
Total developmental period (days)	**18.1 ± 1.0**	**21.1 ± 0.83**
Pupation (%)	74 .0 ± 0.3	69.0 ± 0.2
Adult emergence (%)	100	100
Fecundity (Nos.)	36.6 ± 0.9	33.7 ± 0.9
Sex ratio (♀:♂)	1 : 0.9	1 : 0.9
Oviposition period (days)	28.6 ± 0.6	25.2 ± 1.3
Longevity	59.8 ± 1.2	57.4 ± 0.8
Weight of Pupa (mg)	0.4 ± 0.03	0.3 ± 0.04
Weight of adult (mg)	0.7 ± 0.07	0.3 ± 0.06

*Mean of five replications

Table 2. Growth indices of *Scymnus coccivora* on *Maconellicoccus hirsutus* and *Planococcus citri*

Life stages of *S. coccivora*	*M. hirsutus*	*P. citri*
Larval-pupal index	-	2.19
Pupal weight index	-	1.36
Adult weight index	-	1.89
Adult emergence index	-	1.00
Development index	-	0.86
General growth index	7.71	6.52
Howe's growth index	0.11	0.09
Suitability index	2.54	1.99

Data obtained for *M. hirsutus* was used to calculate growth indices of *P. citri*

Table 3. Feeding potential of *S. coccivora* on *M. hirsutus* and *P. citri*

Life stages of *S. coccivora*	Numbers consumed (Mean ± SD)					
	M. hirsutus			*P. citri*		
	Egg	Nymph	Adult	Egg	Nymph	Adult
Grub (Instar)						
I	42.0 ± 0.8	5.1 ± 0.6	1.3 ± 0.4	14.7 ± 0.8	3.2 ± 0.2	1.0 ± 0.2
II	44.3 ± 1.8	7.3 ± 0.6	1.7 ± 0.3	16.7 ± 2.8	4.4 ± 0.2	1.0 ± 0.2
III	62.6 ± 2.0	10.4 ± 1.1	2.4 ± 0.3	40.2 ± 3.9	10.8 ± 0.9	1.4 ± 0.3
IV	128.4 ± 40.7	31.9 ± 0.8	3.1 ± 0.3	65.2 ± 10.2	25.6 ± 2.5	1.4 ± 0.5
Total	277.4 ± 40.4	54.8 ± 12.3	8.6 ± 0.7	136.9 ± 23.7	44.0 ± 10.2	4.8 ± 0.2
Adult	1301.6 ± 45.9	151.0 ± 3.4	24.5 ± 0.3	1229.0 ± 51.3	139.4 ± 5.0	19.6 ± 0.5
Total Consumption	1579.1± 552.2	205.9 ± 62.3	33.1 ± 10.0	1365.9 ± 534.7	183.4 ± 58.1	24.4 ± 8.2

*Mean of ten replications

Discussion

Studies on the biology of *S. coccivora* on two mealybugs, *M. hirsutus* and *P. citri* indicated that *S. coccivora* had completed its life cycle successfully on the both the host insects but preference was found to be more on *M. hirsutus* than *P. citri.* There was mild variation in egg period of the predator when reared on *M. hirsutus* (3.6 ± 0.4 days) and *P. citri* (4.2 ± 0.3 days); However, earlier reports by Padmaja *et al*., (1995) stated an egg period of 4.0 to 4.5 days of *S. coccivora* on *M. hirsutus* which is slightly higher than the present investigation. The total grub period of *S. coccivora* was shortest (9.6 ± 0.4 days) on *M. hirsutus* nymphs which was extended by 1.1 days on *P. citri*. Slight variation in grub period of *S. coccivora* was noticed (10.6 days) when reared on mealybug nymphs (Mani and Thontadarya, 1987), 10.80 days (Padmaja *et al.*, 1995) and it was 10.45 days when *S. nubilus* was reared on *M. hirsutus* (Kumar and Chakraborty, 1997). The variation in the developmental period of grubs might be due to quantity and quality of the prey made available to *S. coccivora*. *Scymnus coccivora* took 18.1 ± 1.0 and 21.1 ± 0.8 days from egg to pupa when reared on *M. hirsutus* and *P. citri*, respectively which is lower than the finding of Mani and Thontadarya (1987) who reported 20.35 ± 1.04 days from egg to pupa on *M. hirsutus*. The mean number of eggs per female was 36.6 ± 0.9 and 33.7 ± 0.9 when reared on *M. hirsutus* and *P. citri*, respectively, which is in accordance with the findings of Mani and Thontadarya (1987). Grubs and adults of *S. coccivora* collectively required an average of 1579.1 eggs, 205.9 nymphs and 33.1 adults of *M. hirsutus* to complete its life stages, while the rate of consumption on *P. citri* to complete its life cycle was 1365.9, 183.4 and 24.4 respectively, which clearly demonstrates the strong feeding preference of *S. coccivora* on different stages of *M. hirsutus*. In contrast to the present investigations, Mani *et al*. (1987) reported that *S. coccivora* grub consumed 307.7 eggs or 62.2 nymphs or 6.55 adults of *M. hirsutus* under laboratory condition (26-29°C and 63-67% RH). Padmaja *et al*. (1995) recorded that single adult of *S. coccivora* consumed 864.4 eggs while larva consumed 314.2 eggs of *M. hirsutus*. Among various instars of the *S. coccivora*, third and fourth instar grubs consumed about 68.8, 77.3 and 64.5 per cent of total eggs, nymphs and adults of *M. hirsutus*, respectively. Similar pattern of consumption of host insect by *S. coccivora* was obtained by Mani and Thontadarya (1987) and Padmaja *et al*. (1995) who reported that first and second instars of *S. coccivora* fed minimum quantity of mealybugs while third and fourth instars consumed more numbers of *M. hirsutus*.

Conclusion

Most important predator, *Scymnus coccivora* has played vital role for several agricultural and horticultural pests of economic importance. The present study on the biology and feeding potential of *S. coccivora* on two mealybugs, *M. hirsutus* and *P. citri* indicated that *S. coccivora* had completed its life cycle successfully on the both the host insects but preference was found to be more on *M. hirsutus* than *P. citri*. Therefore, *Scymnus coccivora* is highly recommended for the management of invasive mealybug, *Maconellicoccus hirsutus*.

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First record of *Gastrozona fasciventris* Macquart (Diptera: Tephritidae) from Odisha, India

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Fruit flies (Diptera: Tephritidae) represent one of the largest families of Diptera, with about 4,500 species in 500 genera under six subfamilies (Blepharoneurinae, Dacinae, Phytalmiinae, Tachiniscinae, Tephritinae and Trypetinae) known worldwide. About 243 species represent the Indian fauna in 79 genera under four subfamilies (Dacinae, Phytalmiinae, Tephritinae and Trypetinae) (David and Ramani, 2011). Genus *Gastrozona* Bezzi belongs to the tribe Gastrozonini under the subfamily Dacinae. Seven species of this genus are known from India *viz., Gastrozona balioptera* Hardy, *G. montana* Bezzi, *G. parviseta* Hardy, *G. proterva* Hering, *G. nigrifemur* David and Hancock, *G. fasciventris* Macquart and *G. soror* (Schiner) (David and Hancock, 2017).

Fig. 1: *Gastrozona fasciventris*: A) Dorsal view B) Lateral view C) Fore wing

This observation records *G. fasciventris* Macquart from Cuttack district of Odisha (Location: 20°26'52.0"N 85°31'03.9"E). The adult fly (figure 1) was collected on 27.ii.2021 while visiting a pumpkin plant and was identified by using the keys of David and Hancock, 2017. This species has been identified in the following states: Arunachal Pradesh, Bihar, Karnataka, Kerala, and Maharashtra. The current observation perhaps makes the first record of this species from the state of Odisha. There are reports of this species from Malaysia and Thailand collected from bamboo (Dohm *et al*., 2014), and it also has been reared from the shoots of the Siamese bamboo, *Thyrsostachys siamensis* Gamble (Poaceae) (Tigvattananont and Bumroongsook, 2016).

Acknowledgement

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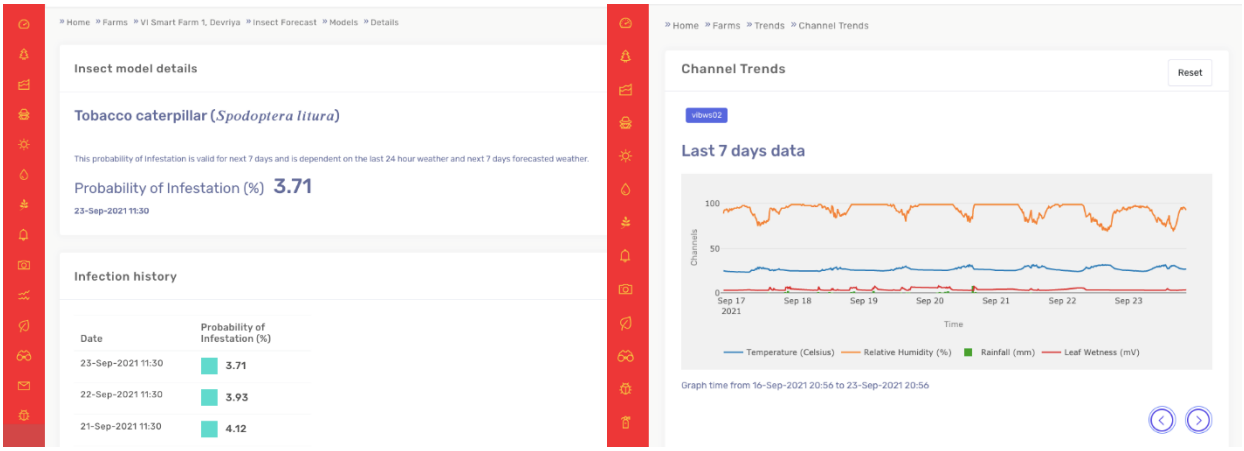
Yuktix GidaBits Platform



Pathogens are expanding in new areas never affected before, exacting significant economic cost on the livestock and crop sector. Prevention and early warning for rapid response are essential.

Solutions that integrate environmental determinants (e.g., soil, vegetation, temperature, rainfall) and epidemiological factors (e.g., vector species, livestock, wildlife, trade, human biological and behavioral surveillance), could be then used to inform about risk mitigation measures, such as restriction of movements or vaccination.

Yuktix GidaBits™ is a complete system for early warning and management of disease for farms. The system comprises of sensor devices that captures environmental determinants at the farm and a software that can run disease models to predict the onset of attack. The grower can get early warning and disease management help via Yuktix mobile app.

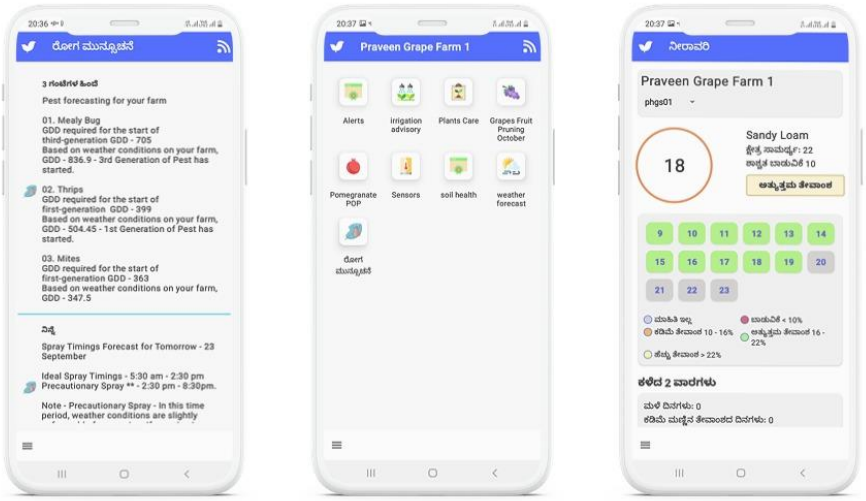
GidaBits IoT devices are deployed at the farm to capture hyper local weather patterns in real time. The IoT devices are solar powered and extremely easy to install. The device provides temperature, humidity, and leaf wetness sensors out of the box. There is provision to add additional sensors like Rain and soil moisture. The devices send sensors data in real time using a 4G modem. The data is stored on a SD card if the 4G network is not available. The stored data is sent whenever the network becomes available.

Yuktix GidaBits devices comes with different micro-weather and agriculture related sensors. All these sensors are best quality, research grade sensors and come with factory calibration certificate. We also provide NABL certification for some of our sensors.

The GidaBits™ cloud software can run the disease and PEST models automatically and distribute the early warning to a list of subscribers. The experts can bring in their own disease models for their specialty crops. The GidaBits platform uses delta T calculations and weather forecast to advise on best spraying times. The disease management advisories are dispensed in consultation with agronomists. The agronomists can use the GidaBits dashboard to access sensors data and calculations and can send disease management advisories to the farms. The system helps to create personalized advisories tailored to the crop being grown at the farm. The platform is scalable in that it takes little effort to add new crop and PEST forecast models and can start dispensing results immediately.

Mobile App

GidaBits mobile app helps growers by showing them disease advisories, the best spraying times and disease management advice from the agronomists. The growers can also take pictures using the mobile app and share it with the agronomist for implementing the best management practices. The mobile app is available in vernacular languages to increase the user engagement.



Yuktix GidaBits system is live in Kolar, Melur, Chikaballapur, Bijapur for powdery mildew, Downey mildew, Anthracnose, Bunch rot (Grape), Bacterial blight, Thrips, Aphids and mite reaching more than 1500 growers. Yuktix GidaBits is also used by partners organizations in Rajasthan, Nashik, Odisha, Jharkhand (Singbhum) covering more than 10,000 farmers.

Yuktix is a Government of India recognized Agritech startup based out of Bangalore, India. Yuktix is recipient of NASSCOM Emerge 50, Indo-Israel Innovation, Elevate 50, Euro Innovation Grant, World Bank Agri innovation contest.

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Damage of lemon butterfly, *Papilio demoleus* (l.) on bael, *Aegle marmelos* (l.) tree

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Introduction

Bael, *A. marmelos* is one of the oldest and underutilized fruit tree species indigenous to India. It belongs to the citrus family Rutaceae and it is also known as Bengal quince, bilva, Indian quince, golden apple, holy fruit, bael, belwa, sriphal, stone apple and maredo in India. It was introduced to Europe from India in 1759. It is a sacred tree in Hinduism and is offered in prayers of Hindu deities Lord Shiva and Parvati and thus, the tree is also known by the name 'Shivaduma' (The Tree of Shiva). Its medicinal properties have been described in the ancient treatise like Charaka Samhita, Upavana Vinoda and Yajur Veda and it has also been portrayed in the paintings of Ajanta Caves. Wide distribution of Bael in Indian subcontinent and other parts of the world reflects its adaptation to a range of agro-climatic conditions. In addition to well-known nutritional, traditional and medicinal benefits, the Bael fruits have considerable processing and industrial values (Singh *et al.,* 2019).

All parts of the Bael plant is of immense medicinal properties. The herbal medicinal preparations of this sacred tree are used to treat chronic diarrhoea, dysentery, peptic ulcers, laxative for astringency, and respiratory ailments (Baliga *et al.,* 2011). Bael has more considerable significance as it has many compounds with anti-cancerous properties. The anti-inflammatory activity was demonstrated by preparations of Bael roots (Kintzios, 2006).

Damage of lemon butterfly, *P. demoleus* on Bael, *A. marmelos*

Survey was conducted in two districts selecting three talukas and two villages in each taluka and 10 trees in each village and total of 60 trees were recorded. The 10 shoots per tree were taken for recording the observations. The Lemon butterflies, *P. demoleus* caterpillars feed on foliage and causes economic losses to farmers. Other insect-pests like Citrus leaf miner (*Phyllocnistis citrella*, Stainton), Spiralling whitefly (*Aleurodicus dispersus*, Russel) and brown scale, *Coccus hesperidum* (L.) are of minor importance, as these are either sporadic in

occurrence or confined to certain pockets. Hundred per cent infestation of lemon butterfly was recorded on Bael tree at Nawagam village (22.47 N latitude, 72.34 E longitude and altitude of 32.4 m MSL), 88 per cent damage at Kathwada village (23.03 N latitude, 72.68 E longitude and altitude of 37.0 m MSL) kheda taluka, whereas 50 per cent damage in Traj village (22.67 N latitude, 72.63 E longitude and altitude of 34.0 m MSL) and 56 per cent damage in Garmala village (22.68 N latitude, 72.67 E longitude and altitude of 34.0 m MSL) of Matar Taluka in Kheda district of Gujarat, India. However, in 84 per cent damage were recorded in Bareja village (22.85 N latitude, 72.59 E longitude and altitude of 30.0 m MSL) and 75 per cent damage in Mahijda village (22.82 N latitude, 72.54 E longitude and altitude of 35.0 m MSL) were recorded in Dascroi taluka in Ahmedabad district. The 10 to 20 larvae were found feeding on leaves and small tender twigs.

