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Insect Environment

(Quarterly journal to popularize insect study and conservation)

ISSN 0975-1963

The first issue of Insect Environment was published in 1996. The sole objective of Insect Environment is to popularize insect study through popular, semi-technical and technical research notes, extension notes for managing insect pests, photographs, short blogs 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 of insects. These will be published in the quarterly *Insect Environment.*

The blogs are for quick dissemination of insect "news". These will be uploaded within a week of submission and will be on the website. Blogs should be about a hundred words with one photograph, in simple English

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Editorial

Climate, paid publications, *Trichogramma*…….

The hottest year, 2023 has receded and the advent of 2024 is being heralded. War cries are abuzz across Middle East to East Europe to Russia. As though these explosions don't influence climate change, the humble coal of India is being pointed at! Come to think of it, the barrage of bombshells and missiles, certainly affect flying and nesting vertebrates and invertebrates – sadly nobody talks about it, but we strongly echo our concern.

Climate spikes are going to be common. An encore of 2015 floods, battered the Chennai city in south India this quarter. When familiar places are hit, we empathize more. Around the same time Selangor in Malaysia- where my favourite Selangor Wildlife sanctuary is located was also affected by floods. So was it, four months after Typhoon Mawar, hit Guam, an island of US territory, the Tropical Storm Bolaven headed for Guam in October, 2023. Guam is a beautiful island in the Pacific and I had the opportunity to spend a transition stop-over here, while flying from Honolulu to Tokyo, way back in 1994, almost 30 years ago! Climate spikes make such islands vulnerable. Incidentally in Guam, for ento-enthusiasts, the fruit-sucking moth, *Eudocima phalonia* is a menace.

The Editors of *Insect Environment* (IE) could personally go to Dr. M. S. Swaminathan's residence in Chennai to pay our tributes to the departed soul. From the word go, Dr. Swaminathan was a supporter of *Insect Environment*. We reference below a message he articulated when we restarted the journal post-covid.

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

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

Dr Abraham Verghese

Editor-in-Chief

Dr. T. M Manjunath is certainly in the forefront of biological control movement and commercial insectary in India. His considered views on the much-hyped *Trichogramma*, on the rice borer in the pages of this issue is well worth reading. Thank you Dr. Manjunath for the correct perspective assigned.

AVIAN Trust, the publisher of *Insect Environment*, held a grand Award Ceremony on 16 December 2023 to award and encourage naturalists and plant protectionists- from students to officials. The Chief Guest was Dr. S.V. Suresha, Vice Chancellor, University of Agriculture Sciences, Bangalore. The photo gallery in this issue on the award function speaks.

A report says that Indian scientists spent $17 million in the year 2020 for scientific publications. Wow! The craze (and need) for promotions, awards and doctoral/post-doctoral acceptance are driving us mad! Publish (whichever way) or perish is getting ingrained in us. But who gets the last laugh? of course, the international publishing business houses. Its time we delink honest research endeavors from impact factor journal and business! The floodgates of Artificial Intelligence is again a fierce game-changer. If not used ethically, fake data and deepfake would overwhelm us.

We thank all our readers (>6000!), authors and photographers for being part of this Insect popularizing movement- the *Insect Environment*, India's *only* research news and blog journal. And, we wish all of you a very profitable new year- to you and your families!

Dr Abraham Verghese

Editor-In-Chief

Insect Environment and AVIAN Trust wishes all of you a very academically rewarding 2024

Research articles

DOI: 10.55278/RBHG3962

Record of the ocellated shield bug, *Cantao ocellatus* (Thunberg) (Hemiptera: Scutelleridae) from Arunachal Pradesh with a brief note on its natural history

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Cantao ocellatus (Thunberg, 1784), commonly known as the ocellated shield bug, is a splendid true bug species, distributed across various places in India: Assam (Yang, 1934), Meghalaya (Paiva, 1919, locality reported as Tura, Garo hills, Assam), Tamil Nadu (Ayyar, 1920), Uttarakhand (Pajni and Sidhu, 1982) and is usually associated with plants of Euphorbiaceae. This species was reported by Ayyar, 1920 on *Mallotusnudi florus* (L.) Kulju & Welzen (Malpighiales: Euphorbiaceae) from Coimbatore, Mysore uplands, the Bababudins and the Western Ghats. He mentioned the role of the bug in the pollination of *Macaranga peltata* Roxb. Mueller (Malpighiales: Euphorbiaceae), commonly called as the 'Moon Tree' and narrated the 'parental care' behavior exhibited by this species. Mcdonald (1988) recorded *Camellia sansanqua* Thunberg (Ericales: Theaceae) and *Macaranga peltata* as host plants of this species. Leong and Lee (2012) gave an elaborate account of the natural history and records of this species from Singapore. In India, the bionomics of this species was detailed by Ayyar (1920) from Coimbatore.

C. ocellatus breeding on *Mallotus barbatus* Müll. Arg. (Malpighiales: Euphorbiaceae) (new record of host species) (Fig. 2a) in large numbers was encountered during the surveys conducted in and around Pasighat (28.0632° N, 95.3239° E), Arunachal Pradesh. Different stages including eggs, various nymphal instars and adults of *C. ocellatus* were observed on the tree. Both adults (Fig. 2e) and nymphs (Fig. 2d) were found sucking from the young flushes and inflorescence.

The adults (Fig. 1a–d) are variable in colour from pale white to bright orange-red, having elongated bodies, usually with elongated spinous humeri. The adults were collected and killed using ethyl acetate, pinned, preserved and deposited in the

National Insect Museum (NIM) collections of ICAR-NBAIR, Bangalore. The images of the habitus of *C. ocellatus* and the *parasitoid* were captured using a DFC 420 camera mounted on a Leica M205A stereomicroscope.

The eggs were laid in groups, usually under the leaf surface. Several females were found guarding the egg masses (Fig. 2f) in the field, obviously to protect the eggs from natural enemies ('parental care' behavior documented in this species). They continued to guard the eggs even after hatching (Fig. 2f) after which, the nymphs were found dispersed (Fig. 2c) towards young flushes to suck the plant sap. The unprotected eggs (eggs exposed beyond the reach of the female abdomen), which are usually found in the periphery of the egg masses, were parasitized by the small, black parasitoid wasps, identified as *Trissolcus* sp. (Hymenoptera: Platygastridae) (Fig. 3 a, b). The parasitized eggs were black as compared to the pale white healthy eggs (Fig. 2 f, also see the egg cases in Fig. 2b).

C. ocellatus is recorded for the first time from Arunachal Pradesh and the DNA barcode sequence of the former is generated and reported herewith. DNA barcode: GenBank accession number OP872658 (1♀, INDIA: Arunachal Pradesh, Mebo, East Siang, 02.x.2022, 28°9'57"N 95°25'11"E, Safeena, M.). The taxonomy and male and female genitalia of this species were elaborately illustrated and described by Tsai *et al.* (2011) and Mcdonald (1988) and therefore, not attempted in this paper. The documentation of this species along with its host plant, DNA barcode and natural history adds to the faunal diversity of Arunachal Pradesh.

We express our sincere gratitude to K. Veenakumari (Retd. Principal Scientist, ICAR-NBAIR) for her kind help in the identification of parasitoid specimens collected in this work and Sringeswara A. N. (Research Scientist, Botanical Garden, University of Agricultural Sciences, Bangalore) for the host plant identification. We acknowledge S.N. Sushil (Director, ICAR-NBAIR) for the facilities extended for the present work.

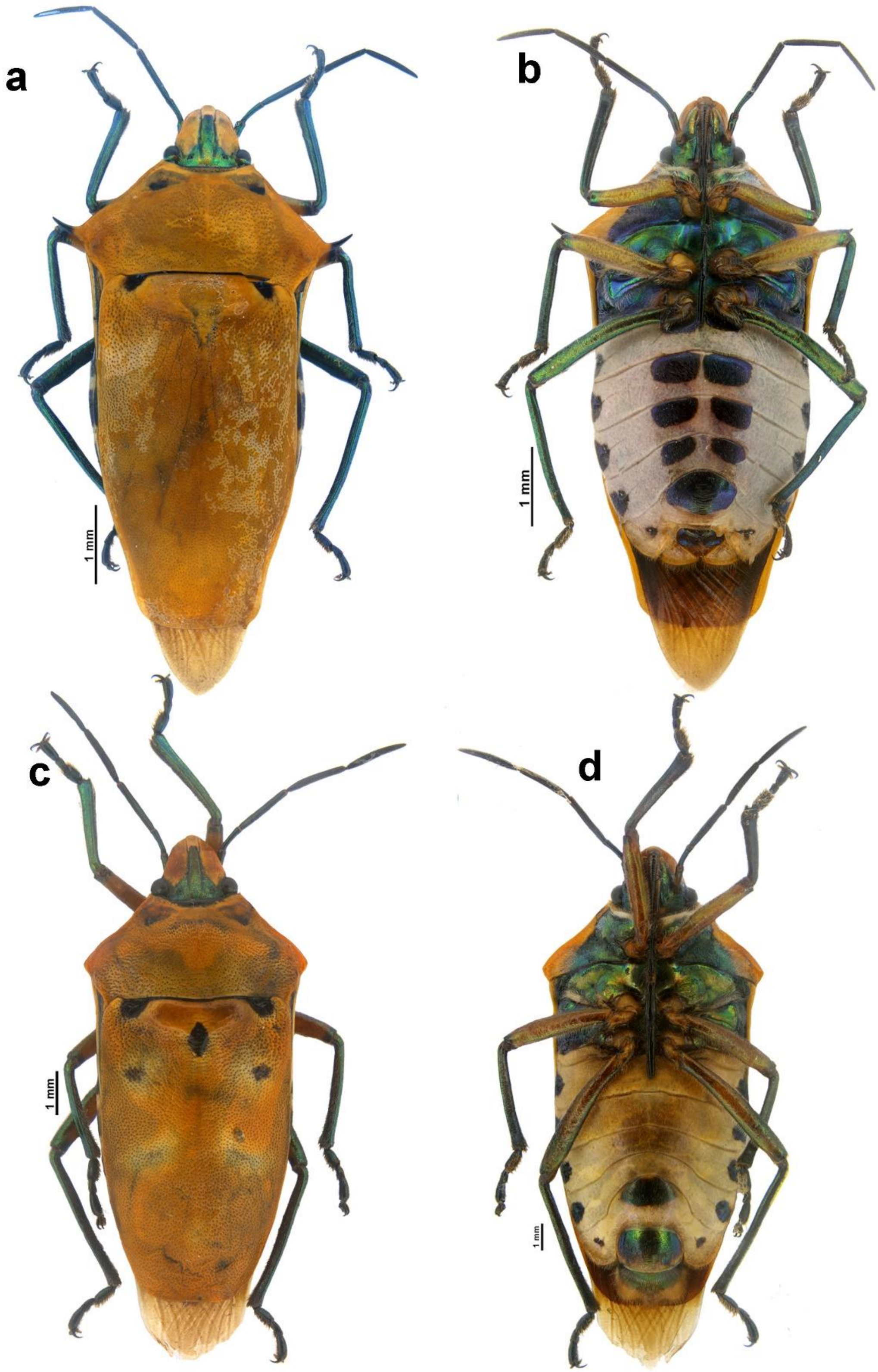

Fig. 1. ***Cantao ocellatus*** **(Thunberg), male & female (habitus). a, female (dorsal); b, female (ventral); c, male (dorsal); d, male (ventral).**

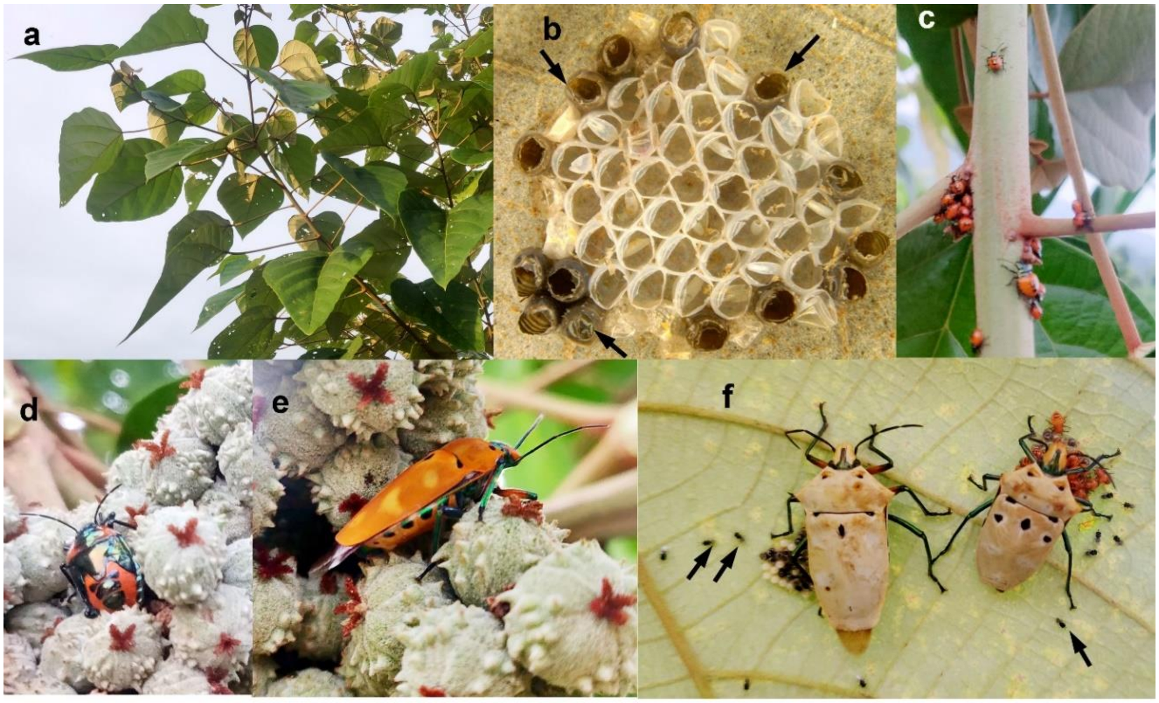

Fig. 2. *Cantao ocellatus* (Thunberg). a, *Mallotus barbatus* Müll. Arg.; b, egg case- black (parasitoids emereged) and white (nymphs emerged); c, dispersal of nymphs; d, nymph feeding on inflorescence; e, adult feeding on inflorescence; f, adult females guarding egg masses with parasitoids emerged from the exposed eggs, which are parastized.

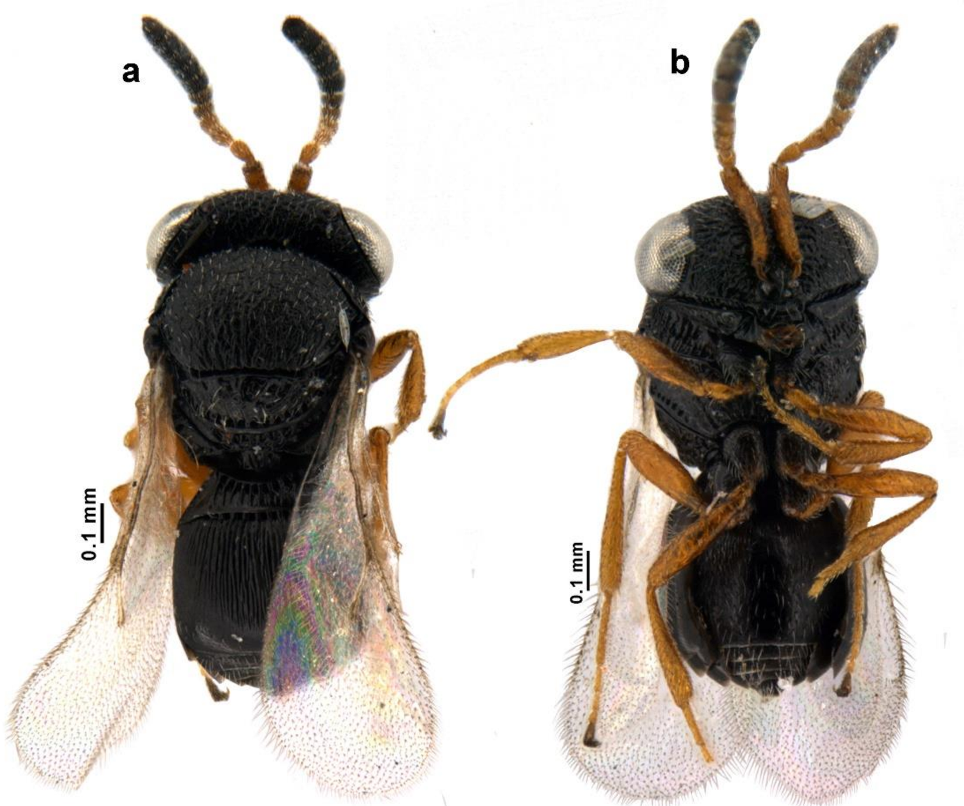

Fig. 3. Egg parasitoids of *Cantao ocellatus* (Thunberg)- *Trissolcus* sp. a, dorsal habitus; b, ventral habitus

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First report of pupal parasitoids *Brachymeria lasus* (Walker) and *Xanthopimpla stemmator* (Thunberg) on *Glyphodes bivitralis,* Guenée (Crambidae: Lepidoptera) from Telangana, India

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The paper reports for the first time the presence of pupal parasitoids *Brachymeria lasus* and *Xanthopimpla stemmator* on the *Ficus* leafroller, *Glyphodes bivitralis* (Guenée), in the state of Telangana, India. *Ficus* is a large and diverse genus of approximately 850 species belonging to the Moraceae family. The different forms of *Ficus* (trees, vines, stranglers, epiphytes, and shrubs) are adapted to diverse climatic and geographic regions (Janzen 1979; Pierantoni *et al.*, 2018). The most popular *Ficus* species is *F. carica*, a deciduous tree that can reach a height of two–five meters and is frequently referred to as a fig tree. *Ficus carica* is thought to have originated from the Middle East and is considered one of the earliest cultivated fruit trees, but it can currently be found in numerous warm regions across the globe (Bonamonte *et al.*, 2010). Fig trees are attacked by many pests *viz.*, leaf webbers, psyllids, bark-eating caterpillars etc. The genus *Glyphodes* (Guenée, 1854) is a leaf webber/roller and has more than 300 species represented by 47 genera occurring in South-East Asia (Robinson *et al.*, 1994). The genus may contain about 120 species throughout the tropics (Robinson *et al.,* 1994) and about 25 and 17 species have been recorded in Southeast Asia and Australia, respectively (Shaffer *et al.*, 1996). *Glyphodes bivitralis* belongs to the Crambidae family of the order Lepidoptera. It is native to Southeast Asia, Queensland, and Hawaii. The larvae of leaf webbers feed on leaves by folding the leaf margin with silken thread and remains inside. The present study was undertaken to identify natural enemies of *G. bivitralis* in the *Ficus* ecosystem of Telangana.

This present observatory study was done at the campus of ICAR-Indian Institute of Rice Research in Hyderabad, Telangana (17°19'13.6"N 78°23'40.4" E), where the leaves of fig tree were seen rolled up from October 2022 to December 2022. About 5 trees were observed with similar symptoms, from each tree 10 symptomatic leaves were collected and larvae were cultured in plastic covers with holes by changing the leaves on every alternate day. After 7 to 10 days, the larvae transformed into pupae and parasitoids were observed from the pupae.

Out of 10 rolled leaves collected from each fig tree, 3-4 pupal parasitoids of *X. stemmator* (Ichneumonidae: Hymenoptera) and 4-5 pupal parasitoids of *B. lasus* (Chalcididae: Hymenoptera) emerged from *G. bivitralis* (Crambidae: Lepidoptera) and were recorded for the first time at the ICAR-Indian Institute of Rice Research in Hyderabad, Telangana (Fig. 1 to Fig. 4). Mittal *et al.* (2011) also reported the incidence of five Hymenopteran parasitoids, three braconids (*Apanteles obliquae* Wilkinson, *Bracon hebetor* Say and *Chelonus carbonator* Marshall) and two ichneumonids (*Pristomerus sulci* Mahdihassan and Kolubajiv and *Xanthopimpla* sp.) which were found parasitizing the larvae of the mulberry pyralid, *Glyphodes pyloalis* Walker (Lepidoptera: Pyralidae) infesting mulberry foliage from Kashmir. *Glyphodes bivitralis* belongs to the Crambidae family of the order Lepidoptera. The larvae are green with black spots on the middle of the thorax and also on the middle of the last abdominal segment. The last instar larvae become brown with similar black marks. Adult moths' wing spans about 26-30 mm. The forewings are light brown with white patches, and the hind wings are white with a broad brown margin (Fig. 2).

Acknowledgment

The author is thankful to Dr. Chitra Shanker, Principal Scientist (Entomology) at ICAR- Indian Institute of Rice Research, for her help in the identification of the leaf webber of *F. carica* and its parasitoids.

Fig. 1. *G. bivitralis*

Fig 2. *X. stemmator*

Fig 3. *B. lasus*

Fig. 4. Emerged parasitoids from pupa of G. bivitralis

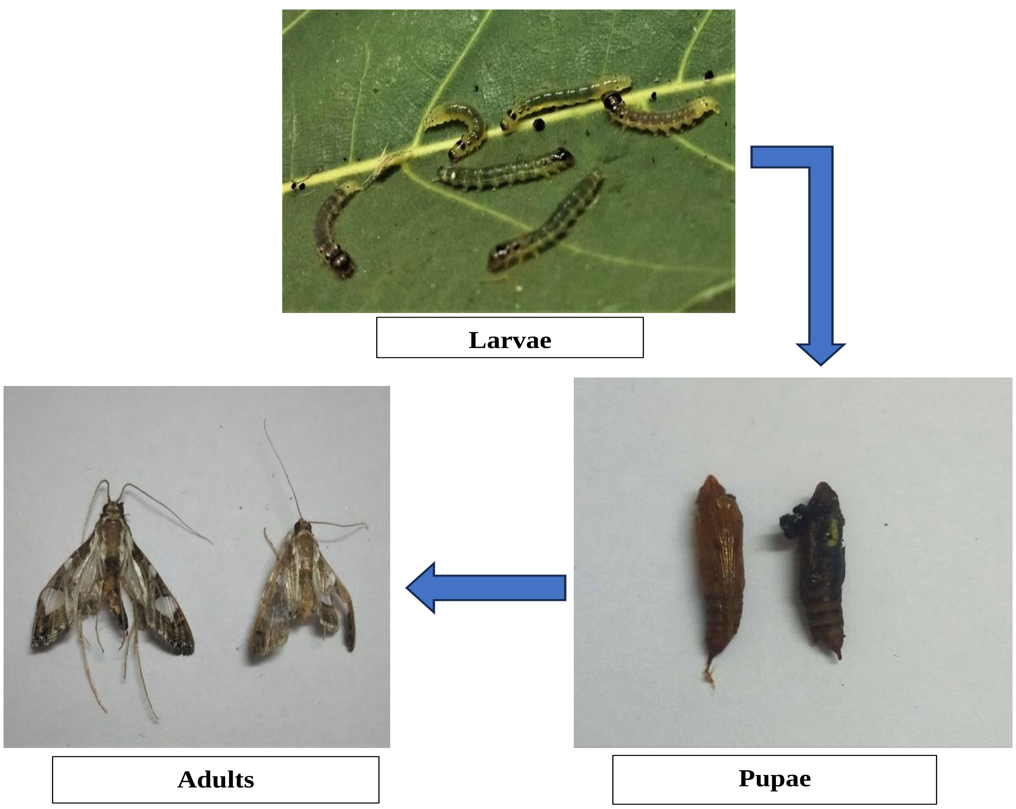

Fig.2. Life cycle of leaf Webber, *Glyphodes bivitralis*

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Infestation of *Xylosandrus compactus* (Eichhoff) (Coleoptera: Curculionidae) on big-leaf mahogany (*Swietenia macrophylla* King) in nursery

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Abstract

Swietenia macrophylla is one of the important commercial tree species, widely being cultivated in farmlands in India due to its high market demand, attractive wood colour, and quality. The present study was conducted at Research Nursery, ICFRE-IWST, Bangalore from April 2021 to March, 2022. A hundred mahogany (1-year old) plants were heavily infested with stem borer, *Xylosandrus compactus.* Application of *Beauveria bassiana* at the concentration of $1x10^8$ spores/ml showed promising results in the management of the stem borer and caused more than 80% adult mortality in the nurseries.

Key words: mahogany, Swietenia, borer, nursery and growth

Introduction

Swietenia macrophylla King (big leaf mahogany) is a tropical tree species native to Central and South America. It has a wide natural distribution, extending from Mexico to Bolivia and central Brazil (Lamb, 1966). It is one of the important premier timbers in the world. *Xylosandrus compactus* (Eichhoff) is commonly known as black twig borer and belongs to the family Curculionidae. It occurs in Southern part of India (Meshram et al. 1993), Sri Lanka, Southern Japan, Indonesia, Vietnam, Malaya, Madagascar, Mauritius, across tropical Africa, Fiji and in the United States in Florida, Georgia, Alabama and Louisiana (Le Pelley, 1968; Ngoan *et al*. 1976; Venkataramaiah and Sekhar, 1964; Vasquez, Tur, & Monteagudo, 1996; Oliveira, Flechtmann and Frizzas, 2008). Delgado and Couturier (2010) reported 38.41% mortality of the seedlings due to the attack by *X. compactus* in Peruvian Amazonia. Greco & Wright (2015) reported that this pest attacks more than 200 species of plants in Hawaii. It was reported as a major pest of tea in Japan and caused extensive dieback (Kaneko *et al.* 1965). The physical damage to infested plants could be the tunneling action of the beetle. This pest is native to Asia and mainly distributed in subtropical and tropical areas. It is adapted to a warm environment (Hayato, 2007; Venkataramaiah and Sekhar, 1964; Vasquez *et al.*1996; Oliveira, Flechtmann and Frizzas, 2008). Wood (1982) reports this pest in the United States as a first report in Fort Lauderdale. Ngoan *et al.* (1976) reports its spread throughout the southeast United States, along the coastal plain from Texas to North Carolina. Mahogany trees are often infested by this pest as stem borers and top shoot borers in the nurseries and plantations in different parts of Karnataka State with severe intensity. The larvae and the adult beetle bore into the stem and feed the pith of the stem. Severe infestation leads to the death of the plant. Heavy infestation of stem borer in one year old seedlings of *S. macrophylla* was noticed in the research nursery of IWST, Bangalore. Therefore, a study was conducted in the nursery of the ICFRE-Institute of Wood Science and Technology, Bengaluru to study the impact of this pest and its management.

Martials and methods

The present study was carried out from April 2021 to March 2022 at the ICFRE-Institute of Wood Science and Technology (IWST) Nursery, Bengaluru (13.0126785^{0}N & 77.57018464^{0}E). The IWST nursery has hundreds of seedlings of bamboo species, sandalwood, rosewood, and mahogany. A total of 800 of *S. macrophylla* plants of one year old were selected for the present study. It was noticed that many mahogany plants were wilted suddenly in the nursery. On observing closely, it was found that 2-3 micro-holes were present in the localized lesion part (about 1cm long) of the stem at the base of all the wilted plants. From infested plants, the adults and eggs were collected in a vial and maintained for future reference. After the dissection of the stems of infested plants, adults and eggs were collected for identification. The stem borer was identified as *Xylosandrus compactus* by Sarah M. Smith, the Curator of Scolytines, Michigan State University and the accession number of the same is UASB 019230110-UASB 019230116. Damage assessment was undertaken on alternate days until the death of the plant. The infested plants were assessed and the number of plants was recorded based on infestation level, intensity of attack, and the mode of infestation (Atuahene, 1972). A patch of fifty infested seedlings was tested with the biocontrol agent of entomopathogenic fungi *Beauveria bassiana* with a concentration of $1x10^8$ spores/ml to confirm the possibility of control measures.

Results and discussion

Xylosandrus compactus, the black twig and stem borer is a very small beetle which is 0.508 mm in size and is shiny, black and cylindrical. It is usually found on the bottom of plant stems. It makes very minute holes in the stem. The eggs are small and oval and are white and translucent. The grubs are white and legless and are very small in size. The grubs are pointed at the rear and the matured ones have a brownish head. The pupa is about the size of the adult. The body is covered with a thick hairiness. The female gets to the seedling and builds a chamber for oviposition (Fig.1)

The study revealed that about 55.6 percent of seedlings were found attacked by the pest *X. compactus*, which is the first report on *S. macrophylla* in this region. This small size black colour beetles caused severe infestation on the seedlings and young saplings of *S. macrophylla*. By making very minute holes, it bore into the stem and fed on the pith of the seedlings and saplings thereby causing damage which finally led to the death of the seedlings or saplings (Fig 2).