The activity of lemon butterfly, *P. demoleus* on Bael plant was noticed from 27th SMW, 2020 (Standard Meteorological week) with 2.4 caterpillars /10 shoots per two districts and was found maximum (6.6 caterpillars/10 shoots) on 37th SMW on leaves and tender twigs with 100 per cent shoot damage. Caterpillar population started declining in 39th SMW with 5.45 caterpillars/10 shoots and completely disappeared in 2nd SMW of 2021. The leaf damage ranged from 1.60 to 14.20 per cent in different months and maximum infestation (14.20%) was observed at 37th SMW, (mean of two districts) 2020.

Caterpillars on stem

Caterpillars on small branches

Whole Bael tree damage

Life cycle of lemon butterfly, *P. demoleus*

Life cycle

The adult female lays eggs singly on the under surface of tender leaves and also on tender twigs. The pooled mean duration of the different stages of lemon butterfly *viz.*, the incubation

period of 2.80 days, larval period of 9.23 days, pre-pupal period of 0.99 days, pupal period of 8.11 days, female adults longevity period of 3.85 days, respectively (Haldar *et al.,* 2017). The average length, width and wing expanse of male butterfly were found to be 27.961 mm, 5.997 mm and 88.518 mm while female butterfly was found to be 29.015 mm, 6.327 mm and 91.072 mm, respectively (Haldar *et al.*, 2017). This species typically has five instars and is capable of producing multiple generations per year depending on temperature constraints. Near the equator as many as nine generations may be seen. The average length of a generation varies from 26 to 59 days. In colder climates, pupae may overwinter.

Adult

Egg

Young larvae

Mature larvae

Pre-pupal stage

Pupal stage

Alternate hosts already recorded:

The lemon butterfly feeds on plants in the Rutaceae family. It is known to feed on cultivated lime, orange and lemons like *Citrus aurantifolia* (Christm.), *C. grandis, C. limon, C. sinensis, Atalanta racemosa, Glycosmis pentaphylla, G. arborea, Ruta graveolens, Aegle marmelos, Murraya koenigii, Chloroxylon swietenia, Ziziphus mauritiana, Acronychia pedunculata, Microcitrus australis.* The lemon butterfly also found to feed on plants in family Fabaceae on species of Cullen: *Cullen australasicum, C. badocanum, C. balsamicum, C. cinereum, C. patens, C. pustulatum* and *C. tenax* (tough scurf-pea, emu-foot, emu grass), and *C. leucanthum* (Sarada *et al*., 2013).

Patel *et al*., (2017) studied the host preference and reported that significant differences in egg laying among different hosts by lemon butterfly, *P. demoleus* was observed. Maximum number of eggs was laid on Lemon: *Citrus limon* (L.) Osbeck (11.03 eggs), followed by Mandarin: *C. grandis* (L.) Osbeck (10.18), Lime: *C. aurantifolia* Swingle (9.34), Curry leaf: *Murraya koenigii* (L.) Sprengel (8.49), Bael: *A. marmelos* Correa (7.64), while minimum number of eggs was recorded on Ber: *Zizyphus mauritiana* Lam. (6.49). The results of survey on host plants revealed that all the plants such as lemon, lime, mandarin, Bael, curry leaf, Ber and babchi supported the larvae of lemon butterfly from 46th to 7th Standard Meteorological Week while maximum larvae were recorded at 49th and 5th SMW. Hence, these plants can be considered as the host plants of lemon butterfly.

Bael tree

Citrus

Curry leaf

Management

- Hand picking of various stages of caterpillars in nurseries and young orchards
- The parasitoids *viz*., *Apanteles* sp. and *Bracon hebetor* (Hymenoptera: Braconidae) are known to parasitize *Papilio demoleus* larvae in India.
- Spraying with entomogenous fungus, *Bacillus thuringiensis* @ 1g/L, Neem seed extract@ 3%, Berliner or nematode DD-136 strain also gives very high mortality of the caterpillars.
- In case of severe infestation, spray with quinalphos 25 EC, 20 ml in 10 litre of water is recommended.

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Sooty mould scavenger beetle, *Leiochrinus nilgirianus* Kaszab (Tenebrionidae: Coleoptera) on palms

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ICAR-Central Plantation Crops Research Institute has discovered a sooty mould scavenger beetle, *Leiochrinus nilgirianus* Kaszab (Tenebrionidae: Coleoptera) on palms infested by the exotic rugose spiralling whitefly, *Aleurodicus rugioperculatus* Martin (Aleyrodidae: Hemiptera) from Kayamkulam, Kerala, India during 2018. Due to excretion of honey dew by *A. rugiopercualtus,* upper surface of whitefly-infested palm leaflets develop black coloured sooty mould belonging to *Leptoxyphium* sp. interfering photosynthesis. Adult *L. nilgirianus* beetles and grubs naturally emerging during monsoon phase (June-July) would eat away the sooty moulds @ 1-2mm^2 per beetle in one minute Fig.1. The special adaptive leg features with bristle hairs aid in proper adhesion and assist in swift movement of *L. nilgirianus* on fungus laden leaflets. Due to beetle feeding, black sooty mould deposits were gradually and completely cleansed and the leaflets become greener, reviving photosynthetic efficiency of palms. *In situ* habitat conservation of *L. nilgirianus* would help to reduce the sooty mould at no cost enabling better environmental health as well. The message is "conserve nature's gift to improve palm health after pest outbreak".

Fig. 1 Beetles feeding on sooty mould, Leiochrinus nilgirianus Eggs & Grub

Fig. 2. Leiochrinus nilgirianus Pupa, Bristle-like hairs on legs, Adults

A laboratory study on oviposition in fresh palm dates by *Rhynchophorus ferrugineus* Olivier

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India produces and markets dates mostly at the *khalal* stage (Green unripe) because climatic conditions do not favor full ripening of the fruit to produce *tamar* stage dates that are usually harvested in the monsoon. Dates are highly nutritious and relished by the people in different parts of India. Dates have been used in various ways and at religious and social festivities in the country (Shaha, 2014). The fresh date market is rapidly growing in India with the states of Gujarat and Rajasthan being the major producers in the country. The red palm weevil (RPW), *Rhynchophorus ferrugineus* Olivier (Coleoptera: Curculionidae) is reported as major pest of palms in diverse agro-ecosystems worldwide. In date palm *Phoenix dactylifera* L., RPW is designated as a category-1 pest by the FAO (Anonymous, 2014). In India too, RPW is a threat to the date palm plantations in Gujarat, Rajasthan, Andhra Pradesh and Tamil Nadu. The date palm variety Bahree (yellow colored fruit) is widely cultivated for harvesting in the *khalal* stage as fresh dates in India and elsewhere.

During July, 2021 an experiment was conducted in Department of Agricultural Entomology of Don Bosco College of Agriculture, Sulcorna, Quepem Goa, India (15.1060^0 N, 74.14860^0 E) to assess the oviposition preference by red palm weevil in *khalal* date fruits of two date palm cultivars. Adult weevils used in the oviposition trials were collected from the coconut field using insecticide free food baited-pheromone (Ferrolure^{TM}) based bucket traps and reconditioned in the laboratory for two weeks by allowing the adults to feed on sugarcane in plastic cages (28 ± 1 °C, 76 ± 3% RH) (Faleiro *et al*, 2014).

Fresh dates *viz*., Barhee and a non-descript red coloured variety used in the test were procured from the local market. In a no choice test, two fertile and gravid adult RPW females and one mature male were caged overnight in 10 containers per variety. Two fresh dates of the

respective variety were provided in each container for egg laying overnight. The number of eggs laid was recorded the next day by carefully extracting the eggs from fruit tissue with a camel hair brush. The experiment was carried out under the completely randomized block design. The trial was replicated twice and data on the cumulative number of eggs laid subjected to statistical analysis (ANOVA) using the Web Agri Stat Package (WASP 1), available at https://ccari.res.in/wasp/index.php. Results on the cumulative oviposition are presented below.

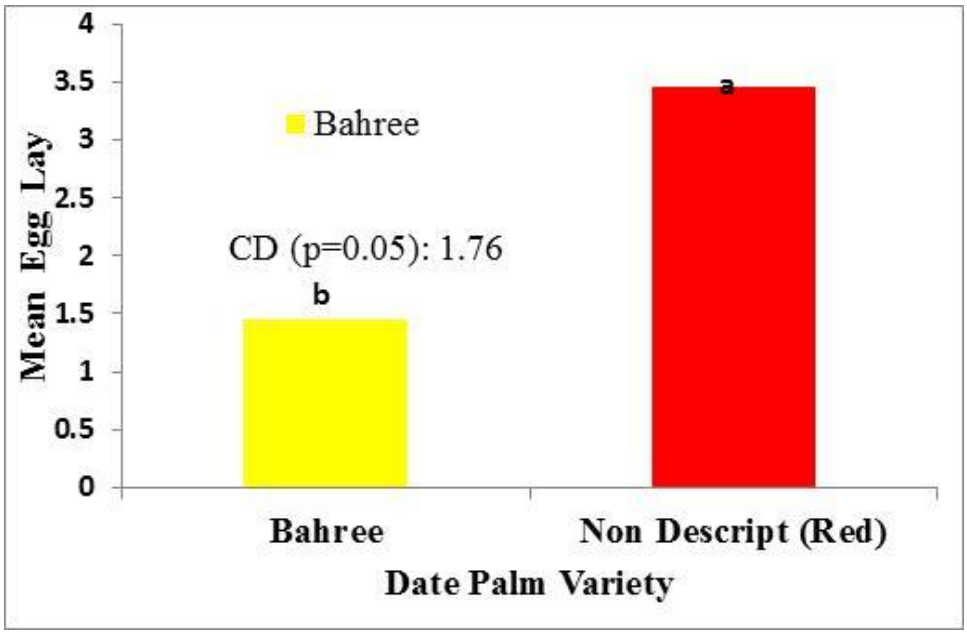

Figure 1. Cumulative mean number of eggs laid by red palm weevil in fresh date fruit

Results presented in figure 1 reveal that RPW can oviposit on fresh dates. The study showed that fresh date fruit of the non-descript red variety was significantly more preferred for egg laying (mean egg lay: 3.45) by RPW as compared to the popular Bahree variety (mean egg lay: 1.45). Al-Bagshi *et al*. (2013) evaluated frond tissue of 25 date palm cultivars for ovipositional antixenosis to RPW and found that the cultivar, Bahree was the fourth least preferred. The question is, can fresh dates pose a RPW quarantine threat? The answer is no, as mere egg laying in date palm fruits by RPW does not ensure completion of the life cycle. These eggs laid in the fruit tissue would perish for want of palm tissue and fibre essential for the completion of the larval and pupal stages (El-Shafie *et al*, 2013).

Like apple (Shahina *et al*., 2009), date fruits is only a laboratory medium for RPW to lay eggs. This study is the first report on egg laying by RPW in fresh dates.

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Field evaluation of secondary metabolite formulation against sweet potato weevil *Cylas formicarius* (Fabricius) (Insecta: Coleoptera: Brentidae)

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Sweet potato, *Ipomoea batatas* (L.) Lam (Family: Convolvulaceae) is believed to have originated from USA. It is the second most important root crop with a world production of 103.11 million tonnes (Cockerham *et al*., 1954). The tuber is an important source of carbohydrate. Sweet potato has assumed great significance in recent years as a health food due to various bioactive phenolic and anthocyanin content. It is referred as three in one tuber combining the properties of cereals, fruits and vegetables owing to its content respectively of starch, pectin and vitamins. Certain varieties having yellow flesh are rich in carotene, a precursor of vitamin.
Sweet potato is prone to various pests and diseases. *Cylas formicarius* commonly referred as sweet potato weevil which is one of the most serious pest of sweet potato, with reports of losses ranging from 10 to 97% in areas where the weevil occurs (Pillai *et al*., 1986).

Fig 1. Sweet potato field trial plot

Fig 2. Sweet potato weevil adult

(Source: www.whatsthatbug.com)

Life Cycle

Adults are ant-like, shiny, blue-black, snout beetles with bright orange red legs (Fig 2). Eggs are laid singly in small cavities eaten out in the stem or tuber. Eggs hatch in less than a week and larvae feed inside for two to three weeks. Larvae are legless, white to cream coloured with a pale brown head. Pupation occurs in the potatoes. The pupal stage lasts about a week to ten days. There can be as many as eight generations per year. A complete life cycle requires one to two months, with 35 to 40 days being common during the summer months. Adults do not undergo a period of diapause in the winter, but seek shelter and remain inactive until the weather is favourable. All stages can be found throughout the year if suitable host material is available (Jansson, 1991).

Although the symptom of infestation is noticed by yellowing of leaves, the damage is not apparent until the tubers are harvested. Thus, incipient problems are easily overlooked. The principal form of damage to sweet potato is mining of the tubers by larvae. The infested tuber is often riddled with cavities, spongy in appearance, and dark in colour. In addition to damage caused directly by tunnelling, larvae damage indirectly by facilitating the entry of soil-borne pathogens. Even low levels of feeding induce a chemical reaction that imparts a bitter taste and terpene odour to the tubers. Larvae also mine the vine of the plant, causing it to darken, crack, or

collapse. The adult may feed on the tubers, creating numerous small holes that measure about the length of its head. The adult generally has limited access to the tubers, however, the damage by this stage is less severe than by larvae. Adult feeding on the foliage seldom is of consequence.

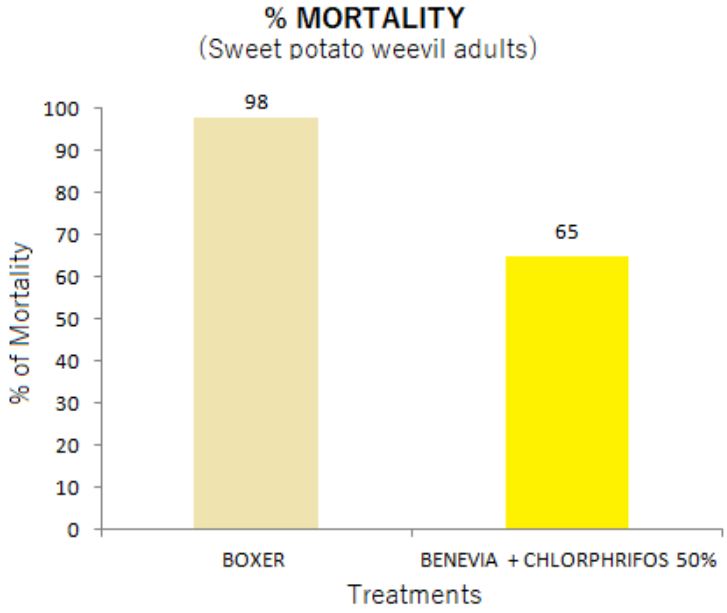
Field evaluation

The secondary metabolite formulation was developed by Agferm Innovations Private Limited using bio process technology. Two different strains of *Bacillus subtilis* were used. The metabolite extraction from the broth culture of the two strains was extracted using non polar solvent and evaporated to obtain concentrated secondary metabolite. This was resuspended in polar solvent and formulated using suitable adjuvants-polysorbate 80.

The trial was conducted at Mohan & Co Farms, Nangali Village, Kolar (Dist), Karnataka in 0.5 acre as shown in (Fig 1). The variety cultivated was Bhadra (CTCRI). Foliar and drenching both applications were evaluated. Two different formulations named Boxer and Rootex were evaluated against the pest in farmers' field and compared the results with leading chemical molecule used by the farmer. Boxer formulation was tried against adults (Table 1) and compared against leading molecule generally used by the farmers Cyazypyr 10.26%OD (Trade name Benevia) and chlorpyriphos combination. Mortality rate was calculated using Abbott's formula.

Table 1: Foliar Spray: for the control of adult population

Date of Application	**Types of Bio Pesticide/ Insecticide**		
	Agferm Organic solution	**Chemical Insecticides**	
20th day after planting	Boxer@5ml/lt	Cyazypyr 10.26% OD@1gm/lt	Chlorpyriphos50%EC @3ml/lt
40th day after planting	Boxer@5ml/lt	Cyazypyr 10.26% OD@1gm/lt	Chlorpyriphos50%EC @3ml/lt
60th day after planting	Boxer@5ml/lt	Cyazypyr 10.26% OD@1gm/lt	Chlorpyriphos50%EC @3ml/lt



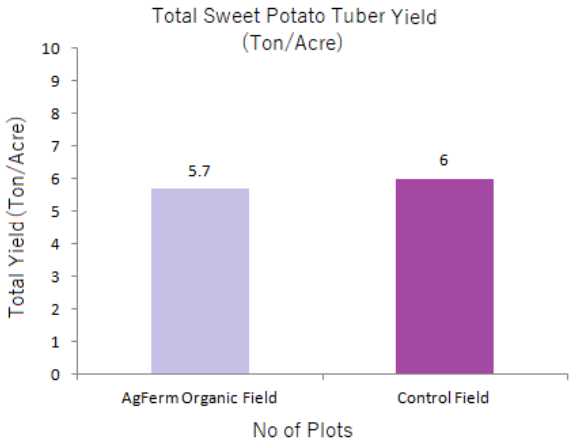
Graph 1. Mortality rate

The farmer practice was to combine two different chemical molecules in controlling the pest. The same was evaluated against our formulation. It is very evident that Boxer was highly efficient in controlling the adult population compared to the chemical combination of Cyazypyr 10.26%OD and Chlorpyriphos. The percentage mortality was 98% in comparison to the chemical combination where the mortality percentage was only 65% as shown in Graph 1.

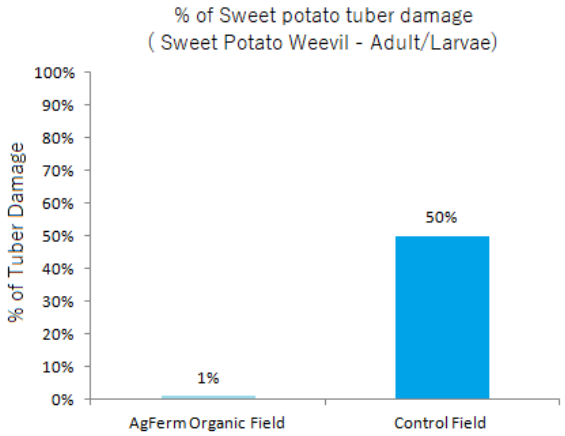
Table 2: Drenching: for the control of larval population that damages the tubers

Date of Application	**Types of Bio Pesticide/ Insecticide**		
	Agferm Organic solution	**Chemical Insecticides**	
20th day after planting	Rootex@5ml/lt	Emamectin benzoate @1gm/lt	Chlorpyriphos50%EC @3ml/lt
40th day after planting	Rootex@5ml/lt	Emamectin benzoate @1gm/lt	Chlorpyriphos50%EC @3ml/lt
60th day after planting	Rootex@5ml/lt	Emamectin benzoate@1gm/lt	Chlorpyriphos50%EC @3ml/lt
80th day after planting	Rootex @ 5ml/lt	Emamectin benzoate @ 1gm/lt	Chlorpyriphos 50% EC@3ml/lt

Four application- drenching was carried out at an interval of 20 days after planting as mentioned in Table 2. There was a clear 99% control of larval population with Rootex. The farmers perception collected during our interaction with the farmer was that the combination of drenching and spray with Agferm's product lead to remarkable decrease in tuber damage. There was no significant reduction in population when Emamectin and Chlorpyriphos drenching was carried out. The larval mortality was only 59% verses Rootex where 99% reduction in larval population was evident.



Graph 2. Comparative yield studies



Graph 3. Damage percentage

Comparative yield studies showed that more number of tubers was harvested about 6tons/acre in the chemical used field against 5.7tons /acre with Agferms organic solution. About 300kg difference in yield was noticed (Graph 2). However, when a comparison on the saleable part of the tuber was assessed, a significant rejection of tubers due to larval damage was inevitable in the chemical sprayed field. With usage of Agferm solutions, the farmer fetched better realization, since the tuber damage was almost nil (Graph 3). The product combination Boxer as foliar spray and Rootex drenching thus proved to be very efficient in controlling the pest population.

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Management of mango stem borer *Batocera rufomaculata* through organic repellant

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Mango stem borer, *Batocera rufomaculata* De Geer (Cerambycidae) internationally known as bark borer/mango stem-borer/ tropical fig borer is a serious pest in many fruit trees across the globe afflicting 26 countries or more in Asia; seven in Africa; three in Europe, North America and many more (Anon, 2021). Although the pest is referred as mango stem borer- it is not limited to mango crop/ trees but infests other fruit trees viz., *Anacardium occidentale* (cashew nut); *Artocarpus heterophyllus* (jackfruit); *Ceiba pentandra* (kapok); *Dyera costulata* (jelutong); *Ficus carica* (common fig); *Hevea brasiliensis* (rubber); *Morus* sp (mulberry tree) and *Spondias* sp (purple mombin) (Anon, 2021a). In India damage inflicted to the afore mentioned economically important horticultural and plantation crops impact economy of the farmers. Also, loss due to stem borer have detrimental effect on income of poor households of the farming community.

At ICAR-IIHR, Bengaluru, an organic formulation has been developed to manage the borer effectively. It was evaluated in mango orchards against *B. rufomaculata* in five major mango growing districts of Karnataka during 2016-2020. Control measures available for stem borer management are less evident with the scanty literature for organic measures. Hence, the study gains importance in promoting organic control measures for stem borer *B. rufomaculata*.

When the tree is infested with stem borer the frass (the debris of borer mixed with cut pieces of stem by the borer) can be visualized at the bottom of the trunk (in severe cases). The borer drills the main stem and the holes can be clearly seen (Figure 1). Before application of organic repellent formulation the grubs can be removed so that further damage is contained (Figure 2).

The organic formulation procured as gratis from ICAR-IIHR was in a paste form. The formulation was diluted with equal quantity of water till it attained melted ice cream consistency

so that the slurry adhered to brush. The consistency was adjusted by adding formulation or water. The slurry thus prepared was brushed till 3 feet height on trunk (Figure 3). Results suggested that re-infestation was nil up to 6 months whereas infestation occurred at 8th month. The formulation was again brushed and obtained zero infestation for next six months. The results also suggested that swabbing of organic formulation twice a year was effective in achieving zero infestation on stem borer infested trees (Table 1). However, on healthy trees, swabbing once a year was effective to give effective control for 12 months (Table 2).

Figure 1. Stem borer infested tree

Figure 2. Removing of stem borer grub

Figure 3. Swabbing of organic repellent on the cleaned bark of mango

The pest *B. rufomaculata* can effectively be controlled in mango by swabbing the organic formulation developed at ICAR-IIHR on borer infested mango trees once in 6 months. Healthy trees can be protected against the pest by swabbing the same formulation once in 12 months effectively without any infestation.

Table 1. Monitoring re-infestation of stem borer in treated mango trees

Districts	Borer infested trees	Re-infestation after treatment (months)				Percent infestation (%)
		2	4	6	8	
Kolar	15	0	0	0	1	6.7
Chikkaballapura	10	0	0	0	0	0
Hassan	18	0	0	0	1	5.6
Tumkur	12	0	0	0	0	0
Ramanagara	18	0	0	0	1	5.6

Table 2. Monitoring healthy trees for stem borer in treated mango trees

Districts	Healthy trees treated	Damage after treatment (months)				Percent infestation (%)
		2	4	6	8	
Kolar	25	0	0	0	0	0
Chikkaballapura	30	0	0	0	0	0
Hassan	22	0	0	0	0	0
Tumkur	28	0	0	0	0	0
Ramanagara	22	0	0	0	0	0

Acknowledgement

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Insect pests of *Melia dubia* Cav. an important commercial tree species

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Melia dubia Cav. commonly called as Malabar neem of the family Meliaceae is the fastest growing and widely planted as plantation tree species in different parts of India, and particularly in Southern India. It is an indigenous species to the Western Ghats of southern India and common in moist deciduous forest (Gamble, 1902). The wood from this tree is mainly used in Plywood Industry. This is a large tree, growing more than a height of 20 meters with a cylindrical straight bole of more than 9 m. length. It grows rapidly and is used for reforestation purposes and yields a useful timber. The wood is useful for packing cases, cigar boxes, ceiling planks, building purposes, agricultural implements, pencils, match boxes, splints and Catamarans. It is suitable for musical instruments, tea boxes and ply board. It is also a good fuel wood.

Melia dubia is susceptible to insect pest attack particularly the sapsuckers and defoliators during the nursery and young plantation stages.

The major defoliators are:

1. ***Bormia variegata*** Moore. (Lepidoptera: Geometridae): The Moth is whitish-grey or pale in colour (Fig 1). Caterpillar is a looper with two pairs of sucker feet on the last abdominal segments, naked, occurs in two colour forms, green with dark lines or pale yellowish brown, full size of 2 to 2.5 inches. Pupa is reddish brown in colour. Young larvae feed gregariously. The larvae consume the leaf completely only leaving the mid vein and some basal portion of leaf (Fig. 2). This pest is more active during April to September.
2. ***Myllocerus tenuicornis*** Faust. (Coleoptera: Curculionidae): Adult beetles are metallic green in colour (Fig 3). Males have pointed abdominal end whereas females have rounded end. Larvae and adult feed on the leaves. Severe feeding results in partial defoliation in tender foliage of young seedlings and saplings. This pest is more serious during May to September.

The major sap sucking pests are:

1. ***Empoasca*** *sp.* **(**Hemiptera: Cicadellidae) The nymphs are more or less transparent at the edge and as they rest closely pressed to the surface of leaves. The nymphs of the hoppers suck the sap of the leaves and tender shoots in the nurseries and in young plantations (Fig 4 & 5). This pest causes damage to the young seedlings during April to June.

2. ***Ferrisia virgate*** (Cockerell) (Hemiptera: Pseudococcidae) The mealybug is very small elongate, oval shaped. The adult female is covered with powdery white wax and has a pair of purplish dorsal stripes along the back. Long, glossy white wax threads extend from the body and there are two long wax tails (Fig 6). The mealybugs are often tended by ants and the ants act to keep other insects away from the mealybug. The mealybugs suck the sap of the leaves and tender shoots in the nurseries and in young plantations. The severely attacked plants show wilting and gradual die-back symptoms. The damage by this pest on the young seedlings is serious during the months of June and July.

Fig. 1 Adult moth of *Bormia variegata*

Fig. 2 Larva of *Bormia variegata*

Fig. 3 *Myllocerus tenuicornis* beetle

Fig. 4 *Empoasca sp*. attack on *M. dubia* seedlings

Fig. 5 *Empoasca sp*.

Fig. 6 Mealybug *Ferrisia virgata*

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Insecticidal control of important insect and mite pests infesting brinjal

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Brinjal (*Solanum melongena* L) is one of the important vegetable crops grown all over the world including tropical, sub tropical and other warmer areas. It is also known as eggplant and is native to India. The crop is attacked by a number of insects namely whitefly (*Bemisa tabaci*), leafhopper (*Amrasca biguttula biguttula*), hadda beetle (*Epilachna vigintioctopunctata*), shoot and fruit borer (*Leucinodes orbonalis*), lace wing bug (*Urentius hystricellus*), stem borer (*Euzophera perticella*) and leaf roller (*Eublemma olivacea*). Apart from these insects, mites (*Tetranychus urticae*) also attack the brinjal plants. This article is focused on nature of damage and management of major insect pest infesting brinjal crop.

Major insect and mite pests of brinjal

1. Leafhopper, *Amrasca biguttula biguttula* (Hemiptera: Cicadellidae): It is also known as jassid and prefer relatively hot and humid weather conditions. Different field crops, weeds and vegetable crops like okra, radish, tomato and potato are known to be attacked by leafhoppers.

Nature of Damage: Both adult and nymph suck the sap from leaves. During feeding, they also inject toxin into the plant tissue which leads to yellowing of leaves. Under severe conditions when the population of insects is very high, the yellow spots appear on leaves due to sucking the sap from the same spot followed by curling, bronzing and drying forming “hopper burn” symptoms.

Management: Spray the crop with 300-400 ml malathion 50% EC in 200-250 litres of water at an interval of 15 days. When fruiting start, spray the crop with synthetic pyrethroids (80 ml fenvalerate 20%EC, 70 ml cypermethrin 25%EC or 200 ml deltamethrin 2.8%EC) in 200 litres of water per acre. Synthetic pyrethroids spray should not be continuously repeated.

2.Whitefly, *Bemisa tabaci* (Hemiptera: Aleyrodidae): Whitefly feeds on a large number of plants including brinjal. It attacks other vegetable plants such as tomato, okra, chilli, cucumber and

sweet potato along with different weeds and field crops. Hot and dry weather conditions favour the population build-up of whiteflies.

Nature of Damage: Both nymph and adult cause direct damage by sucking the cell sap from undersides of leaves. Under high incidence these leaves will turn down yellow and drop off. The vigour of infested plant is greatly reduced. Indirect damage is also caused by honeydew excretion which hampers the photosynthetic activity of plant.

Management: Spray the crop with 400 ml malathion 50% EC in 200-250 litres of water at an interval of 15 days.

3. Hadda beetle, *Epilachna vigintioctopunctata* (Coleoptera: Coccinellidae): Hadda beetle is one of the most important pest on brinjal. It feeds on cucurbits, potato, kidney bean and tomato.

Nature of Damage: Adult as well as grub causes the damage to crop plants by scraping the chlorophyll from epidermis of leaves. During their feeding, they from the parallel band of uneaten plant tissue in regular eaten area which gives lace- like appearance to the leaves. Ultimately leaves turn brown, dry and drop off. Under high population the whole plant gets skeletonised.

Management: Spray the crop with 400 ml malathion 50% EC in 200-250 litres of water at an interval of 15 days.

4. Brinjal shoot and fruit borer, *Leucinodes orbonalis* (Lepidoptera: Crambidae): Most destructive pest of eggplant.

Nature of damage: Damage is caused by the larva alone they bore near the growing point of flower or fruit upon hatching. At early stage the larva feed on tender shoot and bore into shoot and fruit and feed on the inner content by making tunnel. The entry hole is plugged by excreta. In vegetative stage of crop, the dropping of young shoot is a typical symptom of brinjal shoot and fruit borer. Under high incidence more than one larva is found to feed on the same fruit.

Management: Infested shoots and fruits should be removed and destroyed in order to reduce carryover of insect populations. Before the flowering, as the infestation appears, spray the crop

with 75 ml spinosad 45%SC in 200 litres of water per acre and spray the crop 3 times at an interval of 15 days. Harvesting of fruits should be done before spraying. For seed crop, spray with 56 g emamectin benzoate 5%SG is suggested.

5. Red spider Mites, *Tetranychus urticae* (Acarina: Tetranychidae): Mites emerged as a serious problem in vegetable production as they attack many crops like tomato, french bean, cucumber and many other field crops. The multiplication of mites is favoured by dry climate.

Nature of Damage: Adults and nymphs suck the cell sap from the leaves and the infestation starts from the lower portion of plants. White or yellow speckle is formed on the leaves due to reduced chlorophyll. Webbing on the leaves can also occur under high infestation. When the dry climate prevails for long time and the population density of mites gets high, they aggregate at the tip of leaves and form a ball like mass by using the strand of silk which helps in reaching the new leaves of plant by wind and this process in called “ballooning”.

Management: Spray the crop with fenpropathrin 15%+pyriproxifen 5% in 200 litres of water per acre. First spray is given before flowering stage, second and third sprays at 10-12 days interval.

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Interception of Saproxylic Hemiptera, *Fulvius anthocoroides* (Reuter, 1875) on wooden logs imported from Cameroon to India, a new report for Cameroon?

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The wooden logs of more than 20 forest species are imported into India from more than 40 countries, to meet the demand of real estate, furniture, housing, packaging, etc. Padauk, *Pterocarpus* sp. (Fabaceae) is one such commodity being regularly imported from Cameroon, mostly in the form of logs. Between 2018 to 2020, a total 36,223 MT of Padauk logs were imported through Tuticorin port located in southern India alone.

In India, the Plant Quarantine (Regulation of Import into India) Order 2003 issued as per the Destructive Insects & Pests Act, 1914 (Act 2 of 1914) regulate the import of all agricultural commodities. The species/wooden logs that are listed under Schedule VI and VII of the Plant Quarantine Order 2003are allowed for import and as per the import requirements listed under these schedules. In addition, general import requirements for wooden material are listed under Section 9 (Requirement of Import of Wood and Timber), Chapter II (General conditions for import) of the Plant Quarantine Order 2003. The import of wood and wood products requires fumigation/heat treatment /Kiln Dried to be endorsed on the phytosanitary certificate issued in the country of export.

The Plant Quarantine Stations located at different ports inspect the imported consignments as per provisions of Plant Quarantine Order 2003. During 2018-19 and 2019-20, 115 and 184 consignments of Padauk logs were imported through Tuticorin port located in the state of Tamil Nadu, respectively. The volume of imported Padauk logs amounted to 14,848 and 21,739 MT, respectively during the same period.