Ngoan *et al*. (1976), Mannakkara and Alawathugoda (2005), Chong *et al.* (2009) reported that this pest has a wide range of infestation on about 224 plant species belonging to 62 families including agricultural crops and trees. Among these, more commonly attacked non-native host species such as mango (*Mangifera indica* L.), cinnamon (*Cinnamomum camphora* (L.) Nees and Eberm.), cherimoya (*Annona cherimola* Mill.), burutha (*Chloroxylon swietenia* DC.), khaya (*Khaya senegalensis* (Desr.) A.Juss.), kolon (*Adina cordifolia* Roxb. Ridsdale), kumbuk (*Terminalia arjuna* (Roxb.) Wight and Arn), neem (*Azadirachta indica* A. Juss), tamarind (*Tamarindus indica* L.) and mahogany (*Sweitenia macrophylla* King). Delgado and Couturier (2010) report in Peruvian Amazon region *Swietenia* species were severely attacked by this pest in nursery seedlings. *X. compactus* originating in Asia is now established in the tropical areas of Africa as well (CABI/EPPO, 1997). As a control measure, Meshram *et al.* (1993) tried spraying the nursery seedlings with the insecticide Monocrotophos 0.05 percent (Nuvacron EC) in October- November and found it to be effective against this pest. Only a few biological control measures are available to check the pest (Sreedharan *et al.* 1992). Application of several parasitoids has been reported in India. *Eupelmus* sp. (Hymenoptera: Eupelmidae) was found inside black twig borer tunnel in coffee plants in Kerala, India (Balakrishnan *et al.* 1989). *Tetrastichus xylebororum* (Eulophidae) was reported to be associated with *X. compactus* on the island of Java in Indonesia (Balakrishnan *et al.* 1989). The entomopathogenic fungus, *B. bassiana* was shown to infect all the life stages of *X. compactus* in India. It resulted in 21% infection of the beetles present in colonies of robusta coffee branches (Balakrishnan *et al.* 1994). *B. bassiana* is now registered in Hawaii, for the coffee berry borer *Hypothenemus hampei* Ferrari (Coleoptera: Curculionidae). In our studies, it is also concluded that the application of *Beauveria bassiana* at the concentration $1x10^8$ Spores/ml showed promising results and caused more than 80% adult mortality in the nurseries.

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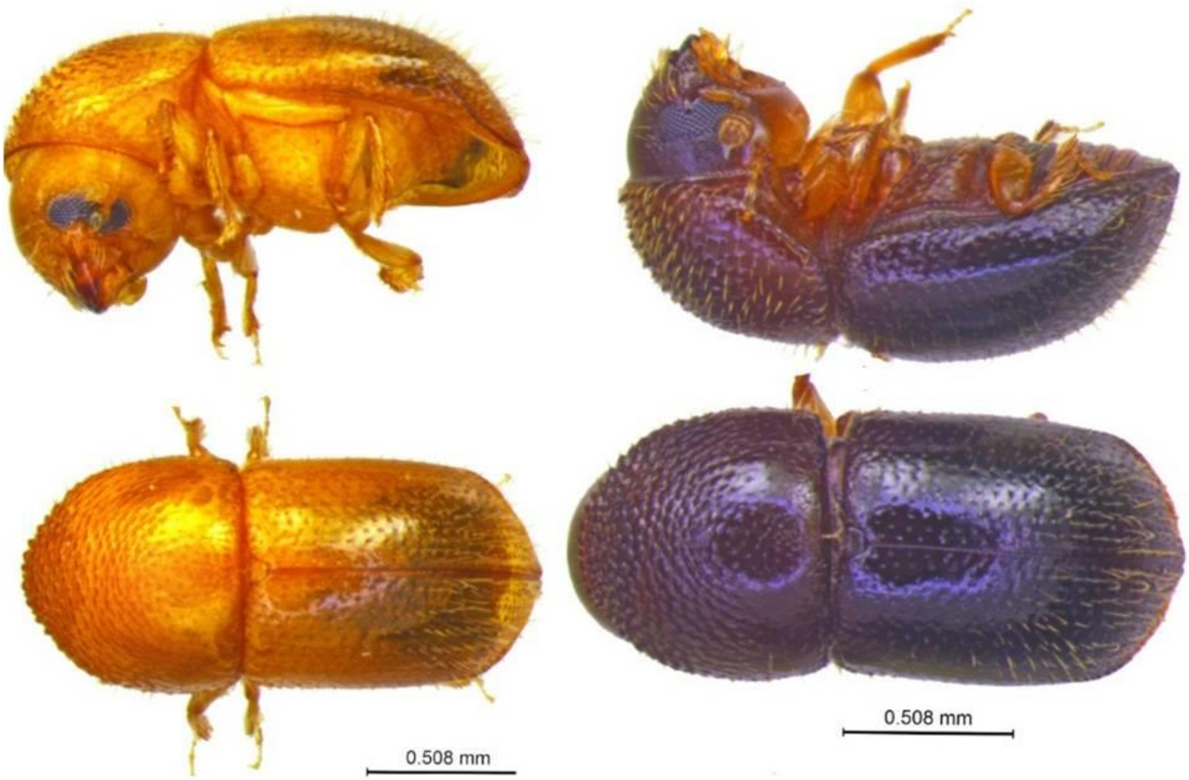

Fig. 1 Adult beetles of *Xylosandrus compactus*

One-year old seedlings of mahogany

Lesion and wilting symptoms of infected plants

Wilting and lesion symptoms

Micro-hole on stem made by borer

Fig. 2 Symptoms of stem borer infestation in mahogany nursery, IWST, Bangalore

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The egg parasitoids, *Trichogramma japonicum and Telenomus dignus*, seem to have doubtful impact on the regulation of rice yellow stem borer, *Scirpophaga incertulas* – It is time for a reality check

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Abstract

The egg parasitoids, *Trichogramma japonicum* and *Telenomus dignus*, generally record a high rate of parasitism of egg masses, often 100%, but critical studies in India revealed that these, either alone or in combination, parasitized only up to 60% of the eggs in an egg mass, allowing the remaining 40% to hatch and cause potential damage. It is so because they could parasitize only those eggs that are laid on the upper surface and cannot reach out and parasitize eggs laid at the bottom layer. As a result of this inherent limitation resulting in partial parasitism of egg masses, these parasitoids, either by way of natural parasitism or artificial releases even in high numbers, seem to have a doubtful impact on the regulation of rice yellow stem borer (YSB), *Scirpophaga incertulas*. *Tetrastichus schoenobii* is also a common parasitoid of YSB, but it appears very late in the field and remains active only for a short period which greatly reduces its importance unless manipulated as suggested. It is time for a reality check and to be pragmatic in our approach in utilizing these parasitoids.

Introduction

Three hymenopterans, *Telenomus dignus* (Gahan) (Scelionidae), *Trichogramma japonicum* Ashmead (Trichogrammatidae) and *Tetrastichus shoenobii* Ferriere (Eulophidae), have been found to be the most common egg parasitoids of the rice yellow stem borer (YSB), *Scirpophaga incertulas* (Walker) (Lepidoptera, Pyralidae), in India for decades. Detailed studies carried out in rice fields located in the campus of the Regional Research Station, University of Agricultural Sciences (Bangalore), V. C. Farm, Mandya (Karnataka), revealed that they parasitize the egg masses mostly alone, but also in combinations. Of the three, *T. dignus* alone accounted for 33.97 % parasitism of the 'egg masses' followed by 32.03 % by *T. shoenobii* and 8.03 % by *T. japonicum*. When a single egg mass was parasitized by more than one species, such combinations accounted for 11.2 % parasitism by *Telenomus* and *Trichogramma*, 4.5 % by *Telenomus* and *Tetrastichus*, 7.2 % by *Trichogramma* and *Tetrastichus*, and 3.05 % by *Telenomus*, *Trichogramma* and *Tetrastichus*. The overall parasitism of 'egg masses' generally remained high, often 100 %, with an average of 81.3 %, giving an impression that these parasitoids contributed significantly towards the control of YSB. However, critical studies between the level of parasitism of the 'egg masses' and 'eggs in egg masses' revealed that the realities are contrary to this general belief and, therefore, it was advised not to use them, especially *T. japonicum* and *T. dignus*, in augmentative biological control (Manjunath, 1990). Despite, these parasitoids, *T. japonicum* continues to be recommended for mass releases for control of *S. incertulas.* The merit of this approach is discussed.

Parasitism of 'egg masses' vis-à-vis 'eggs in egg masses'

In the first place, it should be realized that there is a significant difference between the parasitism of 'egg masses' and 'individual eggs in egg masses.'

The yellow stem borer, *S. incertulas*, lays its eggs in masses. Studies on samples of more than hundred egg masses revealed that the number of eggs laid in an egg mass was up to 162 with an average of 46. These eggs are laid in layers one above the other and then fully covered with a protective mat of light brown hairs. Thus, an egg mass looks compact.

Critical studies revealed that both *Telenomus* and *Trichogramma* parasitized only up to 60% of the eggs in 'egg masses,' allowing the remaining 40 % to hatch and cause potential crop damage. It is so because they could parasitize only those eggs that are laid on the upper surface and cannot reach out and parasitize those eggs that are laid at the bottom layer, thereby resulting in partial parasitism. This inherent limitation greatly reduces their efficacy in controlling the stem borer. Further, even if an egg mass is not parasitized and all the eggs hatch, the natural survival rate of YSB larvae is very low, 5 to 10 %. It is indicated by the fact that the numbers of 'dead hearts' (in the vegetative stage) or 'whiteheads' (in the reproductive stage) encountered in infested spots in rice fields are hardly a few, otherwise, there should have been many more such affected plants. Such high mortality is because in the case of rice yellow stem borer, only one larva can successfully develop per tiller and, therefore, even if several larvae enter a plant, they die due to competition. Another factor is that upon hatching when the larvae try to disperse to the neighbouring plants, they become very vulnerable and are preyed upon by predators, especially spiders. Thus, with or without parasitization of egg masses, the early survival is very low. These factors have not been generally realized while assessing the efficacy of egg parasitoids.

In the case of *Tetrastictus*, its larvae being parasitoid-cum-predator, all the 'eggs' in an 'egg mass' were devoured, thus appearing to be very effective. Although seemingly so, the problem is that it appeared very late in the season almost coinciding with the panicle initiation stage of the crop and thus, by the time it commenced its activity in the field, the pest would have already caused the damage thereby reducing its importance.

Discussion and conclusions

Having lived on the campus of Regional Research Station of UAS-B, V.C. Farm, Mandya, Karnataka, India surrounded by rice fields and spending a considerable amount of time in the fields for several years, closely studying various rice pests (yellow stem borer, brown plant hopper, leaf roller, caseworm, whorl maggot, etc.) biological control was of special interest. After making the above-mentioned detailed studies on the egg parasitoids in the fields and laboratory, it can be categorically stated: "Thus, considering their prevailing limitations, all the three species of parasitoids, *T. dignus*, *T. japonicum* and *T. schoenobii*, either alone or in combinations, do not play any significant role in controlling rice yellow stem borer in India. This aspect is overlooked as one is generally swayed by the high level of parasitism of 'egg masses' without realizing that parasitism of 'eggs in egg masses' is more critical. Therefore, mass-breeding and releasing of these egg parasitoids, especially *T. japonicum* and/or *T. dignus*, for management of *S. incertulas* does not serve the purpose" (Manjunath, 1990).

Despite these findings several decades ago, it is surprising that not only the practice of artificial releases of *T. japonicum* is recommended and continued, but also even success claimed with the control of YSB. In the last two to three decades, several studies were carried out on the egg parasitoids of YSB and papers published, both in India and other countries. Almost all of them concentrated on the parasitism of 'egg masses.' Sharmitha *et al.* (2020) stated "A maximum of 93.33 % of natural parasitism of the egg mass of yellow stem borer was observed, which managed the pest in the egg stage itself" although they also found that the parasitism of egg masses, either alone or in combinations, was partial. Their data also confirmed that the pattern of parasitism by these parasitoids was more or less similar to an earlier report (Manjunath, 1990) and that it has not changed over the last 3-4 decades. There have been several efforts in different parts of India wherein large-scale releases of *T. japonicum* were made ranging from 100,000 to 300,000 parasitoids/ha in one or more batches, and successful control of YSB has been claimed. Such conclusion was based indirectly upon the number of dead hearts or whiteheads found in the experimental fields and also yields obtained (Riba and Sarma, 2006, Karthikeyan *et al,* 2007, Murali Baskaran *et al.*, 2021, Deshpande *et al.*, 2023). Since these releases were made specifically to control the pest in its egg stage, data on the direct impact of parasitism on hatchability would have been more relevant and dependable as reduction in crop damage could have been due to other factors as well. In a study carried out in China, Tang *et al*. (2017) found that even after making large releases of

T. japonicum @ 50,000/ha, 100,000/ha and 200,000/ha, there was no increase in parasitism as “only a relatively small fraction of eggs was successfully parasitized. No clear conclusion could be drawn on the most efficient release rate as no significant differences were found among the three release rates.” As explained, releases in any quantity would not make any impact. As stated, it makes a huge difference between the level of parasitism of ‘egg masses’ and ‘parasitism of eggs in egg masses.’ The researchers will have to bear this in mind while evaluating the parasitoids of egg masses, not only of YSB but also of other pests. It is time to be more practical in our approach towards such biological control.

As *T. schoenobii* can destroy all the ‘eggs’ in an ‘egg mass’ and it’s only limitation being that it starts its activity late in the season, introduction of an exotic strain with prolonged period of activity may be worth exploring - Sri Lanka and Sarawak (Malaysia) could be the potential source (Manjunath, 2020). Another interesting area of research is that since *T. schoenobii* appears in rice field to coincide with the panicle initiation, to find out whether the crop at this stage produces any odour or kairomone that attracts this parasitoid. If so, it may be worthwhile, synthesizing this kairomone and applying it in the field when the crop is young to see whether it can trigger the early activity of *T. schoenobii.* Collaborative research would be helpful in such endeavours. For more data and other details, the references cited here and also the cross references mentioned therein may be consulted. The conclusion is that as per the prevailing conditions, the natural parasitism by, or artificial releases of *T. japonicum* and/or *T. dignus,* seem to have a doubtful impact on the regulation of the rice yellow stem borer owing to their inherent limitations. It is time for a reality check and to be pragmatic in our approach in this regard. The scope for improving the efficacy of *T. schoenobii* is thus indicated.