During our regular plant quarantine inspection, a hemipteran bug was intercepted on two occasions on these logs. The intercepted bugs were collected in sufficient numbers and were stored in 70% alcohol for further study. The bugs were identified based on the habitus and male

genitalia structures, as *Fulvius anthocoroides* (Reuter, 1875) (Hemiptera: Miridae) (Figure 1). The specimens are deposited in the collection of Department of Entomology, Gandhi Krishi Vignan Kendra (GKVK), University of Agricultural Sciences, Bangalore (UASB), India.

Fulvius anthocoroides can be easily identified by the marking on its body, brown head, with antennal segment-II pale at apical third. Clavus yellowish at basal half and at apex. Embolium narrow, reddish brown in the distal part. Corium with pale patch above cuneus and Cuneus brown.

The Miridae subfamily Cylapinae (Hemiptera: Heteroptera) is a small group of zoophagous and probably mycetophagous true bugs (Pluot-Sigwalt & Chérot 2013), inhabiting mainly tropical and equatorial regions of the World. Thegenus *Fulvius*species are predatory and frequently found on tree barkhunting for microarthropoda. In India, three species are known to occur (Yeshwanth, *et. al.,* 2016). The species has its distribution from the Afrotropical and Oriental Regions.

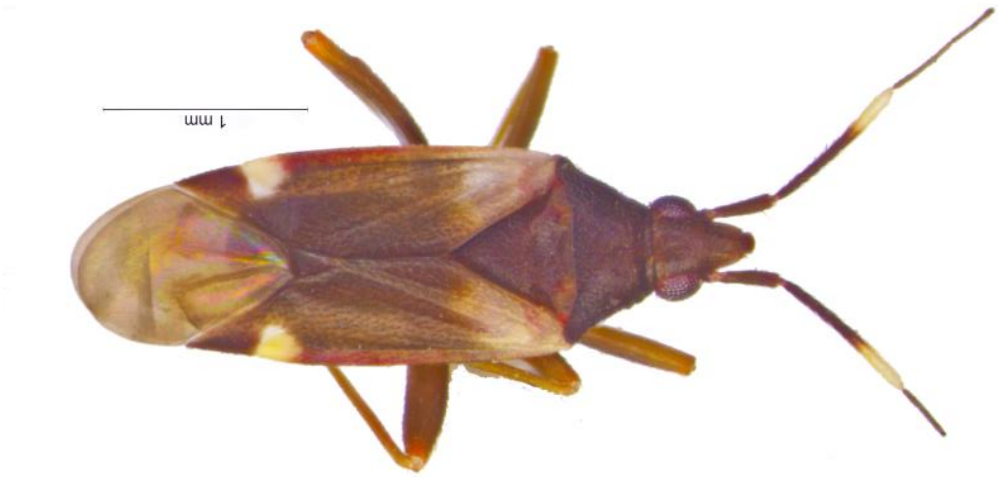

Figure 1. *Fulvius anthocoroides* (Reuter, 1875) (Hemiptera: Miridae).

Distribution:

INDIA: Karnataka, Kerala, Odisha, Uttarakhand and West Bengal (Yeshwanth, *et. al.*, 2016).

WORLD: AFRICA (Gabon, Ghana, Ivory Coast, Malawi, Nigeria, Senegal),CENTRAL AMERICA (Bahamas, Costa Rica, Cuba, Jamaica, Martinique, Panama, Trinidad), NORTH AMERICA (United States of America), SOUTH AMERICA (Brazil, Chile, Ecuador: Galapagos Islands, Venezuela), ASIA (China: Hong Kong, Japan, Malaysia, Seychelles Islands, Singapore, Sri Lanka, Taiwan, Thailand), AUSTRALIA (Christmas Islands), Pacific Islands (Bonin, Mariana, Guam Islands); imported but not established in Western Europe [in France, Great Britain, The Netherlands (Gorczyca 2006) and BELGIUM (Dethier & Chérot 2014)].

*Fulvius anthocoroides*is not known to occur in Cameroon, but occur in neighbouring countries like Nigeria and Gabon. Cameroon is sharing land border with both the countries in addition to Niger, Chad, Central African Republic, Congo and Equatorial Guinea (Gorczyca 2006). There is possibility that the insect might have drifted to Cameroon from the adjoining countries. The present interception is a first report of *F. anthocoroides* for Cameroon. Gorczyca (2000) examined specimens of *F. anthocoroides* collected in the French harbour Rouen on a ship which had come from Senegal. In the present study, the species was collected on wooden logs. It clearly indicates that international trade in wooden logs is aiding the spread to *F. anthocorides* to new territories and it may have been introduced into Cameroon by similar pathways.

Fulvius anthocoroides is reported from India. However, interception of any live insect in an imported consignment leads to apprehension on the integrity of the imported consignment. Therefore, imported logs were fumigated with Methyl Bromide @ 48 g/m^3 for 24 hours at NAP and re-inspected prior to release to ensure pest freedom.

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Incidence of white grub, *Holotrichia consanguinea* (Blanchard) in Cheetwari village of Jaipur district, Rajasthan

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White grubs are serious pests of several crops and widespread across the continents. More than 2000 species of white grubs are known to occur in Indian subcontinent, of which more than 40 species cause serious damage to an extensive variety of crop plants (Veeresh *et al.,* 1991). The species are mostly covered under two major genera *Holotrichia* and *Anomala.* The species of *Holotrichia* are more destructive, polyphagous and predominant in various regions of India (Sreedevi *et al*., 2017). Both, the grub and adult stage of the species inflict heavy damage to various fruit trees, their nurseries, vegetables, lawns and field crops. The immature stages feed on the roots of the crops while the adult beetles feed on the leaves of the trees. The monsoon showers trigger the emergence of adult dark brown beetles from the soil and hence these are generally known as May-June beetles. The loose soils with moderate to low rainfall provide favourable conditions for the survival and multiplication of these subterranean pest and certain species are serious pests of sugarcane, groundnut, etc., particularly in parts of Rajasthan, Uttar Pradesh, Gujarat, Maharashtra, Karnataka and Bihar (Pal, 1977, Sreedevi *et al*., 2014).

The present observations on white grub, *Holotrichia consanguinea* (Blanchard) (Coleoptera: Scarabaeidae: Melolonthinae) are from Cheetwari Village (27^0 9' 02.0" N 75^0 48' 54.9" E) in Chomu tehsil, Jaipur District, Rajasthan, India. The adults were found emerging at dusk in large numbers and actively foraging on Jamun (*Syzygium cumini*) and neem plants *(Azadirachta indica*) (Figs. 1-2), adjacent to groundnut fields. *Holorichia consanguinea* is the predominant species of root grub in Rajasthan, parts of Uttar Pradesh (Sreedevi *et al*., 2017) and several other parts of the country. The taxonomy and biology of *H. consanguinea* infesting groundnut in Rajasthan has been worked out (Rai, *et al.,* 1969, Kumar *et al*., 2017). The damage to groundnut is estimated to range from 20 to 100%. Management of this pest is warranted to curb yield losses. Integrated pest management incorporating the pheromone traps with anisole as

a lure may be advocated in endemic pockets of infestation. Wide area management was undertaken using pheromone Nano formulations in different parts of Rajasthan (https://www.icar.org.in/content/icar-nbair).

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Figure 1. *Holotrichia consanguinea* defoliating jamun leaf

Figure 2. A mating pair and defoliation observed in neem

Study on foraging behaviour of stingless bee, *Tetragonula iridipennis* Smith (Hymenoptera) at natural nesting site

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Abstract

Stingless bee or dammer bee, *Tetragonula iridipennis* Smith is the smallest of the honey-producing bees. They are highly social insects like honey bees living in permanent colonies, nesting in dark places like cavities in tree trunks, empty logs, cracks and crevices in old walls. They are important and effective pollinators of many crops. However, reliable information on stingless bee foraging behaviour is scanty. Therefore, experiment was conducted to observe the foraging behaviour of the stingless bee, *T. iridipennis* Smith in Devarkovil, Kozhikkode (Kerala) during October 2020 to November 2020 at fortnightly interval. The intensity of outgoing bees showed a maximum at 1300 hr (26.72 bees/15min), which kept on decreasing significantly at successive hours till 1600hr (7.27 bees/15min). The incoming forager intensity was lowest at 1600 hr (11.54 bees/15 min). Comparison of the intensity of incoming foragers averaged over time showed the highest intensity of bees (37.65 bees/15min) at 1300 hr. The intensity of nectar foragers kept decreasing from 1300 hr (20.98 bees/15 min) to 1600 hr (7.56 bees/15 min). The pollen forager number also showed a gradual decline from 1300 hr (16.67 bees/15 min) to 1600 hr (3.98 bees/15min).

Keywords: Stingless bee, *Tetragonula iridipennis*, foraging behaviour, foragers, outgoing foragers, incoming foragers, nectar foragers, pollen foragers

Introduction

Stingless bees are the smallest of the honey producing bees, belongs to the family Apidae and sub-family Meliponinae. As in honeybees, their principal resources are pollen and nectar, but they also collect materials such as resin, water, sap, wax, honeydew, extra floral nectar, mud, salts, animal protein, and fungal spores for nutrition or nest-building materials (Roubik, 1980). Large proportion of tropical plant species, summing up to one fifth of the local angiosperm flora

requires the service of stingless bee pollination (Corlett, 2004). There are more than 500 species of stingless bees described all over the world (Michener, 2013). The most common stingless bee species of South India is *Tetragonula iridipennis* Smith (Michner, 1974). They are highly social insects like honeybees living in permanent colonies, nesting in dark places like cavities in tree trunks, empty logs, cracks and crevices in old walls etc. Unlike the other honeybees of the genus *Apis*, they construct numerous elliptical cells for storing pollen and honey by using a special material known as "cerumen" made of wax, resin, propolis and mud. But the sting is greatly reduced without an effective tip. Hence, the defense behaviour is by chasing the intruders by biting, often gets entangled in the intruder's hairs and getting into the nose, ears and eyes. Devanesan *et al.* (2002) observed peak foraging activity of *T. iridipennis* during the month of July and least foraging activity during December and January. Danareddi (2007) reported that foraging behaviour of *T. iridipennis* during different season and activity of outgoing bees was high in October and November, also pollen foraging in the month of February. *T. iridipennis* has two peak hours of foraging activity, which are in the morning and in the afternoon (Layek and Karmakar, 2018).

During foraging the *Tetragonula* bees show preferences for different plants. Transfer of colonies to the hives enhances the potentiality of stingless bees for crop pollination. Hives can be transported where pollination is required. They are important and effective pollinators of many crops. Nine species of crops are confirmed as effectively pollinated by stingless bees and they make a contribution to the pollination of nearly 60 other crops (Heard, 1988). However, reliable information on stingless bee foraging behaviour is scanty. For better utilization of *T. iridipennis*, more knowledge on various aspects of this species is absolutely essential. Hence, to bridge the research gap, the present studies were undertaken to study the foraging activity of stingless bee.

Material and Methods

Studies were carried to generate information on foraging behaviour of the stingless bee, *T. iridipennis* Smith in Devarkovil village, Kozhikode District, Kerala. The location of experiment is situated at an altitude of 11m above Mean Sea level and the latitude and longitude of 11.6698° N, 75.7633° E respectively. Over the course of the year, the temperature in the region typically varies from *23.8°C* to *34°C*. The average Relative Humidity is around 85% and

annual rainfall is 3055 mm. Common bee flora in the region includes Hibiscus, Rose, Communist pacha, Pepper, Nutmeg, Tulsi and Coconut.

Foraging behaviour

For this study one colony of *T. iridipennis* was selected from wall crevice in an abandoned house situated in Devarkovil village, Kozhikkode District, Kerala (11° 40' 26.1156" North latitude, 75° 46' 2.9784" East longitude and altitude of 11 m above mean sea level). The foraging activity in terms of the number of foragers leaving the hives and returning to their hives with pollen load (Pollen foragers) and without pollen load (Nectar foragers) were recorded for a period of fifteen minutes at hourly interval from 1300 - 1600 hour. These observations were recorded at fortnightly interval from October 2020 to November 2020.

Results and Discussion

The numbers of bees leaving the nest and entering the colony for 15 min. were counted at hourly interval for every fortnight from 1300-1600 hrs during October - November 2020.

Outgoing Foragers

The mean number of outgoing bees was maximum at 1300 hr (26.72 bees/15min), which kept on decreasing significantly at successive hours till 1600hr (7.27 bees/15min) irrespective of months (Table 3). The comparative departure intensity of the bees averaged over time during different fortnights showed significant variation in the outgoing movement. It was highest during October second fortnight (20.75 bees/15 min) (Table1) and the number of outgoing bees was comparatively less in November first and second fortnights (17.93 and 16.01 bees/15 min) (Table 2). Least activity was found during October first fortnight (15.7 bees/15 min) (Table 1). There was significant interaction between time and the intensity of outgoing bees. The overall peak intensity of outgoing bees was observed at 1300 hr. Naik (2002) also reported that the intensity of outgoing bees increased gradually in *T. iridipennis* from 0800 - 0900 hr and reaching peak at 1400 - 1500 hr.

Incoming Foragers

The intensity of incoming foragers showed a significant variation during different hours of the day. It was lowest at 1600 hr (11.54 bees/15 min) and then went on increasing to record the maximum value of (37.65 bees/15min) at 1300 hr (Table 3). The comparative departure intensity of the bees averaged over time during different fortnights showed significant variation in the incoming bee activity. It was highest during October first fortnight (26.7 bees/15 min) (Table 1) and the number of outgoing bees was comparatively less in November second fortnight (22.72 bees/15 min) (Table 2).

Nectar Foragers

The intensity of incoming nectar foragers during different hours of the day averaged over the months (October - November 2020) showed significant difference among them. A mean number of 7.56 nectar foragers/15min recorded at 1600 hr varied significantly to 20.98 nectar foragers/15min at 1300 hr (Table 3). There was successive marginal decrease in the nectar foragers from 1300-1500 hr and reached a lowest of 7.56 nectar foragers/15 min at 1600 hr. The fortnight wise average intensity of nectar foragers varied significantly among them. It was highest during October first fortnight (16 nectar forages/15min) (Table 1). It was comparatively less during November first fortnight (14.72 nectar forages/15min) followed by November second fortnight (13.81 nectar forages/15min) (Table 2). Lowest of 12.59 nectar foragers/15min were observed in the second fortnight of October. However, peak nectar foraging was at 1300-1400 hr during the study period and the nectar foragers number showed a gradual decline from 1400 hr onwards.

Pollen Foragers

The intensity of incoming pollen foragers during different hours of the day averaged over the fortnights October and November revealed significant difference among them with a major number of 3.98 bees/15min at 1600 hr. It reached 16.67 bees/15min at 1300 hr. beyond 1300 hr the pollen foragers activity went on declining with every successive hour of the day (Table 3). The fortnightly mean of incoming pollen foragers intensity, averaged over time, also showed significant variation among them. During first fortnight of October, the number of bees was 9.55 bees/15min that increased in second fortnight to 12.3 bees/15min (Table 1). In November the

intensity of bees showed a decline in the number with 10.35 bees/15 min in first fortnight and 8.91 bees/15min in second fortnight (Table 2). There was a significant interaction between time and intensity of bees. The intensity showed a gradual declining pattern from 1300 hr to 1600 hr.

The present results matched with findings by Roopa (2002), that relative percent of nectar foragers in *T. iridipennis* were always higher than that of pollen foragers throughout the study period. Higher percent of pollen and resin foragers were observed during morning compared to nectar foragers in the afternoon. Naik (2002) also reported that among incoming bees, number of nectar foragers exceeded pollen foragers till noon and towards the end of the day. Cervanica *et al.* (1982) also observed active collection of pollen by *T. minangicavan*, *T.iterna* and *T.moorei* in the afternoon and rapid increase in the foraging activity of *T.biroi* as the day progressed.

Table 1. Foraging activity of stingless bee, *T. iridipennis* during October 2020

October first fortnight (11/10/20 to 15/10/20)				
Time	**Bee activity**			
	Pollen	**Nectar**	**Incoming bees**	**Outgoing bees**
1300 hr	15.20	23.00	38.20	25.00
1400 hr	11.80	19.80	31.60	20.60
1500 hr	7.80	13.40	25.80	12.40
1600 hr	3.40	7.80	11.20	4.80
Mean	**9.55**	**16.00**	**26.70**	**15.70**
October second fortnight (16/10/20 to 31/10/20)				
Time	**Bee activity**			
	Pollen	**Nectar**	**Incoming bees**	**Outgoing bees**
1300 hr	19.38	18.46	37.80	30.38
1400 hr	15.76	15.69	31.15	24.23
1500 hr	9.07	10.14	19.92	18.78
1600 hr	5.00	6.07	11.07	9.61`
Mean	**12.30**	**12.59**	**24.98**	**20.75**

Table 2. Foraging activity of stingless bee, *T. iridipennis* during November 2020

November first fortnight (01/11/20 to 15/11/20)				
Time	**Bee activity**			
	Pollen	**Nectar**	**Incoming**	**Outgoing**
1300 hr	16.71	21.28	38.00	26.50
1400 hr	11.91	18.25	30.25	22.91
1500 hr	8.50	11.71	19.76	14.92
1600 hr	4.28	7.64	11.92	7.42
Mean	**10.35**	**14.72**	**24.98**	**17.94**
November second fortnight (16/11/20 to 20/11/20)				
Time	**Bee activity**			
	Pollen	**Nectar**	**Incoming**	**Outgoing**
1300 hr	15.40	21.20	36.60	25.00
1400 hr	11.00	14.80	25.80	19.80
1500 hr	6.00	10.50	16.50	12.00
1600 hr	3.25	8.75	12.00	7.25`
Mean	**8.91**	**13.81**	**22.73**	**16.01**

Table 3. Mean foraging activity of stingless bee, *T. iridipennis* during October and November 2020

Average Bee activity				
Time	**Pollen**	**Nectar**	**Incoming**	**Outgoing**
1300 hr	16.67	20.98	37.65	26.72
1400 hr	12.61	17.13	29.7	21.88
1500 hr	7.84	11.43	20.49	14.52
1600 hr	3.98	7.56	11.54	7.27

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Review Articles/ Short Notes/Essays

The chemosensory system of forensic flies controls their bio-physiological behavior

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The erratic and unpredictable accessibility and availability of carcasses make them temporary resources, which are frequently colonized and exploited by large number of arthropods including sarcophages, coprophages, dermatophages, keratophages, detritivores, predators and parasites (Braack, 1987). Carrion flies, owing to their outstandingly developed antennal sensilla enriched with olfactory receptors/osmoreceptors can detect pungent smell of several ammonia and sulphur-rich volatile compounds released from rotten dead bodies even from a substantial distance.

During cadaveric decomposition, complex compounds as well as several digestive enzymes produced by the body oozes out to chemically alter and degrade the cadaveric remains and a sharp increase of bacterial load from within the dead body are witnessed to fasten decomposition (Mondor *et al*., 2012). Furthermore, the bacteria present in the gastrointestinal tract accelerate soft tissue decomposition using the protein and carbohydrate macromolecules from the dead body. Bacterial growth and proliferation takes place along with the release of apneumones (volatile compounds released from the cadaver) as chemical by-products (Joseph *et al*., 2011; Mondor *et al*., 2012). Volatile molecules of ammonia, cadaverine, hydrogen sulfide, methane, sulfur dioxide, hydrogen and putrescine are responsible for the remarkable putrid odour during putrefaction (Mondor *et al*., 2012). It was also postulated that chemicals released at different stages of decomposition can control the several behavioural aspects in insects (LeBlanc and Logan, 2010; Joseph *et al*., 2011). During early stages of decomposition, sulphur-rich compounds attracts the carrion flies (Joseph *et al*., 2011) whereas ammonia-rich compounds are involved in augmenting oviposition of the flies on the carcass (Ashworth and Wall, 1994).

The receptiveness of the olfactory receptors present in the antenna and mouthparts of several forensic flies enables them to detect gases released by the bacteria during fermentation.

Chemical cues in a huge number of insect group aids in foraging, locating oviposition sites and selecting conspecific mates. Several research reports revealed that among flesh flies, blowflies, and screwflies, significant number of animal-related compounds arouse either a physiological or behavioral response (Wasserman and Itagaki, 2002). Additionally it was also assessed by Wasserman and Itagaki (2002) that the antennae and maxillary palps of flesh fly *Neobellieria bullata* were more sensitive to odors of animals derived extract (blood extract and saturated carboxylic acid) than that of the plant derived products (citral, hexenol, hexenal). Some precise examples of animal/plant extracts and their interaction with insect chemosensory system are enlisted in Table I.

Table 1: Animal/plant extracts and their interaction with insect chemosensory system

Forensic flies	Physiological responses	Animal/ Plant extract
Cochliomyia hominivorax (Calliphoridae)	Olfaction	Dried bovine blood act as olfactory attractant (Hammack *et al*., 1989; Hammack, 1990)
Phormia regina (Calliphoridae)	Olfaction and behavioral responses	Aliphatic alcohols and aldehydes (Dethier, 1976).
Lucilia sericata (Calliphoridae)	Olfaction	C2– C6 alkyl thiols, cyclohexane, ethyl acetate and camphor (Dethier, 1976)
Calliphora erythrocephala (Calliphoridae)	Olfaction aided by single receptor neuron	Meat, carrion, and cheese, some alcohols, aldehydes and mercaptans (Dethier, 1976)
Neobellieria bullata (Sarcophagidae)	Difficulties in larviposition	Liver odor (Mitchell and Soucie, 1993)

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Midnight deroes brought to Daylight: Insights from the *National Moth Week*-2021 (India)

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Introduction

Moths (Lepidoptera: Heterocera) are the close relatives of butterflies due to their similitude in shape and structure. Both moths (Heterocera) and butterflies (Rhopalocera) belong to the same order Lepidoptera. Moths are insects that are usually unseen and unloved. They are the 'unsung heroes' of the Animal Kingdom considering their rich diversity and ecosystem services. However, in nature's perspective, it really doesn't work. On contrary, if we begin to put the concept of systematic classification in it, there are a number of whys and wherefores which differentiate butterflies and moths. The most common difference between butterflies and moths are; butterflies are diurnal and moths are nocturnal. However, there are many moth species that fly during the day hours. The major differences between the moths and butterflies are the antennae; moths have very feathery antennae while the butterflies are having thin clubbed antennae. The frenulum which is the wing coupling device is absent in butterflies, while as it is present in all moths. Moths come in different shapes, sizes and vibrant colours (Figure. 1). The largest species of moth ever recorded is the Hercules moth with a wingspan of about 30 cm (Moscardo and Bertella, 2021). Apart from Bees, flies and other pollinating insects, Moths also take part in pollinating the flowering plants. Besides pollination, moths are the diet of most of the birds, lizards, spiders and a whole range of other animals as well which makes them an extremely important part of our ecosystems. The significant roles played by the moths in our ecosystems makes them remarkable species in the animal kingdom. However, the larvae (caterpillars) of most of the moth species are considered as pests of many vegetable and fruit crops. Most of the adult moth species require nectar from the flowering plants as their food, while many are the pests of fruit and vegetable crops. The caterpillars of most species feed on the leaves of many vegetable and crop plants for their survival. As the larvae transform into pupae/chrysalis, the development and growth starts within the pupae which later emerges into adult moths. This transformation needs a lot of energy which larvae (caterpillars) store as a food

despite the fact they only feed themselves with the leaves of vegetables and other crops. The caterpillars of moths are equipped with biting and chewing mouthparts while adults have the long proboscis for sucking the nectars and other juices from flowers (Dempster, 1983).

Fig. 1: A Golden Emperor Moth (*Leopa katinka)* (Photo: Muzafar Riyaz)

National Moth Week (http://nationalmothweek.org/) is a citizen science project established in 2012 by East Brunswick Environmental Commission in New Jersey. From the time of its establishment, almost 50 USA states and 80 countries are participating in this event. The aim of this initiative is to encourage scientists, research scholars, amateur entomologists and most importantly general public to participate in the survey of moths during the night hours. The National Moth Week is celebrated in the last week of July month. This year (2021), the National Moth Week was celebrated during 17-25 July. Usually, people participate in organized events like virtual conferences or from their own gardens and lawns individually. The National Moth Week project has collaborated with major online databases, depositories like inaturalist, Project Noah, Flicker and India Biodiversity Portal, where people from all around the globe upload their

observations online. Since 2012, the national moth week has been celebrated every year with changes in the dates in the month of July as shown in Table 1.

Table 1. Moth weeks in the month of July from 2012-2021 (Source: http://nationalmothweek.org/)

National Moth Week (Year)	Celebrated on
2012	July 23-29
2013	July 20-28
2014	July 19-27
2015	July 18-26
2016	July 23-31
2017	July 22-30
2018	July 21-29
2019	July 20-28
2020	July 18-26
2021	July 17-25

India has four major hotspots and in terms of biodiversity heritage and management of both flora and fauna. India is home for more than 10,000 moth species with the extension of species ranges from the Himalayas to Peninsular plateaus, Indo-Gangetic plains to Great Indian Desert and from Coastal plains to Islands (Sondhi and Kunte, 2014). The National moth week is celebrated in India with all enthusiasm in both entomologists and common people. Many virtual conferences were organized by both government and non-government organizations and as well as the research institutes, colleges and universities from different parts of the country. The aim of this event is not limited to observe and document the species to the data depositories but to spread knowledge and learn about the management of these night creatures. This event aims at creating awareness among people from different age groups to learn and contribute to the scientific data with the help of citizen science. Although there are only estimates of their population, the diversity is still not known. Since, the discovery of new species of moths are frequently been published in journals accounting for data from such initiatives. It is high time

that people from all around the globe take part in such activities which may lead to even more discoveries of new species and records. The observations from National Moth Week (2021) in India were deposited in two major data depositories, India Biodiversity Portal (https://indiabiodiversity.org/) and inaturalist (https://www.inaturalist.org/). The utmost number of observations was uploaded on India Biodiversity Portal followed by inaturalist and other online databases. The chart showing the number of observations and uploads from 17-25 July 2021 from National Moth Week in India ((Figure 2).

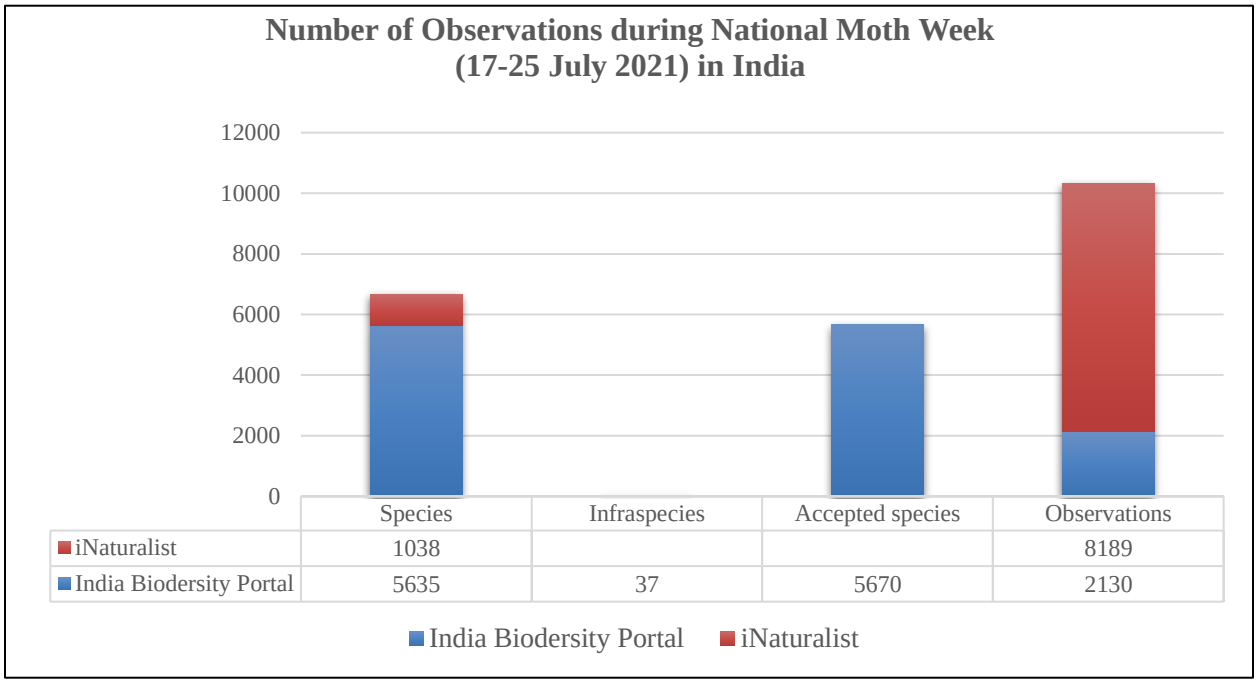

Fig. 2: Number of species and observations uploaded to the mentioned data depositories. (Source: India Biodiversity Portal and inaturalist)

Summary

Citizen science aims at increasing scientific knowledge through collaboration and public participation in scientific research. With this initiative, people from different parts of the world take part in such activities and share and contribute to data monitoring and collection programmes (Salmon *et al.,* 2021). Citizen science allows people to enhance their scientific temperament in the fields and empowers communities to observe nature and with the collective efforts to conserve as well. In India, the majority of people are been taking part in such activities

and people are very enthusiastic about sharing and collaborating to scientific research. More citizen science projects must be initiated in the future as well so that more discoveries of species can be made and together with the public, scientists and researchers will be able to solve the environmental problems.

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A new enemy of Kalpavriksha: Tree of heaven in India

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Coconut, *Cocos nucifera* Linnaeus (**Fam: Arecaceae)** mainly grown in tropical and subtropical parts of the world, is an important plantation crop grown in India. Coconut is known as "Kalpavriksha" or "Tree of Heaven" because almost every part of this tree is useful and it provides many products *viz* food, fuel, oil, coir, fibre and timber. India stands at 3rd place after Indonesia and Philippines with area 2178000 hectare, production 21384 million nuts and productivity 9815 nuts per hectare (Anonymous, 2020). India, Indonesia and Philippines contribute to more than 70 per cent of the copra production of the world (Anonymous, 2021).

Coconut crop is ravaged by many pests but four pests *viz* Rhinoceros beetles, *Oryctes rhinoceros* Linnaeus (Coleoptera: Curculionidae), red palm weevil, *Rhynchophorus ferrugineus* Olivier (Coleoptera: Curculionidae), black headed caterpillar, *Opisina arenosella* Walker (Lepidoptera: Oecophoridae) and Coconut mite, *Aceria guerreronis* Keifer (Acari: Eriophyidae) are considered as major pest of national importance. White grub, slug caterpillars, scale insects, mealybugs, termites, rodents and mites are considered as a minor pest (Abhishek and Dwivedi, 2021). But now a new invasive pest, Neotropical Whitefly, *Aleurotrachelus atratus* Hempel (Hemiptera: Aleyrodidae), is creating havoc in coconut plantations in India. It was first reported from Mandya and Mysore districts of Karnataka colonizing on coconut palm, *Cocos nucifera* and ornamental palm, *Dypsia lutescens* during February 2019 (Selvaraj *et al.,* 2019).

Neotropical Whitefly *Aleurotrachelus atratus* originated from Brazil found attacking *C. nucifera* (Mound and Halsey, 1978) but *Howard et al.,* (2001) reported it from many countries *viz.,* Antigua, Bahamas, Barbados, Bermuda, Brazil, Venezuela, USA, Colombia, Guyana, Saint Helena, Puerto Rico and Florida and considered as widely distributed pest all over the globe. Malumphy and Treseder, (2011) showed polyphagous behaviour of this pest attacking and perpetuating on more than 110 plant species belong to family of Arecaceae, Rutaceae, Cycadaceae, Solanaceae and Lauraceae.

Biological control was known as the best technique after the legislation in the management of the exotic or alien pest. It was considered as the safest and non-toxic method from an environmental point of view and also as a permanent solution. Natural enemies (predators or parasitoid) are generally identified and introduced from the native region the pest. Kityo *et al.* (2017) reported four parasitoid species *viz.*, *Encarsia basicincta* (Hymenoptera: Aphelinidae), *Encarsia* sp., *Eretmocerus cocois* (Hymenoptera: Chalcidoidea) and *Signiphora* sp. (Hymenoptera: Signiphoridae) that effectively reduced the whitefly population in Mozambique, Africa. But no parasitization was shown by these species against neotropical whitefly, *Aleurotrachelus atratus* in India. Selvaraj *et al.* (2019) reported nitidulid beetle, *Cybocephalus* spp. (Coleoptera: Nitidulidae), green lace wing *Dichochrysa astur* (Neuroptera: Chrysopidae), lady bird beetles *Jauravia pallidula* and *Chilocorus nigrita* (Coleoptera: Coccinellidae) as a promising predator of this invasive pest.

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Slippery flowers protect plants from nectar-robbers

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Plants' visual and odor cues such as volatile organic chemicals are factors exploited by insects to locate their host plant for food or habitat or both. While these cues can direct the transit route of insects, they do not necessarily confer their attachment with the host which is essential for propagation of their life events. Mutualism, antagonism and commensalism are the three kind of plant-insect interaction modes known. Insects and their interacting plants are constantly co-evolving in a direction which either supports or antagonizes other. For beneficial insects like pollinators, host plants have evolved characters that favor insect attachment whereas antagonistic evolution as found against herbivores, "nectar-thieves" etc., have rendered plants with such features that deter enemies. These evolutionary events are modifications or changes in surface morphology, biochemistry or physiological processes of the plants.