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Observation of paper wasp nests in holy ghost church campus, Bengaluru, Karnataka

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The family Vespidae consisting of mostly social wasps is divided into three distinct sub families *viz*., Stenogastrinae, Vespinae and Polistinae (Richards, 1971). There are more than 180 species belonging to the genus Ropalidia of which, 27 are documented in the Indian subcontinent, with 16 of them being endemic (Kojima,*et al.*, 2007). Nests built by social wasps independently can be initiated by a lone female (haplometrosis) or by a group of females working together (pleometrosis) (Suzuki *et al.*, 1992). In *Ropalidia marginata*, nests founded by a lone female, the sole foundress builds the nest, performs all protective and nursing functions by herself until the young ones become adults capable of helping the queen with the subsequent brood whereas in nests founded by multiple females, only one female remains the queen and the rest act as worker bees and undertake other responsibilities of building nests and tending to the offspring (Shakarad, *et al.*, 1995).

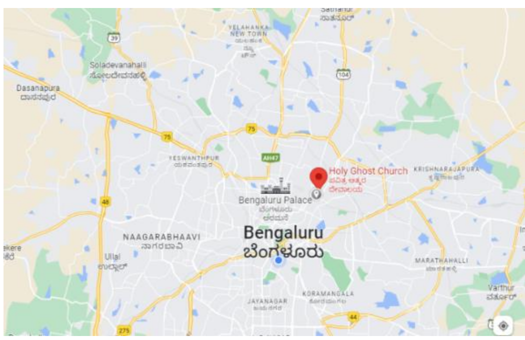
In this paper, two species belonging to Ropalidia were observed (*Ropalidia cyathiformis* and *Ropalidia marginata*). These are two old world primitively eusocial polistine wasps that occur widely in peninsular India (Kardile *et al.*, 2002). A primitive nest appears to have been a solitary, open comb hanging by a peduncle or stalk (Richards, 1971). The nest of the aforementioned species is generally found on leaves, concrete wall, and metallic poles (Mishra *et al.,* 2023). Generally, in primitive eusocial colonies, the queens are distinctive because of their dominance behaviour, in order to maintain reproductive monopoly, but *R. marginata* is unique in the way that the queens don't exhibit dominance behaviour but are docile and use pheromones to control the reproductive activities of worker wasps. This is something that is peculiar in highly eusocial colonies thereby making it very unique (Unnikrishnan *et al.*, 2023). Hence, in *R. marginata*, the queens are always sitters whereas in *R. cyathiformis*, the queens are always fighters (Kardile *et al.*, 2002).

The present study was undertaken in Holy Ghost Church (12.9887669, 77.5932716), located in Bengaluru (Map 1 and Map 2). Holy Ghost Church keeps the history of 70 years, and with its historical walls it also supports the immense biodiversity. The area covered for the observation of the nest is marked as Point A to Point H (Table no. 1). This short-term study was made in the month of October 2023. I phone 12, DSLR Camera and Adcome lens Attachment (12 X and 24 X) devices were used to capture geotagged images of the nests and wasps. Mapping apps, GPS Map Camera, Google Maps were used.

Table 1. Points in the study area covered along with GPS coordinates

Area covered	GPS coordinates
Point A	13.006021˚, 77.617170˚
Point B	13.005944˚, 77.617475˚
Point C	13.006326˚, 77.617447˚
Point D	13.006289˚, 77.617850˚

Area covered	GPS coordinates
Point E	13.006259˚, 77.618206˚
Point F	13.005917˚, 77.618425˚
Point G	13.005644˚, 77.618244˚
Point H	13.005905˚, 77.617853˚



Map 1: Holy Ghost Church in Bengaluru Map (Source: Google Maps)

Map 2: Satellite Map of Holy Ghost church with the points (in red dots) observed for wasp nests

During the present observations, a total of 37 nests of *R. marginata* and *R. cyathiformis* were counted among which total nest count with active individuals were 13 (4 of *R. marginata* and other 9 of *R. cyathiformis*) (Figs.1 and 2) and on other 24 nests no individuals were found. In the active nests, total count of Individuals, number of cells per nest, larvae, pupae and eggs was noted (Fig. 3). Among all the nest highest number of the cells was founded on *R. marginata* Nest (No.25) with 157 cells. Highest number of individuals was found on the nest number 22 and 40; highest count of individuals in a nest was noted to be 8 at the time of observation. The nests were mostly observed on the concrete wall. This is first time observation undertaken in this area.

Fig. 1: An active nest of R. *marginata*

Fig. 2: An active nest of *R.cyathiformis*

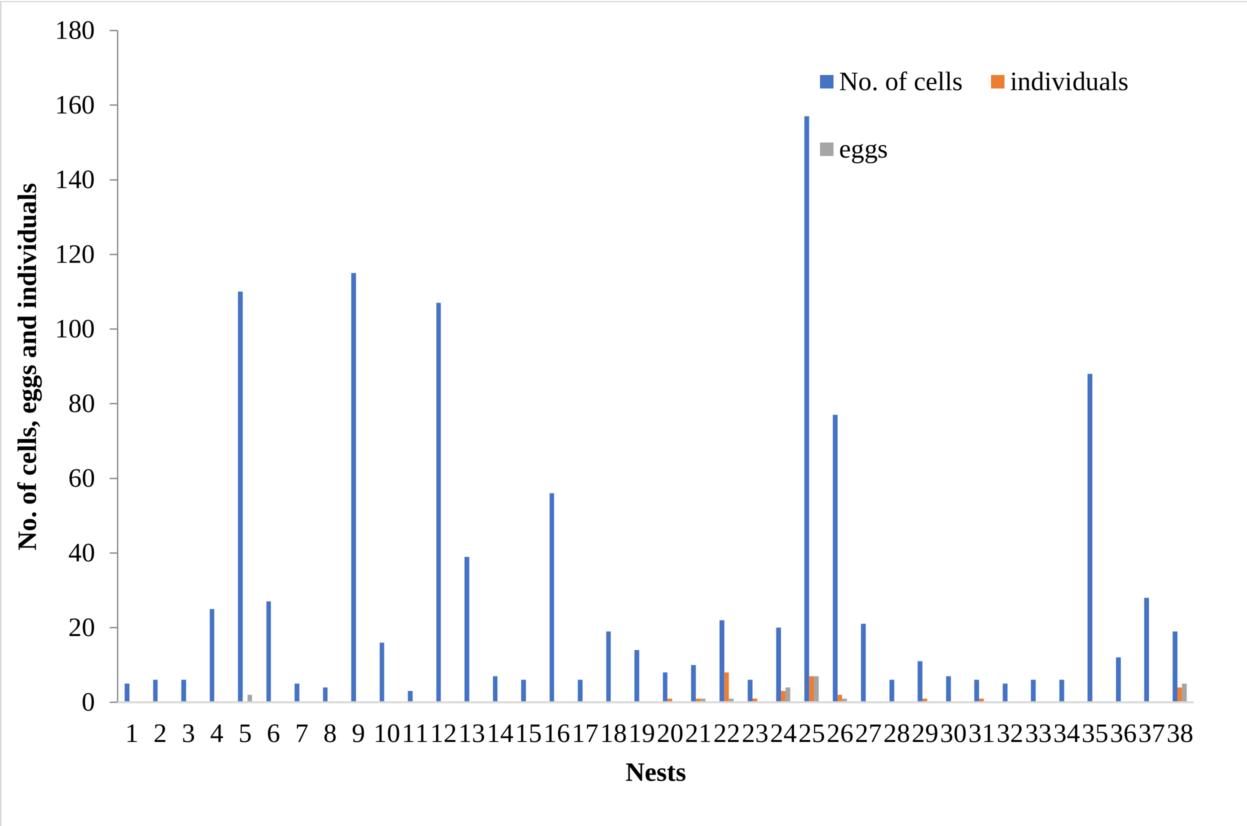


Fig. 3: Representation of nests with active individuals, eggs and cells during the observation

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Review articles & Short notes

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Review of butterfly territorial behaviour and contests over mating territories

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Introduction

Competition for limited resources among animals, such as food, shelter, and mates, often leads to confrontations, particularly among males competing for mating territory, posing risks of injury or death. Resource holding potential (RHP), often related to body size or weaponry, influences the outcome. While game theory aids in understanding these contests, not all animals have physical adaptations for combat (Maynard Smith and Price, 1973). Despite lacking traditional weapons, butterflies compete for mating opportunities, with some establishing territories for aerial interactions and others employing patrolling strategies near food plants (Kemp and Wiklund 2001; Rutowski 1991). The cognitive limitations of butterflies raise questions about their ability to recognize rivals. This ongoing debate intrigues behavioural ecologists, offering insights into the evolution of non-aggressive contest systems (Suzuki, 1976). Butterflies utilize various strategies for mating, like vibrant colours, pheromone emissions, and territorial conflicts. Their vibrant hues aid in species recognition and mate identification, while pheromones facilitate communication and attraction. Male butterflies initially pursue any movement but later consider factors like colour, scent, and behaviour in potential mates. Some female pheromones can be detected by males from distances of up to 10 miles. Males compete for mating opportunities, engaging in energetic disputes with rivals. Courtship involves intricate dances, with some species requiring specific displays from males. Successful courtship demands persistence and a delicate balance of sensory cues, luck, and perseverance. Additionally, some butterflies establish territories to increase their chances of finding a mate.

Mating territory

Butterflies have two primary mating strategies: "perching" and "patrolling". Patrolling males actively search for females in flight, while perching males wait for females to pass by from stationary positions. Perching sites are often associated with resources for females, but may also be located in areas with specific topographical features. Males in perching species tend to be territorial, attempting to exclude other males from their perching sites. These territories are believed to serve as meeting points for the sexes, where mating success is assumed to be higher. However, there is limited empirical evidence supporting this assumption, with the consensus based largely on indirect observations (Takeuchi, 2017).

Territory residency and mating success

Males of *Pararge aegeria* use a perching mate-locating strategy and are found perching in large sunspots on the forest floor. If a flying object enters the sunspot area, occupied by a *P. aegeria* male, the resident male immediately takes off. He pursues the intruder to investigate what the intruding object might be (Bergman *et al.*, 2007). If the intruder is a conspecific female, a flight pursuit follows. But suppose another male enters the sunspot area, in that case, the territory resident will take off and the two will engage in a flight contest, where the winner gets sole ownership of the sunspot and the loser leaves the area and has to search for a new suitable sunspot (Davies 1978; Wickman & Wiklund 1983). So, resident males of *P. aegeria* achieves approximately twice as many mating as non-residents when virgin females of *P. aegeria* are allowed to choose between a resident and a non-resident male in a large enclosure containing one territorial sunspot (Fig.1) (Bergman *et al.*, 2007).

Why do residents receive more mating?

The success of perching males depends on the ability to detect a passing object. However, extrinsic factors impact visual mate detection in butterflies. In a study, butterfly models varying in size and color were presented to perched males of *Asterocampa leilia* (Fig. 2A). Model type significantly influenced male response rates, with the black model prompting the highest response (87%), the white model the lowest (26%), and the grey and tan models at 52% and 60% respectively. Background type also affected response rates, with the sky background eliciting the highest response (87%) and the vegetation (45%) and sand (50%) backgrounds yielding lower responses (Fig. 2B). So, the proximate advantage of territory ownership is that light conditions and contrast greatly increase the male's ability to detect and intercept passing receptive females (Bergman *et al.*, 2015).

Can males discriminate the sex of flying conspecifics

For successful mating, males should recognize the sex of passing butterflies. When old-world swallow tail, *Papilio machaon* males were presented with motor-driven specimens that mimic the flight of butterflies, territorial males responded to flapping specimens with four sequential phases: approach, touch, courtship flight, and copulation attempt (Fig. 3); these responses were observed to be more pronounced towards fresh specimens compared to treated ones, with a preference for female specimens during prolonged interactions (Takeuchi *et al*., 2019).

Contests over mating territory

The contest is a direct and indirect behavioral interaction that determines the ownership of an indivisible resource unit (Hardy and Briffa, 2013). Butterflies lack physical weapons and thus engage in non-contact aerial interactions for territory disputes, characterized by circling flights and followed by horizontal pursuits. Various butterfly species partake in similar aerial contests over mating territories, where a territorial male claims a specific area frequented by females. When a female enters, the male visually detects her and may give chase, sometimes leading to copulation either in flight or when both are alight. In the presence of intruding males, territorial disputes involve aerial displays and chases, often ending without physical harm, serving as contests to determine territorial ownership (Kemp and Wiklund 2001; Kemp 2013; (Takeuchi 2011). This behavior is known as the 'war of attrition,' where prolonged displays establish the victor, with the earlier retreater being deemed the loser.

How these butterflies settle their disputes

As butterfly males compete for mating territory, it is necessary to know how these males settle their contests. Contests in nature are asymmetric and male–male agonistic interactions should be settled in favour of the individual with the greater fighting ability, termed resource holding potential (RHP). Winner and loser males should consistently differ in some morphological or physiological traits (Takeuchi, 2017). Butterfly contests pose a challenge due to the uncertain costs they impose on opponents, with the actual costs remaining undetermined (Kemp and Wiklund, 2001). The territorial contest in butterflies was initially considered an example of the bourgeois strategy, which was later refuted by studies showing that territory owners could indeed regain their territory after temporarily leaving it (Davies 1978; Wickman and Wiklund 1983; Kemp and Wiklund 2004). Residency effects have been observed in butterfly territorial systems, exemplified by the extended chasing behaviour of longer-term territory holders (Takeuchi 2006a, b, 2016; Takeuchi and Honda 2009). These results were attributed to the males' minimizing risks through prolonged interaction (Takeuchi *et al*., 2016).

Although fighting costs remain unclear, differences in morphological or physiological characteristics between territory owners and intruders have been noted in various butterfly species. Body size differences have been observed in different ways, with owners being either larger or smaller than intruders, depending on the species (Hardy and Briffa 2013; Hernandez and Benson 1998). Flight muscle ratios and fat reserves also vary between species, with some exhibiting larger flight muscle ratios and larger fat reserves, suggesting different strategies in energetic contests (Peixoto and Benson 2011, 2012; Takeuchi 2006b, 2011). Additionally, age differences between owners and intruders have been recorded, with older males investing more in current reproductive opportunities due to potentially fewer future chances (Kemp, 2000, 2003; Kemp *et al*., 2006). Despite the presence of similar forms of aerial contests across different butterfly species, the characteristics correlated with ownership show significant variability.