Aerial tissues of higher plants have cuticular lipids that were earlier thought to protect them from desiccation (Domínguez *et al*., 2017). This trait that has been under selection by plants for various other functions that it carries out, such as protection from abiotic and biotic damages. A plants cuticle layer is the physical interface where insect interacts with its adhesive regions. Structural morphology as well as biochemical constituents of this layer is crucial in determining insect attachment. Cuticles are composite heterogeneous structures comprised of several layers where waxes are primary constituents. Waxes can either be present between the cuticular layers or deposited over the cuticle called epicuticular waxes. Very long chain fatty acids and their derivatives such as aldehydes, alcohols or alkanes form waxes (Wang *etal*., 2020). The assembly and arrangement of these waxes form a 3-D structure of the cuticular and epicuticular wax layer. Compositional and structural variation of different types of fatty acid causes variation required for a specific function.

These wax coatings on plant generally forms a slippery surface and such surfaces are well known to play role in myrmecophilous interactions. In some species like *Macaranga* ant plants,

evolution in these cuticular layer has led to formation of selective layer specific to the insect species visiting them. Their slippery stems are easy for the beneficial ants to visit but hinders accessibility of antagonist ants (Markstädter *et al*., 2000). Other plant species such as the bamboo has heavy wax encrustation along with trichrome on young culms that hinders ant accessibility protecting the stems (Gorb *et al*., 2017). Interestingly carnivorous plants like *Nepenthes* also have slippery surfaces but with several other biomolecules in complexes which otherwise traps the occasionally visiting insects and inhibit their escape. Ants are a nuisance to some plant species like *Salix, Eriope* etc. because they rob off nectars from their flowers and are thus called "nectar-thieves" or "nectar-robbers". This hampers pollination of these species. They thus have a wax covered slippery floral stems that acts as defense system against ants hindering their movement and this phenomenon is known as 'greasy-pole syndrome'(Gorb & Gorb, 2017)

Apart from the stem, floral parts are also known to have slippery surfaces and hypothesized to be a plants' strategy to ward off nectar-thieves. In some species the slippery surfaces of the perianth are due to dense wax crystals which function to inhibit non-pollinator bees from visiting their flowers. Flowers of *Fritillaria koidzumiana* and *Codonopsis lanceolata* also have slippery surfaces which were hypothesized to be deterrent to ants which would otherwise steal nectars from their exposed nectaries. This was studied in detail by Takede *et. al.*, at Kyoto University that while flowers of *Fritillaria koidzumiana* and *Codonopsis lanceolata* are easily pollinated by their respective pollinators bee and hornet, their nectar-robbers; ants, could not track or move over the flower surfaces and their nectars was protected from stealth (Takeda *et al*., 2021). Keen observations of the group made them conclude that the floral regions where the pollinators and the antagonist visit are different. Floral regions visited by antagonists had slippery surfaces while the area where pollinators attached for nectar sucking, hence facilitating pollination did not have slippery surfaces. Microscopic imaging of these two surfaces cleared the picture as it was observed that epicuticular wax crystals were densely arranged on the perianth areas where ants could potentially walk making it slippery. Hornets and bees visited the non-slippery distal areas that lacked waxes completely as shown in figure 1.

This is a new perspective on plant defense system against insect which is flower-mediated. Earlier studies on slippery surfaces affecting attachment of pollinators have been linked to epidermal cell structures but role of differential wax deposition in a new paradigm in

this study. Slippery surfaces on flowers is a general morphological characteristic found in several plant species. From results of their study it may be speculated that the flower-mediated strategy may be a common mode of defense against antagonist pollinators or insects in the plant kingdom, which is yet to be explored.

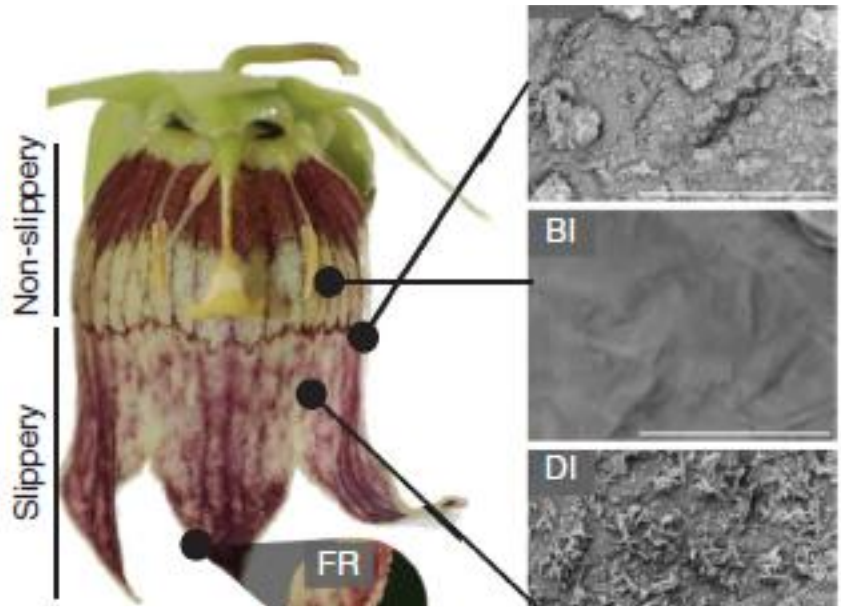

Figure 1: Epicuticular wax crystal structure on slippery and non-slippery regions in flower of *C. lanceolate* Image adapted from Takeda *et al*., 2021

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Eco-friendly commercialization and conservation of butterflies to support rural economy

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Abstract

Butterflies are fascinating creatures of order Lepidoptera with special place in the insect world. Rich diversity indicates good health of a particular habitat. Insect ecologists also focus on butterflies as the best group of insects for examining the patterns of biodiversity. Butterflies are of great aesthetic value. They form a part of the nation's heritage and need to be conserved. Butterflies are good flagship species to stimulate invertebrate conservation awareness in society. We can help in butterfly conservation by encouraging butterfly gardens, butterfly farms in homes and institutions. Butterfly cultivation will be a profitable agro-based industry in India and will surely give a major boost to agriculture by accelerating its productivity. Eco-friendly commercialization with fascinating diversity of butterflies is today's reality. Butterfly farming can provide jobs to the local people and promote conservation of natural resources.

Key words: Butterfly, conservation, butterfly farming, eco-friendly commercialization

Introduction

In India nature worship has ancient history. Veneration of nature is entrenched deeply in Indian psyche. Religious, cultural and mythical background indicates a strong alliance with fauna and flora as sacred symbols. Sacred groove tradition is very ancient in which protection is provided to patches of forests dedicated to deities or ancestral spirits. Groves are rich heritage of India, and play an important role in religious and socio-cultural life of the local people (Malhotra, 2007). According to Dr. Kumud Kanitkar, who has conducted an exhaustive study of animal sculptures and motifs in Indian culture, "The Romans saw animals as fierce creatures which had to be killed or controlled for human survival. The Greeks saw them as symbol of power living in a separate world of their own. But ancient Indians saw them as they should be seen – friendly, loyal and graceful." True to Indian tradition and beliefs conservation of beneficial insects and preventing some of the useful species from extinction can be achieved

through eco-friendly commercialization, sound production and protection management strategies, along with saving the endangered species and fragile ecosystems.

Butterfly diversity and its importance

India is mega diversity country home to more than 1500 butterfly species. Butterflies have been linked with different spiritual concepts in different cultures. The word *Psychology* has the Greek origin meaning a butterfly, conscious self, soul. According to Greek philosopher's butterfly life cycle resembles human life. They have great aesthetic value and formed a part of our natural heritage. Butterflies are fascinating creatures of order Lepidoptera with special place in the insect world. Butterflies are economically very important insects because they act as pollinators. Caterpillars of some butterflies feed and develop on weeds instead of agricultural crops thus helping in controlling weeds. Some caterpillars are insectivorous feeds on aphids, mealybugs, ant larvae and are useful in controlling them. Thus, butterflies can appropriately be called 'friends of farmers'. Often advertisers and illustrator use butterflies to indicate something is environmental friendly. Today conservation biologists use several species of butterflies as an indicator species to identify habitat that are critical and need to be protected. Butterflies are also monitored to indicate climate change and environmental degradation. Thus, like other animals and birds butterflies are now studied as living ecological components (Kehimkar, 2008). Because of their rich diversity, wide distribution, specificity to vegetation type, rapid response to perturbation, taxonomic tractability, statistically significant abundance and ease of sampling, they have been considered useful organisms to monitor environmental changes (Gaonkar, 1996). Insect ecologists also focus on butterflies as the best group of insects for examining the patterns of biodiversity. They indicate wide range of other invertebrates, which comprise over two-third of all species. They also support a range of predators and parasites.

Butterflies have fascinating life cycle that are used in many countries to teach children about natural world. Transformation from egg to caterpillar, chrysalis to adult winged jewel is one of the most cherished wonders of the nature. In many parts of the world butterflies are used as main resource for promotion of eco-tourism. Butterflies are good flagship species to stimulate invertebrate conservation awareness in society.

Threats to Butterflies

Butterflies are victims of illegal trading and commercialization especially for monetary benefits and to satisfy false aesthetic interest of collectors. Flourishing illegal trade of butterflies is a threat to butterfly diversity. According to Red Data Book published by Zoological Survey of India (Gupta and Mondal, 2005) butterfly trading is quite extensive and occurs at all levels from personal collectors to substantial business. Lucrative trade of butterflies is prevalent in Western Himalaya (Himachal Pradesh, Ladakh and North-western parts of Uttar Pradesh), the Eastern Himalaya (Sikkim and in the north of West Bengal) and Western Ghats. The butterflies are collected from Ladakh, Lahaul, Spiti, Sikkim and Meghalaya feeding into 100million US dollars international trade (Menon, 1996). Butterfly trading has spread worldwide due to its increasing demand. At some places butterflies are released at special occasions. Butterflies are very popular among insect collectors, researchers studying systematics, ecology, ethnology, evolution, and conservation. There is high demand from museums, college laboratories, schools, big hotels, tourist places. These are also used to mount in plastic or glass to decorate purses, trays, screens, wall hangings etc. Other than these, butterflies have demand for ornamental and decorative purposes.

Thus, illegal trading, habitat loss due to deforestation and urbanization along with use of pesticides, deforestation and pollution are the main threats to butterfly diversity.

Conservation measures

Conservation measures to protect these magnificent insect are very necessary. Some of them are as follows:

- Documentation: The first step towards conservation. (Clark, 2002, Godfray, 2002)

- Public Awareness: Popularizing butterflies among public especially among students through environmental education will urge conservation rather than wanton collection. Forest conservators should actively participate in creating awareness about rare, endangered species and implementation of the law regarding wildlife protection. Bombay Natural History Society's Conservation Education Centre (CEC) in Mumbai is generating public

interests in butterflies through organizing local field visits and crash course like Introduction to Butterflies and Butterfly Gardening.

- Code of Insect Collection: For the legitimate use code of insect collection should be strictly followed in the field. There should be strict implementation of Wildlife Protection laws (Andrew *et.al.* 2017).

- Development of butterfly park, cultivation and protection of larval and nectar host plants, provision of protection and maintenance of mating sites can surely help for the butterfly conservation.

- Nair *et.al.*in 2014 underlined the importance of institutional campuses as a preferred habitat for butterflies. If the landscaping and maintenance of gardens are carefully planned, the diversity of butterflies may increase in college / institution campus, providing a rich ground for butterfly conservation as well as for research.

- Agricultural buffers are strips of native grasses and wild flowers planted along agricultural field margins. These buffers provide a solution for increasing native pollinators and improving habitat, and also provide financial benefits to farmers (Jolie, 2012). Farmers should be encouraged to adapt eco-friendly practices like integrated pest management, organic farming and maintaining hedgerows.

- In the cities butterflies can be protected and conserved by maintaining nectar plants as avenue plants, in the potted plants on windowsill. Maintenance of a proper landscaping and plantation of butterfly nectar plants in big institutions especially schools and colleges, offices and will not only help for butterfly conservation but also add to the aesthetic value of the place.

All these measures will surely lead towards the conservation of the butterflies.

Eco-friendly Commercialization

Kipepeo Project from the north coast of Kenya, East Africa is very good example of Eco-friendly commercialization of butterflies. Initially this project started in 1993 to help farmers to

compensate for the damage caused by elephants and baboons. Now farmers are very actively involved in the export of butterfly pupae and eco-tourism and there is considerable increase in the local income. This project has won the Dubai International Prize in 1998 for its successful efforts in enlisting people's support for the conservation of Arabuko-Sokoke forest, by involving forest-edge communities in butterfly farming (Kehimkar, 2008). In Australia and USA, some species, e.g., the Monarch, are reared in large numbers on demand and released during special occasions like wedding, forming part of an industry (Sigh, 2011).

In India Bannerghatta Butterfly Park, Bengaluru, Butterfly conservatory at Ponda, Ovalekar Wadi Butterfly Garden at Thane and Butterfly Garden in Kevadiya in Narmada district, Gujarat are good initiatives towards conservation of butterflies in India. Krushnamegh Kunte, PhD and Associate Professor, National Centre for Biological Sciences (NCBS) said, "Parks like the one Bhopal would be great for creating awareness about butterflies, their caterpillars, their interesting interactions with plants, and connecting especially young people with insect biodiversity ". Butterfly farming is a sustainable resource which results in money. It encourages habitat conservation along with improved knowledge of local flora and fauna among common people. Legalizing butterfly farming will not only end poaching but also generate potential employment opportunities and will enhance ecotourism. Formation of Butterfly Park and ecotourism will lead to in situ conservation and effective tool of environmental education. It has great potential for alternative income production by incorporating butterfly exhibitory in ecotourism enterprises. If this method of breeding butterflies in their native habitats is widely used, it can potentially protect butterfly habitats, target species as well as other butterfly species, and involve the local people in the conservation of forests and wildlife without displacing them (Kunte, 2007).

Around 41.49% of total labour is associated with agriculture in year 2020. Farmer suicides account for 11.2% of all suicides in India. According to Dominic Merrott (2016) socioeconomic factors, rather than mental health problems, are associated with farmer suicides, with increased indebtedness playing the predominant role. Butterfly cultivation will be profitable agro-based industry in India and will surely give a major boost to agriculture by raising its productivity. Eco-friendly commercialization of butterflies will surely help for the butterfly conservation along with upliftment of the society especially farmers. It can be considered as a

natural way out of poverty. Thus, eco-friendly commercialization of butterflies through formation of butterfly gardens will be of great importance from monetary as well as educational point of view. But there is difference between butterfly park and butterfly conservatoires. Conservatories are more helpful for conservation and breeding of endangered, threatened species of butterflies especially in wild and urban habitats. There must be well planned breeding programmes and release of lab-raised butterflies in the natural habitat. Raising butterflies in the butterfly gardens for commercial purpose, their breeding, habitat and larval host plant protection has to go hand in hand to achieve balance in the ecosystem.

Summary

Butterflies are very important creatures and efforts are needed to conserve them in order to have balanced, healthy environment. As a business- cum-educational enterprise, butterfly gardens and butterfly houses are becoming increasingly popular in many countries. We should all join our hands in saving these charismatic flagship species along with eco-friendly commercialization.

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Chaos surrounding concurrent outbreak of locusts and other species of grasshoppers in India

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Almost after 26 years, India witnessed multiple upsurges of locusts in scheduled desert areas of Rajasthan and Gujarat during 2019–2020. This phenomenon was unheard of and mesmerizing for youths under the age of 35 years constituting more than 65% of Indian population. Pictures and videos of swarms were widely circulated by the tech savvy young population, print and electronic media. During the period, every insect found in groups were mistaken for desert locusts and farmers were in fear envisioning their potential to damage the cultivated crops. The residual population of desert locusts that escaped the control operations in the scheduled desert areas crossed the borders and invaded parts of Maharashtra, Madhya Pradesh and Uttar Pradesh, which made the matter even worse.

Concurrently, outbreak of other species of grasshoppers were also reported in other areas viz., Kerala, Karnataka, Andhra Pradesh, Tamil Nadu, etc. Outbreak of Spotted Coffee Locust,*Aularches miliaris* Linnaeus (Orthoptera: Pyrgomorphidae) was reported in Kerala; *Poekilocerus pictus* (Fabricius) (Orthoptera: Pyrgomorphidae) in Tamil Nadu, Karnataka and Andhra Pradesh and *Hieroglyphus nigrorepletus* (Bolívar) (Orthoptera: Acrididae) in Andhra Pradesh. These outbreaks were mistaken for desert locusts and created panic among farmers and general public (Table 1).