Residency effect and experience on contest outcome

The intricate dynamics underlying territorial contests in butterfly species shed light on the pivotal role of residency asymmetry and experience in determining the outcomes of owner-intruder conflicts. In *Pararge aegeria*, conflicts of owner-intruder led to the consistent triumph of initial winners even when assuming the role of the intruder in successive contests. This phenomenon hints at the self-reinforcing nature of prior winning experiences, consolidating the dominance of aggressive resident males (Kemp and Wiklund, 2004). Similarly, experienced males of *Chrysozephyrus smaragdinus* regardless of physical attributes such as forewing length or age, demonstrated a heightened motivation to retain their territories, effectively maintaining their dominance over naive intruders. This tendency underscores the notion of subjective resource value, where residents, through their sustained investment in territory establishment and defense, accrue a higher pay-off, solidifying their position as the predominant beneficiaries in these territorial struggles. Such findings prompt a deeper exploration into the intricate interplay between innate behaviour, prior experiences, and perceived resource value (Takeuchi, 2009).

Body size as a predictor of contest outcome

The importance of body size in determining success in physical contests within the animal kingdom is vividly exemplified by the case of the Satyrine butterfly, *Lethe diana*. Male butterflies engage in intense territorial disputes, employing linear chases and strategic monopolization of open spaces within the woods. It was observed that the male owners, those who consistently reclaimed territories, displayed a marked advantage in terms of body mass and larger body size is favored in such confrontations (Fig. 4A) (Takeuchi, 2011). Interestingly, a contrasting trend emerges in the nymphalid butterfly *Heliconius sara*, where smaller males are found to be more successful in defending mating arenas within the subtropical Brazilian forest (Fig. 4B). Males with shorter wing lengths enjoy longer territorial tenures, underlining the diverse dynamics at play in different species' competitive strategies (Hernandez and Benson, 1998).

Flight Muscle Ratio (FMR) as predictor of contest outcome

FMR, or flight metabolic rate, is a crucial determinant in the resolution of conflicts among male butterflies competing for territories. In *L. diana* owners with higher

FMR and higher body mass tend to dominate contests and superior flight performance correlates with ownership, emphasized by well-developed flight muscles in the owners (Fig. 5A) (Takeuchi, 2011). However, contests in *Hermeuptychia fallax* unveil a complex relationship between FMR, body mass, and contest outcomes. Males with higher body mass but lower FMR are more likely to emerge victorious in territorial contests (Fig. 5B) (Peixoto and Benson, 2012).

Body fat as a predictor of contest outcome

Fat reserves in *H. fallax* shed light on the significance of endurance in territorial disputes among males. Higher fat reserves and the predominance of males in the resident role suggest that endurance plays a critical role in determining the outcome of territorial conflicts (Peixoto and Benson, 2011). Conversely, in *C. smaragdinus* contest outcomes were negatively influenced by fat reserves. Residents exhibit lower fat content compared to intruders suggesting that the former consume more energy during territorial defence (Takeuchi, 2006). These insights collectively emphasize the intricate interplay between fat reserves, endurance, and territorial behaviour in the context of male residency status within these butterfly species.

Age as a predictor of contest outcome

The phenomenon of seasonal plasticity in body size is notably evident in *Hypolimnasbolina*, with older males exhibiting a distinctive pattern of size fluctuation between autumn and spring. The seasonal dynamics of the contest outcome in this species seemed to be heavily influenced by age rather than size. Winners in spring were generally larger and older, whereas winners in autumn tended to be relatively smaller and older, suggesting that age served as the sole consistent predictor of contest outcome (Fig. 6A) (Kemp, 2000). Contrarily, the negative impact of age on contest outcome was also observed in *H. fallax*, younger males with greater residual fat content predominantly assumed the resident role, implying that the endurance of younger males was superior, potentially explaining their dominance in the resident position (Fig. 6B) (Peixoto and Benson, 2011).

Female motivates the losers

Interestingly, when loser males of *Pararge aegeria* were made to interact with females for 30 minutes, it resulted in a higher likelihood of winning subsequent contests against the original resident male in comparison, to the control group, spending the 30 minutes alone. In *P. aegeria*, the rate at which a resident male encounters other butterflies is a good indicator of the probability of also encountering receptive virgin females, *i.e*. a good predictor of territory quality (Bergman *et al*., 2010).

Conclusions

In contests over territories, one male monopolizes a territory which is a mate-finding strategy where the probability of encountering a receptive female is high. Males visually detect passing females and pursue them for a mating chance, although females have no preference for these territories. Individuals win the contests because of differences in morphological or physiological traits and these traits vary widely among species. In contrast with contests of other animals, where size and other morphological traits are usually correlated with RHP and can impose physical costs on their opponent, the ability to inflict physical costs on their opponent plays a minor role in butterfly contests. Apart from this motivation plays an important role in contest settlement like residency experience and interaction with females increases individual's motivation to fight and they stand to gain a higher pay-off in terms of mating chance.

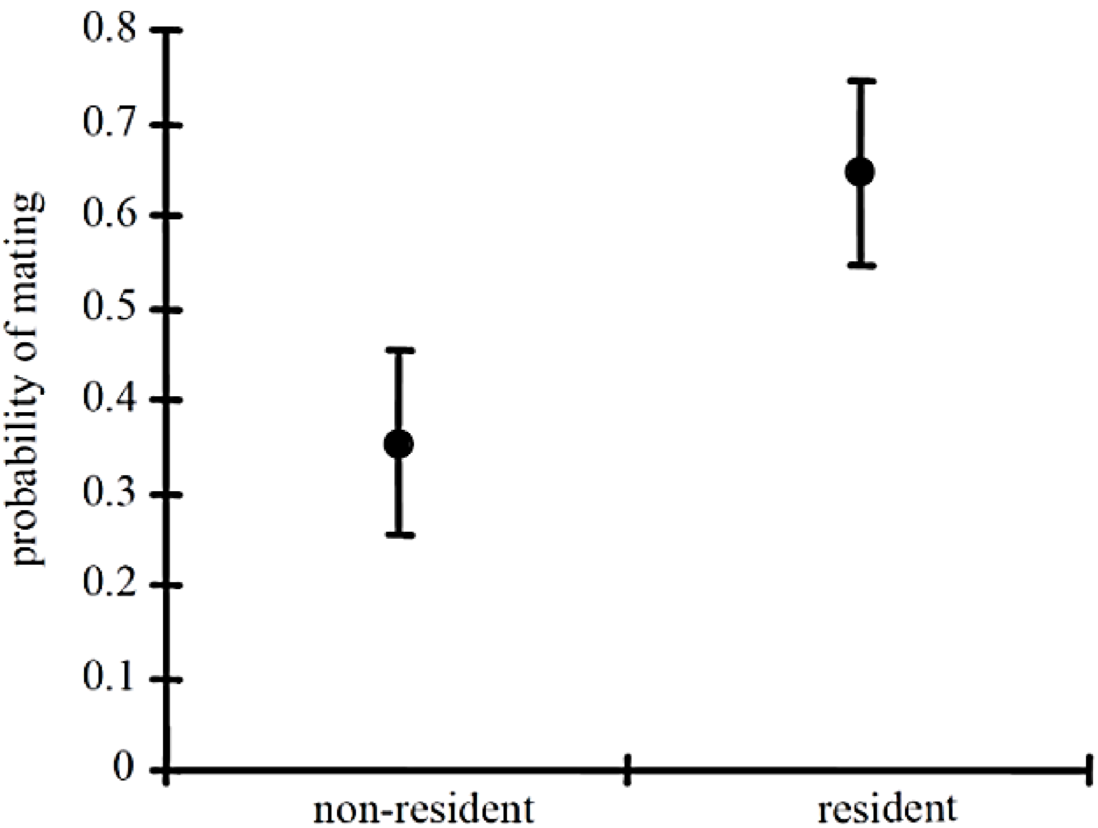

Fig. 1 Mating success of resident and non-resident males of *P. aegeria.*

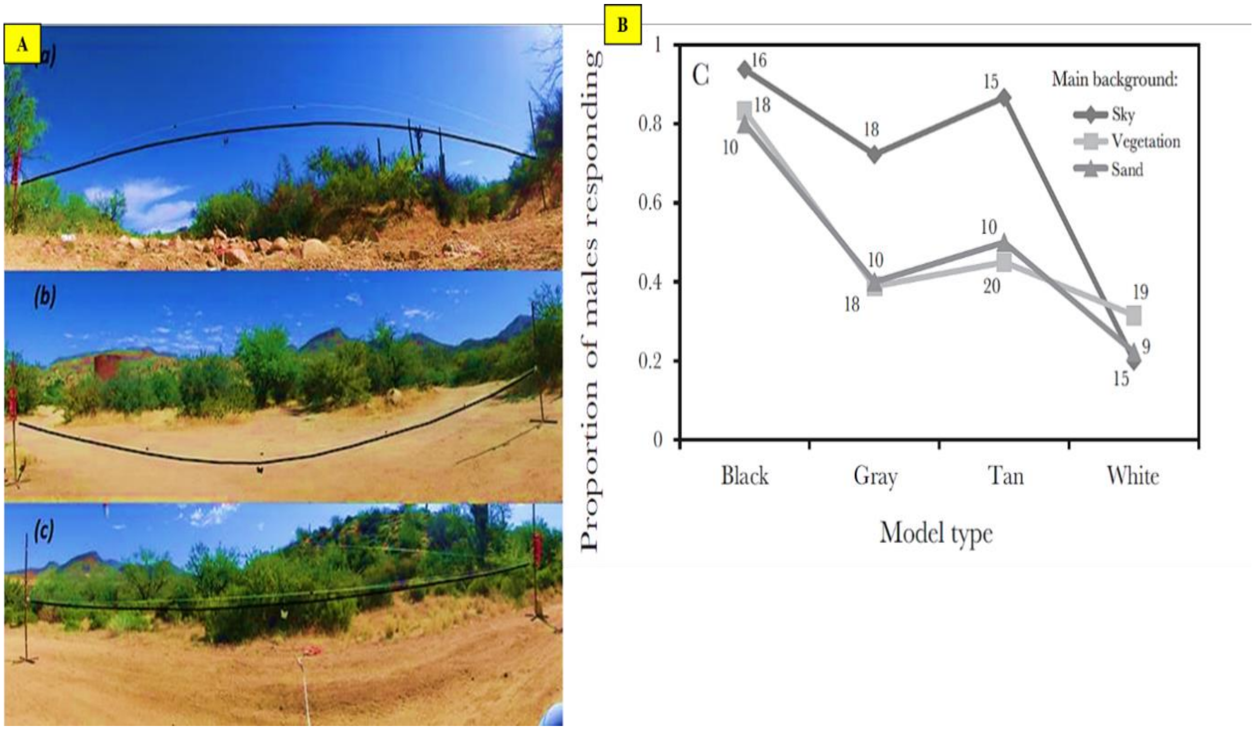

Fig. 2 A) Background classification images; B) The relationship between the proportion of perched males responding as a function of model and background type.

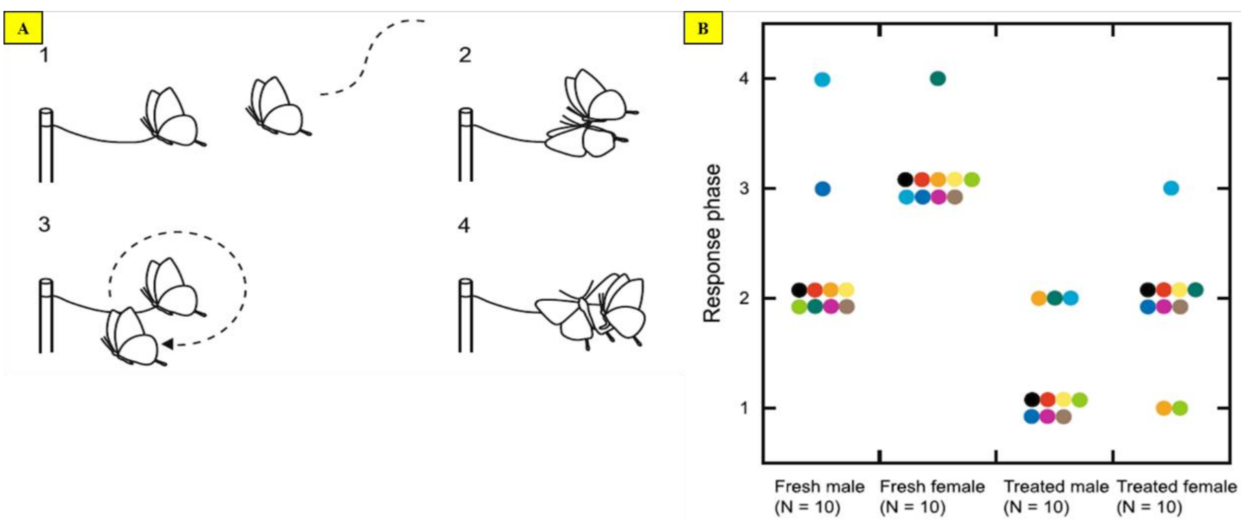

Fig. 3 A) Male response phases. 1. Approach; 2. Touch; 3. Courtship flight; 4. Copulation attempt B) Male responses to each specimen. Different colors indicate different individuals.

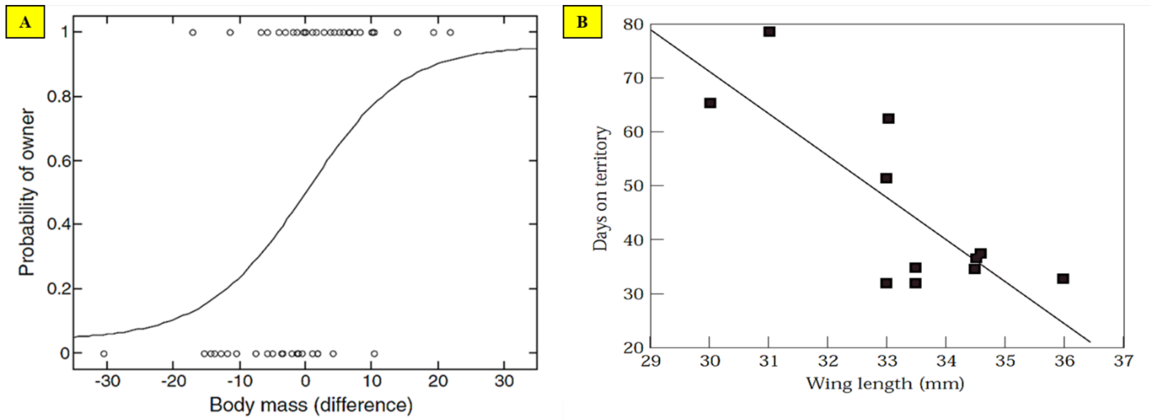

Fig. 4 A) Probability that the focal male was an owner as a function of body mass; B) Relationship between wing length and territorial time span (days).