Locusts are also grasshoppers. But, locusts can exist in two different behavioural states namely, solitary and gregarious states. At lower population densities, locusts behave like individuals, whereas at higher density, individuals undergo physiological and behavioural changes which form bands of nymphs and swarms of adult. In addition to changes in behaviour, changes may be accompanied by changes in body shape and colour, and in fertility, physiology and survival. These changes are so dramatic in some species that the swarming and non-

swarming forms were once considered to be different species. The scale of population increase and migrations also distinguish those species known as locusts from grasshoppers.

Table 1. Outbreak of grasshoppers during 2019–2020 in India.

Sl. No.	Species	Host plants	Location
01.	*Schistocerca gregaria*Forsskål (Orthoptera: Acrididae)	Many	Rajasthan and Gujarat
02.	*Aularches miliaris* Linnaeus (Orthoptera: Pyrgomorphidae)	*Wrightia tinctonia* and Cashew	Vizianagaram and Vishakhapatnam Districts, Andhra Pradesh.
		Areca nut, Banana, Coconut	Thrissur District, Kerala.
		Banana	Idukki and Malappuram Districts, Kerala.
		Cocoa, Coffee, Dadap tree Mango, Black Pepper and Teak,	Wayanad District, Kerala.
03.	*Poekilocerus pictus* (Fabricius) (Orthoptera: Pyrgomorphidae)		Tumakuru District, Karnataka.
		Banana and *Calotropis* sp.	Krishnagiri District, Tamil Nadu.
			Srikakulam and Vizianagaram Districts, Andhra Pradesh
04.	*Hieroglyphus nigrorepletus* (Bolívar) (Orthoptera: Acrididae)	Maize	Medak District and Siddipet, Andhra Pradesh.

(Anon., 2020; DPPQS, 2021; NBAIR, 2021; Milu Mathew*et al.,* 2021)

Four species of locusts namely Desert locust, *Schistocerca gregaria* Forsskål; Migratory locust, *Locusta migratoria* (Linnaeus); Bombay Locust, *Nomadacris succincta* (Johannson) and Tree locust, *Anacridium* sp. (all Orthoptera: Acrididae) are known to occur in India. The desert locust is the most important pest in India and is also an intercontinental pest (Fig. 1).

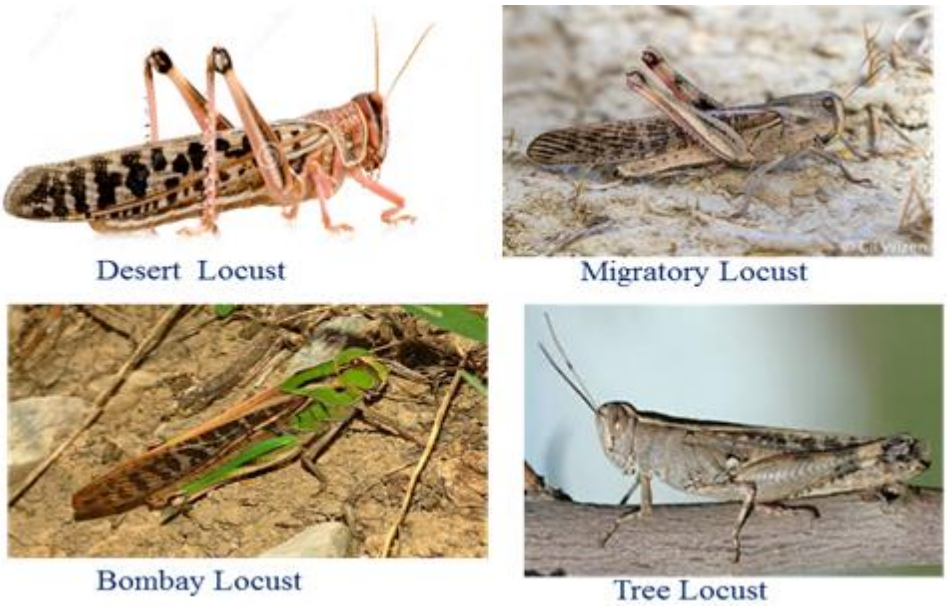

Fig. 1. Locust species in India (DPPQS, 2021)

Life cycle of locusts consist of three stages namely egg, nymph and adult. Eggs are laid in moist sandy soil in pods at a depth of about 10 cm. Gregarious females usually lay 2–3 egg pods at an interval of 7–10 days and each egg pod has 60–80 eggs on an average. Solitarious females lay 3–4 times and each egg pod having 150–200 eggs on an average. Eggs do not hatch in areas below 15°C. The incubation period is 10–12 days at an optimum temperature of 32–35°C.There are five nymphal instars in gregarious form and 5–6 instars in solitary form. Every instar changes the colouration, which is characteristic of locust. The biology of other grasshoppers is almost similar except that they can breed on different soils (DPPQS, 2021).

The Directorate of Plant Protection Quarantine and Storage (DPPQS) under the Ministry of Agriculture and Farmers Welfare have the international obligation and commitment to monitor, forewarn and control the occurrence of desert locusts in Scheduled Desert Areas (SDA). Locust Warning Organization (LWO) of the Directorate is monitoring the desert locust outbreaks and undertakes management operations as per "Standard Operating for Desert Locust in India". The SDA is located in Rajasthan, Gujarat and Haryana States (DPPQS, 2021).

Aularches miliaris Linnaeus (Orthoptera: Pyrgomorphidae) in Kerala

Schistocerca gregaria Forsskål (Orthoptera: Acrididae) in Rajasthan. (PC: FAO, 2021)

Fig. 2. Grasshoppers outbreaks in India

Outbreaks of other grasshopper species were mistaken for desert locusts by farmers, general public, print and electronic media, etc. Many such outbreaks of grasshoppers were flagged by respective State Governments and brought to the notice of the Directorate and its sub-offices located in many states. Outbreaks of other grasshopper species outside SDA is out of purview of LWO, however is a concern of Plant Protection Divisions of Central and State Departments. However, the outbreaks of other species of grasshoppers were localized and they subsequently vanished into the nearby forest after attaining adult stage in most of these places.

Moreover, other grasshopper species have low migratory potential and there were no interstate migrations reported. The pests never attained a major status on any of the crops (Milu Mathew *et al.* 2021).

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Effective utilization of available resources by ants: an observation from Buxa Tiger reserve

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The ants of the genus *Crematogaster* are commonly called Saint Valentine Ants, due to their heart shaped abdomen. They are also called Cocktail Ants and are commonly found in our surroundings mostly on arboreal habitats. *Crematogaster* ants build carton nests using different kind of raw materials which are maintained for many years (Fig. 1). The nest structure and size vary based on species and population size. In forests, carton nests of *Crematogaster* look outstanding on tall trees. Pagoda like nests contains multiple chambers with minute openings. These openings are shaded to avoid direct sunlight and rain water in to the chamber. Usually, no ants can be located on the surface of the nest as they remain inside their chambers. On provocation, the members can be seen peeping out of the chamber.

The raw materials used for making up these nests range from jute fibres, mud, dry leaves, twigs, paper like materials etc. Here there is an interesting observation from the dry deciduous forests of the Buxa tiger reserve. These forests are dominated by plenty of elephants. Inside these forests, nests of *Crematogaster* are a common sight on tall trees. But inside core areas, some nests were located, built by the species *Crematogaster rogenhoferi* Mayr exclusively built with elephant dung. These nests were built on a height of around four meters from the ground. Hordes of elephants move throughout the forests, at all times. So, dung is spread everywhere and is a plentiful resource. It was interesting to see that one of the new nests was being constructed with fresh elephant dung. The beautiful nests were perfectly smoothened on surface with small entry/exit holes on which the ants could be seen. The nest's moist appearance showed that, a large number of colony members perhaps worked together in a short time so that the alignment of the chambers as well as the surface structure can be shaped before the dung dried up. Outside appearance of the nest is entirely different from that of the nest made by *Crematogaster flava* Forel, which was located on the roadsides of the same forest range. The nest of *C. flava* were made up of paper like materials and unlike *C. rogenhoferi* are rough on surface. So as to protect from consistent rains, they prefer to build the nests under thick canopy. Here it shows an interesting example for the capacity of ants to utilize the available resources.

Fig.1 Nest of *Crematogaster rogenhoferi*

Woodpecker's holes on mango trees: A wound worth bearing

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It is a familiar sight in any fruit orchard to find trees with characteristic holes of about 2-3 cm diameter on main trunk or branches made by the wood pecking birds. These holes might slightly bring down the aesthetic look of a tree but the ecological function behind them is of immense value. Hence a mango farmer would be more than happy to see these winged wonders pecking the trees. Mango pest management experts too vouch for encouraging woodpeckers in fruit orchards. The mission of these woodpeckers on tree trunk is tracing and extracting the stem borer larvae which form part of their delicious food. Woodpeckers (Family Picidae) are small to medium size birds of varying colours. About 230 species of woodpeckers are known worldwide and about 12 species are known from India and some of them are white-bellied woodpecker, greater flameback, lesser flameback, rufous woodpecker, speckled piculet, heart-spotted woodpecker etc. (*https://nice.ncbs.res.in* › 2020/10/14). Signs of woodpecker foraging and predation on trees is also an indication of infestation by wood-boring beetles (Coleman *et al.,* 2011) and they are considered as important natural enemies of emerald ash borer, *Agrilus planipennis* Fairmaire a serious pest of ash trees in North America (Jennings *et al*., 2016). In India, Chakravarthy (1988) recorded predation of Golden-backed woodpecker,*Dinopium benghalense* (Linn.) on cardamom shoot-and-fruit borer, *Dichocrocis punctiferalis* (Guene) in Chikmagalur district of Karnataka.

The Cerambycid mango stem borer, *Batocera rufomaculata* De Geer is the most destructive and widespread polyphagous tree borer under tropical conditions. Besides mango, it attacks guava, fig, jackfruit, drumstick, aonla etc. Since the grub stage has a prolonged duration of about 6-8 months and feed by tunnelling the stem, damage often leads to the death of the affected tree. Research on stem borer management at ICAR-Indian Institute of Horticultural Research (IIHR), Bengaluru has yielded an effective prophylactic measure in the form of a product called "Arka Borer Control (ABC)", an improved version of earlier formulation popular

as "Sealer cum Healer" (Shivananda and Reddy, 2019). ABC and woodpeckers form an effective combination of mango stem borer management. While application of ABC protects mango trees by preventing the beetle from egg laying, the woodpeckers extract and kill the larvae of borers in already infested trees. This is the reason, it is considered "wound worth bearing".

Presence of these uniquely drilled holes on mango stems is an indication of the activity of woodpeckers and the natural control of stem borer in an orchard. During surveys of mango orchards at IIHR, Hesaraghatta, Bengaluru as well as in farmers' fields in Chittoor district of Andhra Pradesh, It was observed that trees that recovered from borer damage had 2-6 holes made by woodpeckers at different heights. The role of different birds like sparrows and crows in pest control is well evident where they pick up the openly visible insect larvae either on plant or from soil surface following a deep ploughing. However woodpeckers are more specialized in tracing, extracting and catching their prey from tree trunks and thus deciphering the cues which drive the woodpeckers to exactly locate the borer on a tree would be an interesting research topic.

Fig. 1. A woodpecker picking larva from a tree
(Photo credit: https://ornithology.com/why-do-woodpeckers-peck)

Fig. 2. A mango tree trunk with holes made by woodpeckers

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Record of the mealybug *Phenacoccus solenopsis* Tinsley on red amaranthus in Bengaluru

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The cotton mealybug *Phenacoccus solenopsis* Tinsley was first reported in 2007-2008 (Dhawan *et al*, 2007, Bambawale, 2008, Suresh and Kavitha, 2008). Typical of many mealybugs this species too has the tenacity to infest several hosts (Vennila *et al*, 2013). It has been reported on 205 hosts (Anonymous, 2021). Considering this, recording this on red amaranthus (*Amaranthus tricolor*) in a terrace garden is not surprising. However, if infested, no management options are available for a short duration crop like amaranthus, except selectively discard leaves, which are infested. Apparently this mealybug spread to amaranthus from adjacent tomato plants (*Solanum lycopersicum*). So, if infestations are noticed in a mixed vegetable garden, management like neem soap sprays should be initiated in other crops.

The nymphal period of both males and females last for 18-29 days (Pawar *et al*, 2017) and would be the potential duration of the mealybugs, once the crawlers establish. Considering the duration of growth period of amaranthus to be about 45 days, preventing crawlers from establishing on the crop, through vigil and early brushing–off of nymphs, seem to be the only way out, and is feasible in a kitchen/terrace garden.

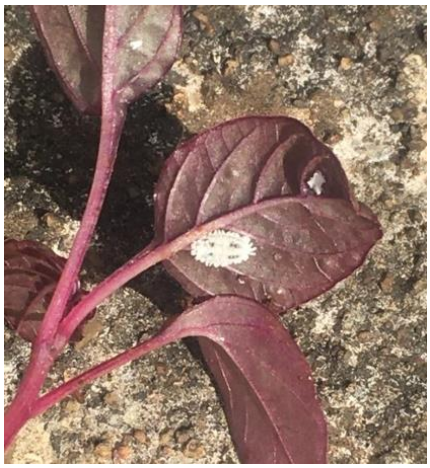

Fig. 1 *Phenacoccus solenopsis* Tinsley on *Amaranthus tricolor* (Red amaranthus)

Acknowledgement: Thanks are due to Dr. Sunil Joshi, ICAR-NBAIR, for identifying the mealybug.

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Zombification: Parasites mind control host insects

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Zombification: Insects are susceptible to diseases and attacked by different microbes including bacteria, virus and fungi (Helen, 2013). The parasite's genome controls host's behaviour by altering physical or biochemical characteristics of the host. The complexity of this interaction between host and parasite has been a subject of fascination for many researchers. The parasites have developed mechanisms to control their hosts and create insect 'zombies'. In vodou, a mute and will-less body, robbed of its soul and given the semblance of life by a supernatural force, usually for manual labour or some evil purpose is referred as "Zombie'. Such zombies in the natural world represent one of the most impressive examples of behavioral manipulation (figures 1 and 2).

The agenda of the parasite is to extend its phenotype by ensuring its ultimate survival, capacity to reproduce and be transmitted to new susceptible insect hosts (Loretto, 2019). Therefore, the pressure lies on the parasite to exploit the host efficiently, while the pressure lies on the host to eliminate the parasite or at least mitigate the impact of its infection. These controlling manipulations by parasites can result in peculiar behaviour in the host. The degree of parasite's manipulation can range from pre-existing behaviour to an expression of wholly different characteristics that have never previously been sighted in pre-infected hosts. The only assumption drawn now is that the parasite's genome influences the expression of behaviour in host (Doherty, 2020).

Tug of war: Instead of just passively being manipulated, the host can actively avoid parasitic exploitation by behavioural or social immune response (Loretto, 2019). These are particularly exhibited by social insects such as ants, honeybees and termites. *Metarhizium* fungal spores are tackled by hygienic behaviours of social insects to avoid pathogens and parasites by grooming behavior, including self-grooming and allogrooming to improve survivorship (Okuno *et al*., 2012). Behavioural prophylaxis can also occur through social withdrawal and death in isolation. For example, garden ants (*Lasiusneglectus*) infected by *Metarhizium anisopliae* stay away from

the brood chamber, and moribund ants cease social contact with their nest mates and leave their nests hours or days before death (Hughes,2011).

Zombie-insect examples:

Fig. 1. Zombie ants found with mind controlling *Ophiocordycepsunilateralis*, fungi
Photograph: David Hughes

Fig.2. Jewel Wasp with its prey a cockroach
Photograph Courtesy: Journal of Molecular Graphics and Modelling

In zomb(con)clusion! Alteration of host's behaviour by parasite are intricate and diverse and of great scientific interest. However, there are still significant gaps in our understanding the mechanisms underlying these behaviours. The acquisition of genomic information, secondary metabolism, chemistry, and insect neuro-physiology would help uncover the biological secrets behind changes in 'zombied' insect behaviour (Hughes, 2011) exploring new opportunities to further study these mechanisms.