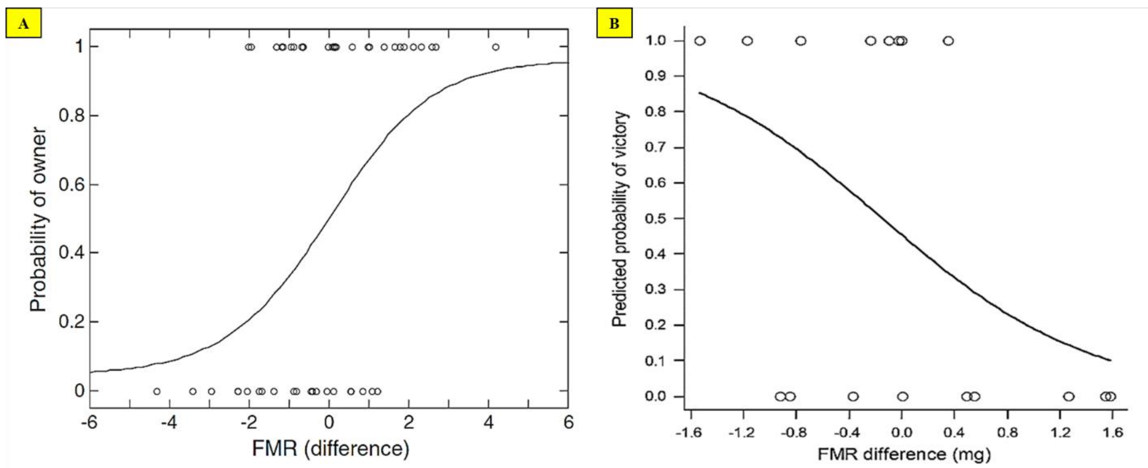

Fig. 5 A) Probability that the focal male was an owner as a function of the difference in FMR; B) Probability of victory of focal males of *H. fallax* in relation to FMR.

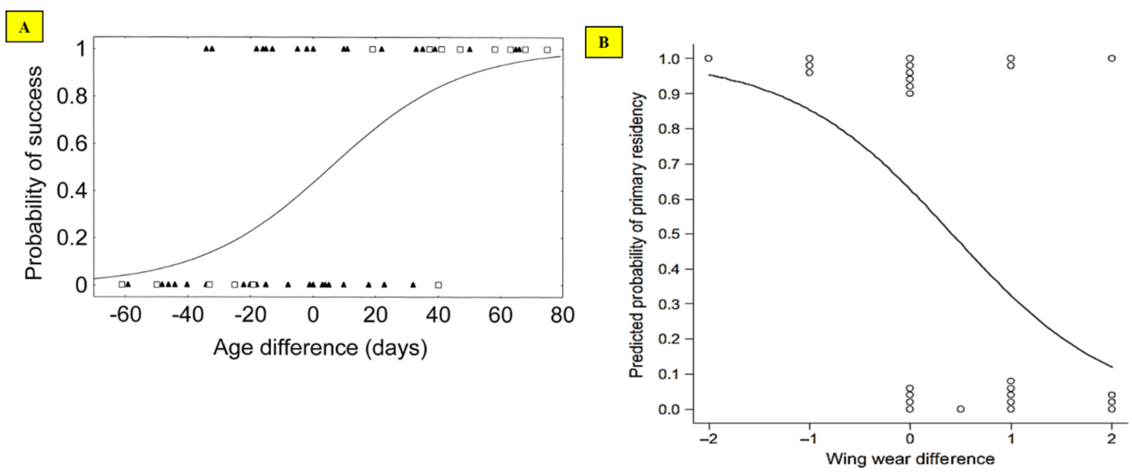

Fig. 6 A) Probability of success of focal males as a function of age in spring (squares) and autumn(triangles); B) Predicted probability of a male of *H. fallax* to be in the resident role in relation to the difference in wing wear.

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Male parental care in insects

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Abstract

Parental care is traditionally defined as costly behaviour by parents that increase the fitness of offspring. It may be uniparental, biparental or alloparental. In uniparental care, paternity assurance is usually repeated for copulation just before oviposition. Biparental care is favoured when sexual selection is not intense and when the adult sex ratio of males to females is not strongly skewed. Alloparental care is a seemingly altruistic and reproductively costly behaviour observed in over 120 mammalians and 150 avian species. Male parental care evolved exclusively from no care. Supporting models like the "enhanced fecundity model" and "overlapping brood model" hypothesize that male care is favoured because females do avoid care of their offspring. Biparental care largely arose by males joining caring females and was more labile in Holometabola than in Hemimetabola. Paternal care can be maintained under sexual selection which helps caring males to attract more mates.

Introduction

A fundamental question in evolution is 'which sex should care for offspring'. The caring sex is thought to be determined by several non-exclusive factors, for example, mate competition, territoriality, physiology of gamete release, cuckoldry risk and sex-specific life history (Kokko and Jennions 2003). To date, though, comparative-phylogenetic studies of transitions in the caring sex have been restricted to vertebrates despite calls for similar studies of invertebrates (Mank *et al*. 2005). Insects constitute one invertebrate group where parental care is extremely diverse. Parental care is traditionally defined as costly behaviour by parents that increase the fitness of offspring. For the purpose of increasing offspring fitness, parental care was present, ranging from temporary egg-guarding to feeding of offspring by both parents up to adulthood. Care can be by females, males, or both (Beal and Tallamy 2006). Insects contain some of the best-characterized examples of exclusive male care, the rarest form of care in nature.

Why is parental care needed?

Behavioural process of increasing the offspring survival prospects by protecting them from predators, food shortages, desiccation, and a range of other environmental hazards. Parental care represents only one among several alternative solutions to overcome problems associated with environmental hazards that reduce offspring survival.

Benefits of parental care

Parents increase offspring survival during the stage in which parent and offspring are associated. Parents improve some aspect of offspring quality, which leads to an increase in offspring survival and/or reproductive success in the future (*i.e.,* when parents and offspring are no longer associated) such as provisioning, protection from parasites, parasitoids and disease etc. Parents manipulate offspring development rate, which increases overall offspring survival or reproductive success across multiple life-history stages.

Types of parental care

Uniparental care: In uniparental care, the mechanism of paternity assurance is usually repeated copulation just prior to oviposition. A female may court a male to induce/carry more of her eggs, presumably because male care is a valuable resource that increases her lifetime fecundity.

Biparental care: Biparental care tends to be favoured when sexual selection is not intense, and when the adult sex ratio of males to females is not strongly skewed. For two parents to cooperate in caring for the young, the mates must be coordinated with each other as well as with the requirements of the developing young, and the demands of the environment (Remes *et al*. 2015).

Alloparental care: Alloparental care is a seemingly altruistic and reproductively costly behaviour that has been observed in over 120 mammalians and 150 avian species (Riedman, 1982). This parenting strategy involves individuals providing care to non-descendent offspring. There are both adaptive benefits and potential costs of alloparenting to the individuals involved.

Maternal versus paternal

Maternal care is the most exclusive form of parental care and the most rudimentary form and is provided by females who incorporate toxins into their eggs, oviposit them in protected places, or cover their eggs with a hard shell or wax-like compound before abandoning them. For example, many species of insects guard their young against predators by using chemicals or defensive behaviours and care may end when the young hatch, or it may extend until larvae or nymphs are mature. Paternal care is often evident in animal kingdom. For instance, in fish, about 30% of the 500 known families show some form of parental care, and most often (78%) care is provided by only one parent (usually the male). Male care (50%) is much more common than female care (30%) with biparental care accounting for about 20%, although a more recent comparative analysis suggests that male care may be more common (84%) (Farrell, 2011). In seahorses, males brood the eggs in a brood pouch until they are ready to hatch. In jawfish, the female lays the eggs and the male then takes them in his mouth. A male can have up to 400 eggs in his mouth at one time. The male can't feed while he hosts the young, but as the young get older, they spend more time out of the mouth. This is sometimes termed mouth brooding. Interestingly, the California mouse (*Peromyscus californicus*) is a monogamous rodent that exhibits extensive and essential paternal care, and hence has been studied as a model organism for this phenomenon.

Amphibians and in birds fathers contribute equally with mothers to the care of offspring in as many as 90%. In phylum Arthropoda, Giant water bugs, sea spiders, two genera of leaf-footed bugs, two genera of assassin bugs, three genera of Phlaeothripid thrips, three genera of harvestmen, and in millipedes of the family Andrognathidae (Fig. 1) display male parental care (Tallamy, 2011).

Indirect paternal contributions to offspring:

Males may invest in offspring with nutritional offerings to the female in the form of nuptial gifts of captured prey items or even their own bodies. They may transfer proteins or protective substances in a spermatophore: Male katydids, for example, provide a spermatophore during copulation that may be as much as 40% of their body mass; spermatophore nutrients have shown to be important to the reproductive success of females. Male arctiid moths, *Utetheisa ornatrix* provide a different sort of indirect paternal contribution when they transfer protective pyrrolizidine alkaloids to females during mating. These alkaloids are passed to the eggs, which are then unappealing to predators.

Rise of paternal care

The rise of paternal care can be explained by two hypotheses *viz*., the Mating Effort hypothesis and the Maternal Relief hypothesis given by Minge *et al*. 2016.

1) The Mating Effort hypothesis: It suggests that males may provide care for offspring in an attempt to increase their own mating opportunities and thus enhance their future reproductive success.
2) The Maternal Relief hypothesis: It proposes that males provide care to reduce the burdens associated with reproduction for the female, which ultimately generates shorter inter-birth intervals and produces more successful offspring.

Paternal certainty is relatively high in monogamous species (Rosenbaum *et al*. 2018). Males are less likely to be caring for unrelated offspring. In contrast, paternity certainty is reduced in polygamous species.

A few examples of paternal care in insects

Giant water bug: The male carries the clutch of eggs on his back. All the males of the subfamily Belostomatine carry their clutches to the surface periodically. This allows the embryos developing inside eggs to breathe more efficiently. It is a lot easier to get oxygen from the air than from the water. Eggs that are abandoned or deposited anywhere other than on the backs of the male never hatch. In contrast, almost 100% of brooded eggs hatch. Brooding is thus an obligate behaviour, one that is necessary for the continued survival of these species. Exclusive paternal care of eggs or young is restricted to about 100 species of insects, almost all within the Hemiptera. For example, in a giant water bug, *Abedus herberti*, females adhere their eggs to the wing cover of a male, who stops feeding and instead spends his time until eggs hatch aerating and protecting them from predators. In the Giant water bug, *Diplonychus rusticus* (Heteroptera: Belostomatidae), it is seen that females prefer egg-caring males for a mate and as a result, more eggs are on the back of egg-caring males (Fig. 2).

Hemipteran Bugs: Especially among the Hemiptera, parental care is provided solely by the male. Without exception, the males involved go to great lengths to ensure their paternity. In several tropical assassin bugs (Reduviidae), males protect their paternity by riding their mates from copulation until oviposition, effectively preventing any additional mating (Odhiambo 1959). After oviposition, the male dismounts and straddles the eggs to guard them from parasites and predators. A well-documented example is the reduviid *Rhinocoris albopilosus* in which only males guard the broods (Odhiambo, 1959). Typically, in the brood guarding behaviour, the female lays multiple egg masses in a confined space and it seems that the number of egg masses corresponds to the amount a male will protect. Males guard as few as one, to as many as seven egg masses. The male usually assumes a guarding position directly over the egg masses or will stand not more than 3-4 cm from the nearest egg mass.

Pipe-organ mud-daubing wasp, *Trypoxylon politum*: In the pipe-organ mud-daubing wasp, *Trypoxylon politum* and a few other species, males guard females' nests during provisioning. They chase away parasites and ants and defend their position from conspecific males. Just before oviposition, males engage in an unusual sequence, repeatedly holding, pulling and copulating with the female. Male guards chase parasites and predators from the nest and its provisions. Cuckoo wasps and miltogrammine flies parasitize the nests during provisioning (Coville and Coville 1980) entering and ovipositing just after the host female has left. When a guard was present, these parasites never entered successfully, but when there was no guard, they did so readily. Also, the most obvious benefit of male guarding is that mating takes place at the nest and the male can defend his position from other males.

Conclusion

Parental care is an energy-expensive behaviour. In order to increase the survival of offspring parental care is a must, it may be through the selection of a safe oviposition place to feeding of young ones. It also has negative effects on parents, it reduces the number of matings, some have to sacrifice themselves for their offspring and in many ways it affects the parents. In order to overcome the disadvantages, they have evolved like maternal and paternal care which improves offspring survival as well as their survival and other needs. Mostly parental care is studied in vertebrates but it has to be studied in insects as well. Among insects, maternal care is studied more while paternal care studies are less, which should be exploited more

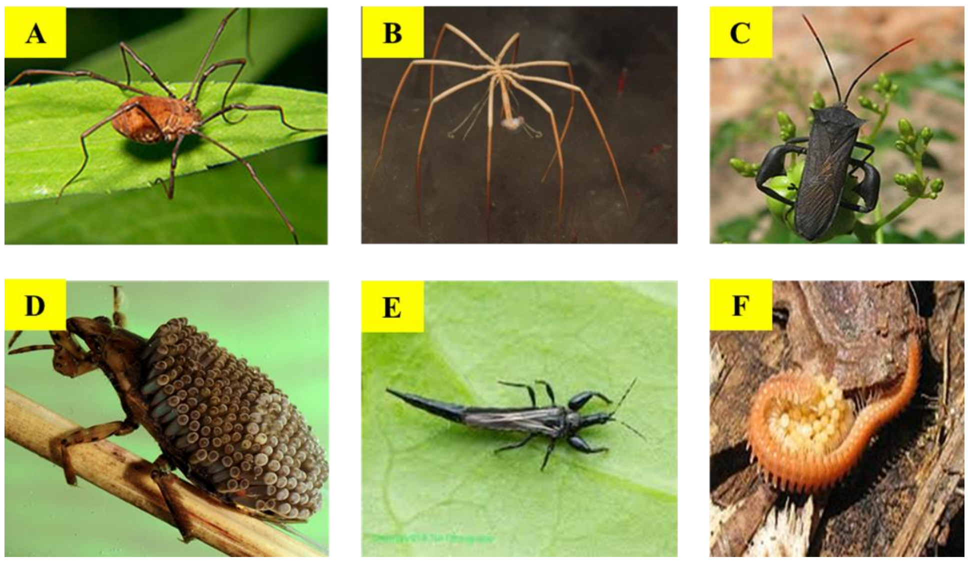

Fig. 1 Paternal care in phylum Arthropoda A) Harvestmen B) Sea spiders C) Leaf-footed bugs D) Giant water bug E) Phlaeothripid thrips F) Millipedes of Family Andrognathidae

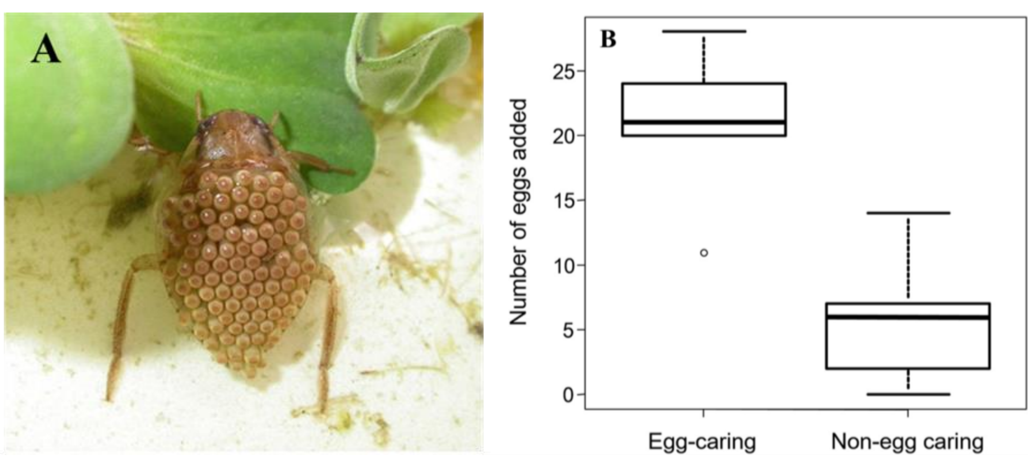

Fig. 2 A) Male of the giant water bug *Diplonychus rusticus* carrying clutch of eggs on his back B) Number of eggs added to the back of egg-caring and non-egg caring males of the water bug *Diplonychus rusticus* (Ohba *et al*. 2018)

Fig. 3 Male of reduviid bug, *Rhinocaris albopilosus*

Fig. 4 Male pipe-organ mud-daubing wasp, *Trypoxylon politum* guarding nest against a parasitic fly.