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The nocturnal hungry visitor- the horned caterpillar of the common palmfly, *Elymnias hypermnestra*

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My ornamental palm plant had four beautiful fronds and it was healthy ornamental plant which was indoors and would be put out once a week for sunlight. A few weeks ago as there wasn't much sunlight, I left the palm outside. A week later to my surprise two of the healthy fronds looked like someone had given it a 'hair cut' rather a 'leaf cut'. The fronds were cut evenly on both sides and there were only stubs. I was sure it was the handiwork of one of the pests, but I had not noticed any eggs or beetles on the palm leaves. During the day I would check and find nothing on or on the underside of the palm leaves. One evening as it was getting dark, out of curiosity, I checked the palm and when I turned the fronds, I finally caught this hungry nocturnal visitor. An active green 'horned caterpillar'. I watched in fascination as it chewed away a large chunk of the tender leaves in no time. This was a caterpillar of the common palmfly *Elymnias hypermnestra*. I recalled having seen a brown dull and drab butterfly hovering around the grass in the evening a week or so before my palm got the 'leaf cut'.

The common palm fly, *Elymnias hypermnestra*, is a species of Satyrine butterfly found in South and Southeast Asia. It belongs to the Order: Lepidoptera and Family: Nymphalidae. The family Nymphalidae are called Brush-footed butterfly or four-footed butterfly. They are called by this name due to the fact that they have reduced forelegs which are hairy resembling brushes. Thus they possess only four functional legs for perching or walking. The front legs are held up below the head.

Family Nymphalidae is the largest family of butterflies with around 6,000 species. This family includes other well known powerful fliers such as Nawabs and Rajahs and migrants such as the Milkweed butterflies. The common palmfly belongs to the Sub family: Morphinae-Amathusiids. The main features of this subfamily is their colour, most of them are drab but very

few are brilliantly coloured. The undersides of the wings have eyespots or can be variegated. Their antennae are long and slender and gradually thick at the tip.

Their antennae never appear to be abruptly clubbed. Both sexes have the characteristic hairy and small brush like feetand in males it is smaller compared to the females.

Fig. 1 The *Areca* palm

Fig. 2 The cut leaves of the fronds

The common palmfly move close to the ground, are weak fliers and settle with their wings closed. The males have wings that are blackish brown with purple gloss, there are a series of large purplish or bluish spots around the apex and wing margins. The female has a large orange patch on each wing. It mimics the unpalateable Danaine, the Common Tiger *Danaus genutia*but has a broader black border and black stripes on the upper part of both wings. The life cycle of the butterfly comprises of the eggs, larva, pupa and adult. The time from the egg stage to adult is about 30 days. There are five instars and a lot of changes in the head and the horns occur after each moulting process. The caterpillar is a 'horned caterpillar' known because of the characteristic features of having a pair of prominent 'horns' on its head. The caterpillar is a green, fusiform setose worm with a pair of longitudinal yellow dorsal and lateral lines. The head is brownish in colour, with two erect brownish setose processes. The anal segment has two red

slender backward projecting processes. The caterpillar is crepuscular in behaviour feeding only during dawn and dusk. The horned caterpillar of the common palmfly on my ornamental plant was the nocturnal voracious hungry culprit who chewed up the tender fronds and made it look bald.

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BOOK REVIEW

Arora Ramesh and Sharma Sushma (2021): *An Introduction to Integrated Pest and Disease Management.* Kalyani Publishers, New Delhi, 180pp., Rs 250/-, ISBN: 978-93-90522-25-5.

The textbook entitled 'An Introduction to Integrated Pest and Disease Management' (IPDM) is primarily aimed at the students of B. Sc. (Hons) in Agriculture and Biotechnology as per the latest syllabus approved by the Indian Council of Agricultural Research, New Delhi. With over four decades of experience in teaching, research, development, validation and dissemination of IPM in a variety of crops, Dr Arora is uniquely qualified to write this textbook. Dr Arora is a prolific author and has authored/ edited 17 books on pest management and sustainable agriculture but most of these books are meant for researchers and post graduate students. He has also contributed nearly 50 chapters in edited volumes published by leading international publishers including CABI, Taylor & Francis, Springer, Kluwer, Oxford, Harwood, Panima and Narosa among others. This is his first textbook for UG students. Dr Sushma Sharma, Assistant Professor of Plant Pathology at Eternal University, Baru Sahib, Himachal Pradesh. is his co-author in this textbook.

The pest problems in agriculture are probably as old as agriculture itself. As soon as the land was cleared of the natural vegetation and replaced by a single or a few species of plants, humans' battle with pests began. However, in traditional agriculture, the yields obtained were low and the proportion lost to pests was also low most of the time. The farmers were unable to prevent these losses caused by pests, pathogens, and weeds. Over centuries, farmers developed a suite of mechanical, cultural, physical and biological control measures to minimize crop damage caused by pests. The concept of integrated pest management (IPM) originated in the 1960s and has evolved during the last 50 years to emerge as the dominant paradigm in the management of crop pests and pathogens. Taking into consideration the recent advances in the teaching of crop protection, the Fifth Deans' Committee rightly recommended an integrated course on pest and disease management in the revised B.Sc. (Hons) Agriculture syllabus in 2017. Accordingly, the course entitled 'Principles of Integrated Pest and Disease Management' was approved by the Indian council of Agricultural Research (ICAR), New Delhi. The book thoroughly covers the

latest syllabus of the ICAR for the course on IPDM for students of B.Sc. (Hons) Agriculture as well as biotechnology in India.

Some of the highlights of the book include easy-to-understand style and language, precise definitions of technical terms in each chapter, a tabulated history of the landmarks in management of insect pests and diseases, summarized scheme for identification of pests, pathogens and nutritional disorders observed in crops, important examples for utilization of various pest management tactics in Indian agriculture, and a comprehensive list of invasive pests and pathogens of crops recorded in India. The book lays emphasis on ecological, biological and biotechnological approaches for the management of pests and pathogens in the agroecosystem. Recent developments in the utilization of information and communication technologies (ICT) for modelling, decision-making and dissemination of IPM are also adequately covered. Climate change and biodiversity loss have emerged as huge challenges for agricultural sustainability. Therefore, an additional chapter on the impact of climate change on arthropod biodiversity and pest management has been included in the book.

Although the book is primarily aimed at the UG students and teachers, it would prove equally useful for students of master's programmes in Plant Protection, Entomology, Plant Pathology and Nematology in India and other South Asian nations. The agriculture extension workers and the faculty in Krishi Vigyan Kendras (KVKs) will also find it an invaluable source of information.

Overall an excellent book for students, teachers, researchers and extension officials. A must for every library. Very relevantly written in the context of current pest and climate changes.

Congratulations authors.

Editors-in Chief

INSECT LENS

***Solitary bee, Nomia* sp.**

Alkali bees are ground-nesting bees with a preference for salty soils. Looks similar to honeybees but slightly smaller than the honeybees and have a more elaborate striping pattern: black abdominal segments are separated with gorgeous iridescent stripes made of enamelled scales.

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Tiger beetle, Prothyma proxima

Tiger beetle affords excellent examples of protective resemblance and mimicry. Known for their aggressive predatory habits and running speed. The members of this family are easily recognized by large head with prominent eyes.

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Indian Potter wasp, Delta pyriforme

Potter wasps are named for the way they build their hives. Hives are truly pottery artists and create unique and beautiful pot-like homes for their off-springs. Female construct the hives with mud and it has tiny cells between the layers. Female will either gather droplets of water soon after rain fall mixed with her own saliva to make the mud.

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Fruit fly, Bactrocera sp. on Basil leaves- Males get attracted to Methyl eugenol in the plant, which is essential for gonad development

Author: Gautham Gavas , Age: 11 years, Bharatiya Vidya Bhavans, Poochatty, Thrissur

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Crab spider predating a rock bee, Apis dorsata

Crab spider is called so due to their resemblance to crabs. They either actively hunt for prey or sit and wait for potential prey hence, they are also called ambush predators.

Author: Dr. M. Jayashankar, Assistant Professor, Department of Zoology, St. Joseph's College (Autonomous), Bengaluru

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Male Pantropical Jumper, Plexippus paykulli

Plexippus paykulli is a cosmopolitan species of jumping spider. It is usually associated with buildings and may be found near light sources catching insects attracted by the light. It is named in honor of Swedish Ornithologist and Entomologist, Gustaf von Paykull.

Author: P. Maheshwari, Chennai, Tamil Nadu, India

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Sphaerospora scripta (long hoverfly)-The imagines of long hover fly exhibit Batesian mimicry and are harmless. They feed on pollen and nectar and visit the flowers of low growing plants, like a dandelion as seen in the photo.

Author: Rohini Girish

Place: Tussen de Vaarten, Almere, The Netherlands

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Bombus terrestris (buff-tailed bumblebee)-Bumble bees are highly valued pollinators worldwide and substantially add to the value of crop production. Buff tailed bumblebee/ large earth bumblebee is a eusocial, fat and a hairy bee that generally builds its colonies underground.

Author: Rohini Girish

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Lime butterfly caterpillar on lime tree cultivated in terrace garden was found parasitized

Author: Dr. A George
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Helicoverpa armigera Larva going for pupation and initial stage of pupa in chickpea

Author: Kotak Jigar N. and Rathod Atul R., Technical Assistant, Junagadh Agricultural University, Junagadh, Gujarat

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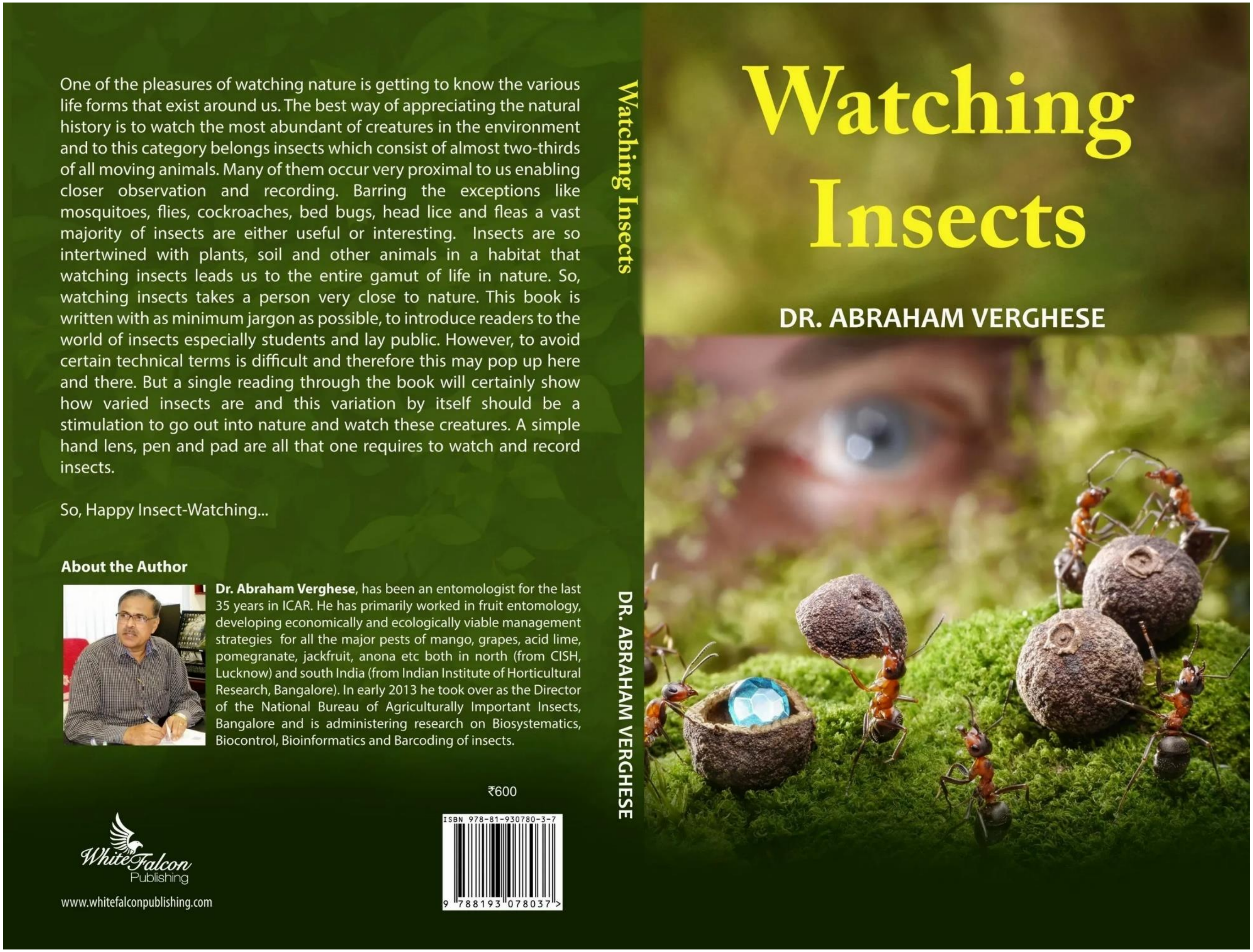
One of the pleasures of watching nature is getting to know the various life forms that exist around us. The best way of appreciating the natural history is to watch the most abundant of creatures in the environment and to this category belongs insects which consist of almost two-thirds of all moving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

OBITUARY

Dr. R. J. Rabindra

A master biocontrol strategist

3-6-1949 to 30-6-2021

Any combat needs a strategy. So it is when fighting intruder insect pests. To do this purely by biocontrol means is truly laudable. It is here I give the late Dr. R.J. Rabindra, a big thumbs-up.

Dr. Rabindra was initiated into biocontrol by his mentor late Dr. S. Jayaraj (Ex Vice Chancellor, TNAU, Coimbatore, India) and between them NPV was brought to a viable proposition from the eighties onwards. But insect viruses failed to measure up to the required extent of control on account of its instability in the environment, inadequate quality supply and rare natural epidemics. Dr. Rabindra himself was a guarded advocate of NPV. But the quality training in TNAU, where he qualified and worked from his early to mid-career always gave him an edge in biocontrol execution in agriculture and a zeal for the same, much more than his peers around.

With this, he joined the then NBAII (earlier PDBC) as the Director in 2001. It was then, that I used to meet him more frequently, and as a field entomologist, and farmer-driven, I used to tell him that biocontrol has failed our farmers; or rather you scientists have not given viability to it. My view was biocontrol was stuck in the "Corcyra Box", and expansionism was hardly possible. He agreed. But his strategization acumen came to fore when papaya mealybug, an invasive perhaps, was detected in a huge damage mode. He and the team at NBAII swung into action to import *Acerophagus papayae*, rear and release. The strategy was to take it to the field, allow perpetuation of its own and natural spread, than frequent releases in one place. It worked. The parasitoid spread mainly through farmers from one field to another, and perhaps through other dispersal means. Dr. Rabindra obviated the need to mass multiply in lab in volumes and

make frequent shipments to old released areas. Of course, he ensured supply to newer areas. This strategy worked and was aided by the fact that papaya was a crop with low or no insecticide pressure. The success for the same reasons could be perceived in combating eucalyptus gall wasp and sugarcane woolly aphid which were carried out by him and his able team at the present NBAIR. In sugarcane even native natural enemies were used. , Dr. Rabindra found a native parasitoid, *Encarsia*, from the North-East which he released in other sugarcane areas of the country. In all these crops a bouquet of natural enemies co-multiplied *in situ* in field and brought the pests down.

The huge funding from ICAR for biocontrol was felt justified during his period, and in 2012, Dr. Ravindra and team were honoured for their contributions by the Director General, ICAR.

Dr. Rabindra, thus was a visionary promoter of entomological research, and put the biocontrol success on international maps. His contributions are still highlighted by ICAR as achievements in this field. Administration was not his forte, but as a human resource manager, he endeared to many. When one's contribution benefits farmers and earns in crores of rupees for the country, it is deemed one has significantly contributed. He always had this sense of contribution, worn on his face, revealed through is endearing and inimitable smile.

He was my predecessor. I had the privilege of occupying his chair as Director, at NBAIR, Bangalore, from 2013 to 2016. And, as a project coordinator of BC, I personally witnessed his remarkable on-field biocontrol in action especially in papaya and sugarcane.

He was very conscious of exotic insects invading our country, and kept alerting us of maintaining vigil across our borders. One example is the *Brontispa* a pest on coconuts in Myanmar, which he felt could easily crossover to India, if we ever were slackening in vigil.

Dr. Rabindra was an excellent singer and knew the Bible well. So, in Dr. Rabindra's passing away, we should not be grieving in the true Christian spirit, as for a Christian, death is only a passport to heaven, to be with the Lord Jesus. Dr. Rabindra for all his faith will be a welcome angel in heaven. Probably Dr. Rabindra had a premonition of his heavenly call. In March, 2020, while addressing the entomologists who had gathered at the auditorium of TNAU, Coimbatore, for a trans-boundary-pest meet he urged the youngsters to excel and said, "after all you have a role to play in future; people like me are in our twilight years!" He perhaps knew he was for the last time, addressing from the podium in his favourite auditorium in TNAU!

Dr Rabindra: we miss you! We salute you!

Dr. Abraham Verghese
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