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Landscapes and floral resources –important components for insect biodiversity and biological control

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Insects are wonderful creatures in nature and are admired for the multitude of functions they possess. The benefits derived from insects are enormous and the gains are directly related to their diversity. Biodiversity by and large leads to community stabilization, ably supporting all forms of life on this earth. Insect biodiversity per se is of utmost importance for all the vital functionalities of various ecosystems. Landscapes in general and floral resources contribute to the biodiversity and conservation of functional insect groups. The insects though, comprise both harmful and beneficial groups, the diversity of either of the groups is economically important, and understanding their dynamics aids in managing 'insects with insects'.

In an era where agricultural land is shrinking day by day and experiencing a decline in the net cultivable area, there is a greater demand for higher agricultural production and productivity coupled with reduction of crop losses, which take place due to various factors. Reducing crop loss contributes to net production and food security. In this direction, sustainable crop protection measures play a crucial role in enhancing productivity and profitability. In the recent past, the deleterious effects posed by chemical pesticides necessitated the exploration of alternate plant protection strategies, especially biological control which is ecologically feasible, environmentally compatible, and economically viable. In this direction, conservation biological control is gaining momentum where biocontrol agents *viz.*, parasitoids and predators, the natural enemies of insect pests, are being conserved and augmented for controlling the insect pests (Barbosa, 1998). It is one of the sustainable approaches that alleviate chemical pesticide usage in managing crop pests (Begg *et al.*, 2017). These bioagents are valuable natural resources that need to be conserved to keep the pestiferous insects below the economic threshold level. The ecosystem services rendered by natural enemies in suppressing the insect pest population are invaluable and estimated at a value of $4.5 billion on this service annually in the United States alone (Losey and Vaughan, 2006).

Conservation biological control is where natural enemies are integrated into crop ecosystems for the purpose of natural pest management, aiding in the sustainability of agricultural production, and conservation of natural resources that fit into the sustainable development goals set by the United Nations Organization. Conservation biological control is the fourth method of biological control in addition to classical, augmentative and inundative biological control. The abundance and diversity of biocontrol agents are directly proportional to the conservation measures that include plant and habitat diversification along with enhanced landscape complexity (Begg *et al.*, 2017). The agricultural crop ecosystems receiving high doses of chemical pesticides are posing a threat to the natural enemy diversity and survival. The insect pests being ‘r’ strategists and natural enemies being ‘K’ strategists, a small factor contributing to the rapid buildup of parasitoid and predator populations, will limit the insect pest abundance in the crop ecosystem.

The designing of landscapes and the type of floral plants chosen matters a lot in promoting the insect parasitoids and predators as the insects have their own preferences towards floral resources. Though the natural enemies are entomophagous, preying upon insects, a certain part of their life depends on floral resources. Therefore, the survival rate of the insects’ natural enemies will be enhanced with floral diversification. Maintaining diverse flowering plants will nurture a wide range of beneficial insects, be it pollinators on insect biocontrol agents, where the adult insects rely on pollen and nectar as their diet. The manipulation of agricultural landscapes for the conservation of natural enemies has been widely practiced and reported in Western Europe and North America while other parts of the world are comparatively slower in adoption.

The landscape management for conservation of insect biocontrol agents includes plant diversification and non-crop vegetation conservation supplemented with artificial foods (Penalver-Cruz, 2019). The areas surrounding the agricultural crops must be planted with diverse flowering plants and maintain the natural habitats to attract and conserve natural enemies. This conservation biological control gels well with nature-based solutions, which are being given top priority by the International Union for Conservation of Nature (IUCN) and working towards the sustainable management and restoration of ecosystems for the well-being of all. In this direction, the replenishment of natural resources through clever management is the need of the hour. Protection and conservation of nature including conserving all life forms on this earth ultimately requires us to remain in harmony with nature.

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Shaping landscapes to "Bee at home"

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Flowering plants and insects have co-evolved for a long time (estimated to be about 400 million years) and their interactions resulted in a highly synchronized mutualism that benefits both mankind and the environment. While plants reward insect visitors with resources like pollen and nectar, bees, in turn, help them in transferring, though inadvertently, pollen from anthers to stigma on the same plant or between plants of the same species, thus helping in their pollination without which many cross-pollinated plants would have gotten extinct. About 80% of flowering plants are benefitted from animal pollinators of which insects, especially bees, constitute a major chunk. Pollinator fauna is not limited to a few species of honey bees and brightly coloured butterflies that are more frequently seen on flowers. In fact there are thousands of species of native bees, butterflies, moths, hummingbirds, wasps, flies and beetles that are not seen but have been strengthening our ecosystems.

Of late, natural populations of bees, both wild and managed, are declining at alarming rates leading to a "pollinator crisis" that could have cascading effects on food production, nutritional security, and biodiversity. Anthropogenic interventions, invasive species, insecticide poisoning, habitat loss, and climate change are major factors behind the pollinator decline. In this context, there is a need to have concerted efforts at individual as well as community levels to conserve native bee fauna and enhance their ecosystem services.

Bee positive landscapes

Since habitat loss is one of the major causes that resulted in bees deserting their natural nests, redesigning or shaping landscapes, both natural and managed, with bee-friendly interventions would go a long way in conserving bees and many other flower-visiting insects. There are different kinds of landscapes like orchards, agricultural lands, forests, grasslands and manmade ones like parks and gardens. Every kind has the potential to make it more bee-friendly.

What to do?

Following are some approaches to make landscapes amenable for the conservation of pollinators in general and bees in particular.

- Enrich the existing landscapes with perennial plants (trees and shrubs) known to have pollen and nectar. Gathering information on the flowering time of each species is essential so that plants of staggered flowering times can be chosen. It facilitates the availability of floral resources for longer periods. Perennial flowering plants with abundant nectar reserves are ideal to be incorporated. For instance, the Mexican creeper, *Antigonon leptopus* with its attractive pink flowers (white variants also found) rich in pollen and nectar, makes an ideal choice. It flowers for about 8-10 months in a year and attracts honey bees and many other insects in large numbers. This creeper was introduced at ICAR-Indian Institute of Horticultural Research, Bengaluru where it was planted along borders and trained on compound walls. It serves as an ornamental plant as well as a bee foraging source (Reddy, 2020) (Fig. 1).

- Medium-sized fruit trees like guava, citrus, Singapore cherry or ornamental plants like bottle brush, Antigonon are some of the options. These can be supplemented with annual flowering herbs which have to be planted at frequent intervals.

- In orchard-based landscapes, annual flowering plants like niger, mustard, and sunflower can be grown as intercrops during the off-season to sustain bees and other pollinators. To the maximum extent possible, clean cultivation must be avoided. In one of our studies, it was established that mango orchards following clean and intensive cultivation attracted a significantly lesser number of pollinators compared to the ones following conservation horticulture.

- 'Less lawn more plants' should be the concept to save on resources in maintenance and enhance pollinator visitation. Unfortunately, many urban gardens are partial towards extended lawns which are of little use to bees. Besides enriching existing landscapes with flora and practices that support bees, creating 'pollinator gardens' in urban areas would help in retaining and augmenting bee fauna. Landscape architecture has to shift its approach from exclusive eye-catching beauty to that of ecological relevance too.

- Providing nesting sites such as bamboo pieces and mud pots help wild bees to settle in landscapes. Native wild bees have very different nesting requirements than that of domesticated ones as they are solitary or nest in very small numbers. The majority nest in the ground and others in tree barks, rat tunnels, underneath flower pots, wooden supports given to creepers etc.

- Above all they should be maintained, as far as possible, free from chemical pesticide applications.

- Burning field bunds or public landscapes decimate several soil-dwelling beneficial insects.

Conclusions

There is an absolute need to spread awareness among the public on the importance of conserving pollinator fauna and how one can contribute to this endeavour. Besides a playground, all schools should have a pollinator garden and involve school students in its maintenance. Ironically, most of us equate insects with only disease-causing mosquitoes and agricultural pests. But the beautiful world of insects beyond and their services to the environment and human welfare are rarely appreciated. Behind every fruit and vegetable, every drop of sweet and delicious honey, every string of silk saree, every pinch of cosmetic creams, every inch of land cleared of decomposed wastes… there is an insect.

The concluding take-home point is; “More blooms..more buzz.”

Antigonon creeper on compound wall

Rock bee foraging on Antigonon

Fig. 1. Mexican creeper, *Antigonon leptopus*, an ideal bee foraging plant for landscapes

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Habitat manipulation and landscape patterns in national parks and wildlife sanctuaries as areas insect conservation

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Insects are declining mainly due to the overuse of pesticides in intensive agriculture, rapid growth of urbanization and of course, changes in climate. As we all know many scientists are warning that the loss of insects may lead to the loss of the human population. So, if our future generations have to survive on this earth, we must act at this very moment and conserve the insect population.

Conservation mainly depends on the protection of natural habitats and the creation of habitats through modifying landscapes, which helps every species to survive and find suitable places for survival (living).

National parks and wildlife sanctuaries are the only protected places where human interference is very meagre or nil. However, in recent days national parks have been used for public recreation activities. Suitable strategies can be adopted to change the entire landscape in such a way that the flora and fauna attract insects which can provide for a habitat for different insect species. A plan must be made in such a way that these national parks should be a learning place for children that also creates awareness among people for the conservation of insects and thereby the survival of mankind.

The best example is the Butterfly Park at the Bannerghatta National Park, where they developed the host plant garden for different butterflies, which is the permanent natural habitat for many species of butterflies. It also creates awareness about insect (butterfly) conservation among the visitors. Here they also mass multiply the different (including endangered/extinct) species of butterflies and release them in nature (their natural habitat).

Wildlife sanctuaries are large areas compared to national parks and are legally protected from human interference. These can be best utilized to conserve endangered species. We can develop host plant gardens however, it requires knowing/studying the habits and habitat of the species to develop the same. Due to their large size/area, a plan for conserving aquatic insects, aerial insects, forest insects, soil-borne invertebrates can be made in a phased manner or in separate blocks. These types of adoptions/modifications in landscapes of wildlife sanctuaries will serve the purpose of conservation and benefit mankind across the globe. However, the major problem to adopt these changes in national parks and wildlife sanctuaries across the country/globe is the lack of awareness among the policy makers and political support.

As Samwaysa *et al*., (2020) explained, we must communicate the importance of insect conservation much better, especially using the tools of insect conservation psychology, which includes the important and interrelated components of education and citizen science.

For effective conservation of insects, citizens could play a major role where they can develop small gardens in their surroundings that can provide a natural habitat for any type of insect that can live/survive. Citizens can create amateur clubs and they can co-ordinate/contribute to setting up of habitats, educating young children about the importance of insect conservation and their benefit to future generations.

Insect conservation philosophy and psychology can be applied for improved education, civil society engagement, and science-based implementation of conservation strategies may be used as a solution for preventing further extinction of the insect population as given in Fig. 1.

Insect conservation by adopting habitat management is most crucial and effective as once the habitat is developed there are good chances of it turning into a natural habitat. These may not require much care for further stabilization in the ecosystem as well. However, to take up the initiative for the development of a habitat or landscape, a cordial liaison is required among the policymakers, stakeholders, and landowners. Together we can leave a sound legacy to future generations.

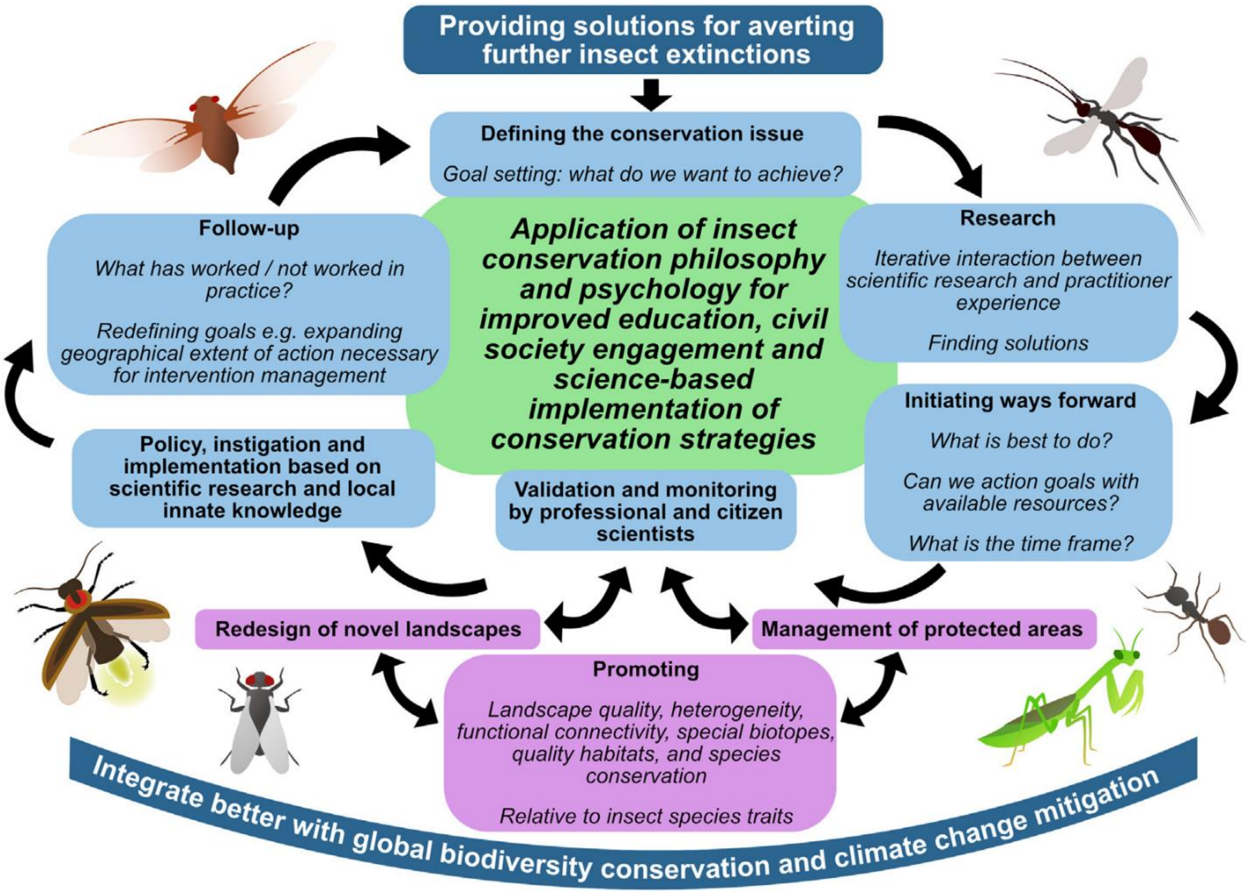

Fig. 1 Solutions for insect conservation (Adopted from M. J. Samways, *et al*., 2020)

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M. J. Samwaysa, P. S. Bartonb, K. Birkhoferc, F. Chichorrod, C. Deacon, et al., 2020. Solutions for humanity on how to conserve insects. *Biological Conservation* (242):108427. (https://doi.org/10.1016/j.biocon.2020.108427).

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INSECT LENS

Dune cricket, Schizodactylidae

It is usually found in desert and sandy areas. Species are predatory, including Schizodactylus inexspectatus. T. B. Fletcher notes that one captive individual did not feed on any vegetable matter. Fossils are known since the early Cretaceous.

Author: *Dr N Mukesh*

Location: *In sandy soil, Dunes of Fatehpur, District - Sikar, Rajasthan*

Spiny leaf beetle, Dicladispa sp. (Chrysomelidae: Coleoptera)

The larvae tunnel inside leaves between the upper and lower surface. A hyaline window appears where the intervening leaf tissue has been removed.

Author: *Dr. Sevgan Subramanian*

Location: *International Centre of Insect Physiology and Ecology, Kasarani, Nairobi, Kenya*

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Miniature incubators with marvelous architecture (Egg mass of stink bug (Pentatomidae: Hemiptera))

The eggs were photo documented in the month of September 2022 on the bark of Neem tree (Azadirachta indica) at the height of 1.21 m from the ground and the girth (stem diameter) at this height was 0.55 m.

***Author**: Mr. Rushikesh Rajendra Sankpal*

***Place**: Warud Chakrapan- Kawatha Bk, Dist- Hingoli, Maharashtra (19°48'50.5"N 76°50'25.8"E)*

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Wood spider, Hersilia sp. (Hersiliidae: Araneae)

Lives almost exclusively on tree trunks or stone walls and immobilizes the prey by spreading silk, while jumping over and running around it.

***Author**: Anil V Kohle*

***Location**: Agriculture Research Station, Amgaon, Dist. Gondia Maharashtra*

Emigrant butterfly, Catopsilia pyranthe (Pieridae: Lepidoptera)

As name implies, it is strongly migratory in behaviour and found in many habitats including Acacia scrub, dry open woodlands, beach hinterlands, gardens and wasteland. Both sexes commonly visit flowers of Lantana and Catunaregam.

Author: *Dr N Talari*

Location: *Cassia sp. at Vadlamudi, Guntur*

Small carpenter bee, Ceratina sp. (Apidae: Hymenoptera)

These bees make nests in dead wood, stems or pith. One species is unique for having both social and asocial populations, Ceratina australensis, which exhibits all of the pre-adaptations for successful group living. This species is socially polymorphic with both solitary and social nests collected in sympatry. They are very commonly mistaken for "sweat bees" (family Halictidae).

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Greater Banded Hornet, Vespa tropica (Vespidae: Hymenoptera)

It is a predator of paper wasps and possesses a potent sting, which can cause extreme pain and swelling. Vespa tropica are raiders of the nests of other wasp species and take captured larvae back to their own nest to feed their larvae. They have been observed to catch honeybees quite frequently, and even dragonflies have been noted as prey.

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Syrphid, Paragus serratus predating on Aphis spiraecola on Ixora shrubs (A tritrophic interaction of Pest, Predator and Plant)

Ixora shrubs dotting urban landscapes with flaming clusters of tubular flowers, in red orange yellow etc., are a gardener's delight. But these get infested with aphids (plant lice), especially in winter. The Rashvee-International Phytosanitary Research and Services team found Aphis spiraecola and A. gossypi on young leaves of Ixora in the urban gardens of Bangalore. As these plants are least sprayed, there were syrphid, Paragus serratus and coccinellid predators preying on the unwary aphids, which occurred in small colonies.

***Author**: Dr Rashmi M. A.*

***Place:** Bengaluru*

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Asian weaver ant, Oecophylla smaragdina (Formicidae: Hymenoptera)

These are arboreal in nature and found in tropical Asia and Australia. These form colonies with multiple nests in trees, each nest being made of leaves stitched together using the silk produced by the ant larvae. Hence, the name 'oecophylla' [=leaf-house(in Greek)].

Author*: Dr Rashmi M. A.,*

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Fistulococcus pokfulamensis (Coccidae: Hemiptera) on mango leaf

Fistulococcus pokfulamensis was reported for the first time from India (Karnataka) in 2022 by Dr Sunil Joshi (ICAR-NBAIR, Bengaluru). Fistulococcus pokfulamensis was known previously only from Hong Kong, infesting a gymnosperm. In India, it has been recorded on Syzigiumcumini, Vaccinium corymbosum and mango. The spread of the scale on mango pan India was also forewarned by Joshi et al., 2022.

***Author**: Dr Rashmi M. A.,*

***Place:** Bengaluru*

***Email**: internationalphytosanitaryrs@gmail.com*

Lablab bug, Coptosoma cribraria (Plataspidae: Hemiptera)

It is a piercing-sucking insect, nymphs and adults feed on tender stems, petioles and leaves. Heavy populations can result in some defoliation and development of sooty mold. In addition, this bug emits an unpleasant smell when disturbed and produces a yellow substance when crushed that can stain cloth, wood and other surfaces. Also, in some cases reported to cause painful skin irritation.

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Egg parasitism of hover fly on Aphids, Macrosiphum sp. (Plant-pest-paraisitoid: A tritrophic interaction)

Trichome-mediated plant defences are implicated in both the second and the third trophic level. First, trichomes can provide major resistance against a number of herbivorous arthropods like aphids, but can also interact directly or indirectly with their natural enemies. Here, both adults and larvae of hoverflies have been reported to be more abundant and better suited to exploiting aphids on smooth, flat surfaces.

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Fall armyworm, Spodoptera frugiperda (Noctuidae: Lepidopterra)

Fall armyworm (FAW) is native to tropical and subtropical America. Its presence in India was first reportedin May 2018.

Author: *Dr. Nagaraj, D. N Project Head (Entomologist.,) Ento. Proteins Pvt. Ltd., Mangalore*

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Weaver ant, Oecophylla smaragdina (Formicidae: Hymenoptera)

Weaver ants are highly territorial and aggressively defend their territories against intruders. Though, they prey on insects harmful to their host trees, weaver ants are sometime used by indigenous farmers, particularly in Southeast Asia, as natural biocontrol agents against agricultural pests. Although weaver ants lack a functional sting they can inflict painful bites and often spray formic acid directly at the bite wound resulting in intense discomfort.

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Eggs of cone-nose bugs or Assasin bugs - (Harpactorinae: Reduviidae: Hemiptera)

Can there be a better design for Soya sauce bottles than this? !!

Author: *Dr. Sevgan Subramanian*

Location: *International Centre of Insect Physiology and Ecology, Kasarani, Nairobi, Kenya (December 2023)*

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Melon Fly, Zeugodacus cucurbitae (Diptera, Tephritidae)

Melon Fly feed on the juices of decaying fruit, nectar, bird feces, and plant sap. Mature melon fly males are attracted to several attractants like anisyl acetone, cue-lure, raspberry ketone and zingerone. Also, they are pollinators of orchids, Bulbophyllum (Orchidaceae) species, that release floral fragrance containing either raspberry ketone or zingerone as floral attractant and reward.

Author: *Dr. Sevgan Subramanian*

Location: *International Centre of Insect Physiology and Ecology, Kasarani, Nairobi, Kenya (December, 23)*

Email: *ssubramania@icipe.org*

Pericyma sp of Moth (Erebidae : Lepidoptera)

The Genus is found to be widespread in the old world tropics. Regions in Africa and India show the greatest diversity. Some of the Indian species of adults are also considered to be piercing fruits.

Author: *Ruchita Naidu D, Teaching Assistant, Department of Zoology, St. Joseph's University, Bangalore, India.*

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EXTENSION

OUTREACH BY RASHVEE-IPRS AND AVIAN TRUST

Planting sapling and discussion with Hon MOS Agriculture Shobha Karandlaje at ICAR-NBAIR, on Biocontrol on 19th November 2023

Participated in Biocontrol Expo organized by ICAR-NBAIR, Bengaluru on 19th November 2023

With Director, ICAR-NBAIR, Assistant Director General (Plant Protection & Biosafety), Agriculture Commissioner, and Plant Protection Advisor at Biocontrol-Expo 2023

Dr. Abraham Verghese was conferred the Harold Maxwell Lefroy Memorial Award-2022 from the Dr. B. Vasantharaj David Foundation for his Commendable Contribution to disseminating Insect Science at the 5th International Conference on Recent Advances in Agricultural Industrial Entomology and Environmental Science at Loyola University in Chennai India on 29th September 2023.

Dr. B. Vasantharaj David was honored with the title "Insect Environment Ratna" for all his Excellent Contributions to Insect Science in the last 7 decades by the editors of Insect Environment, Dr. Abraham Verghese and Dr. M A Rashmi at the 5th National Conference on "Recent Advances in Agricultural and Industrial Entomology and Environmental Sciences and their Impact on Food and Environmental Security" jointly organized by Dr. B. Vasantharaj David Foundation and Entomology Research Institute (ERI), Loyola College, held on September 29-30, 2023 at Entomology Research Institute, Loyola College, Chennai 600034.

Awardees at the 5th National Conference on "Recent Advances in Agricultural and Industrial Entomology and Environmental Sciences and their Impact on Food and Environmental Security" jointly organized by Dr. B. Vasantharaj David Foundation and Entomology Research Institute. (ERI), Loyola College.

R-IPRS Incubation Facility at BESST-HORT, ICAR-IIHR

Dr. Abraham Verghese and Dr. MA Rashmi with Dr. M. V. Dhananjaya, Chief Executive Officer, BESST-HORT, Principal Scientist at ICAR-IIHR

Participated in the Krushi mela- 2023, University of Agricultural Sciences, GKVK, Bengaluru at the ICAR-NBAIR Stall

Explaining fruit fly management to a mango farmer at Ramanagaram district Karnataka, India

AVIAN trust participation in AIKYAM -Knowledge Fest, Jain Heritage School, Bengaluru

One-day workshop at Hospalya village, Magadi taluk, Ramanagaram district Karnataka, India organized by KVK Ramanagara and NABARD-IRIDS, Magadi. Lecture and discussion By Dr. Abraham Verghese on Latest Integrated Pest Management and GAP Practices in Mango on 22.12.2023

Semiochemical and commercialization seminar held at Indian Academy of Sciences on 23.11.2023, Dr Abraham Verghese 3rd from left along with scientists from different organizations including industry

AVIAN TRUST AWARDS CEREMONY- 2023

AVIAN Trust seminar and award function was held on 16th December 2023 at Regional Plant Quarantine Station, Bengaluru.

Dr. S.V Suresha, Vice Chancellor, UAS Bengaluru inaugurated the Award ceremony and gave an inspiring talk on the "Biodiversity of Soil Organisms impacting Soil Health".

D.K. Nagaraju, Joint Director, Regional Plant Quarantine Station, Bengaluru delivered a very informative talk on "Impact of Invasive Species on Biodiversity

Dr. S.V. Suresha was conferred with Soil health and Environment Award 2023 for his outstanding contribution to holistic development of agriculture which includes soil, water, plant and environment

Dr. J. P Singh, Plant Protection Adviser GOI was conferred with “Plant Protection and Biodiversity Award-2023” (In-absentia) for his contribution to plant protection and conservation of biodiversity and many important issues related to quarantine and trade

Dr. A. K. Chakravarthy, Former Head and Scientist, ICAR-IIHR was awarded Insect Conservation Award-2023 for his contribution to Entomology and Insect conservation in the last 4 decades

Students from various universities and colleges participated and won awards
In the Picture students' team from Soundarya Institute of Management and Science, Bengaluru

Dr Satappa Bhambar Kharbade, Associate Dean, Rajarshee Chhatrapati Shahu Maharaj College of Agriculture, Rahuri awarded with Plant Protection Award-2023

Dr. S. Dayakar, Professor and Head (Entomology), Acharya N. G. Ranga Agricultural University, Andra Pradesh

Dr. Nisha M M, Managing Director, AgFerm Innovations Pvt Ltd., was awarded Plant Protection Entrepreneur Award

AVIAN Trust Awardee Scientists of ICAR

Students and Official awardees participated in AVIAN Trust Award Ceremony on 16th December 2023