MEETING REPORT

Ecology and behaviour: Cornerstones of pest biology and management*

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*A report on lecture series ‘Insect Ecology and behaviour’ jointly organized by the Division of Entomology and Nematology, Indian Institute of Horticultural Research (IIHR), Bengaluru and the Association for Advancement of Pest Management in Horticultural Ecosystems (AAPMHE) held at IIHR, Hessaraghatta, Bengaluru.

Insect pests are considered as the major biotic constraints to agricultural crop production around the globe. Brown plant hopper of rice, fruit borer, stem borer, hispine beetle, fruit fly, red palm weevil, locust, corn borer, coconut mite, coconut wilt, banana viruses, sugarcane woolly aphid, papaya mealy bug etc. are few economically important pests (Khetarpal and Kavya Dashora, 2014). The major factors that seem to influence the insect pest scenario involve elimination of natural enemies, resurgence of pests, pest adaptation to new hosts and frequent secondary out-breaks (Rai et al., 2014). A comprehensive understanding about pest species interactions with biotic and abiotic components of environment, its biology and behaviour serves as a template to formulate successful management strategies that eventually result in prevention or reduction in yield loss. So, a lecture series on ‘Insect ecology and behaviour’ was organized jointly by the Indian Institute of Horticultural Research (IIHR) and Association for Advancement of Pest Management in Horticultural Ecosystems (AAPMHE). Dr. Renee M. Borges, Professor and Chairperson, Center for Ecological Sciences, Indian Institute of Science (IISc), Bengaluru, India, delivered cutting edge lectures on “Insect ecology” on 11th February, 2016 and Dr. Raghavendra Gadagkar, Chairman, Centre for Contemporary Studies, IISc, delivered lectures on frontier areas of “Insect behaviour” on 29th February, 2016 at IIHR, Hessaraghatta, Bengaluru. Over 100 entomologists, researchers across different disciplines and students attended the lectures and participated.

Dr. Borges stressed the importance of understanding a network of interactions that exists among insect species in ecosystems. As examples, she dealt in detail on fig–fig wasp interactive system followed by ant–plant mutualisms. She mentioned there are many species connected with fig–fig wasp interaction system viz., pollinators, gallers (early arrivers), specific predators, parasitoids (late arrivers), nematodes, ants and dipterans (Fig. 1). Fig, a key-stone species has a globose inflorescence known as syconium, an incubator for wasps. It consists of 100-1000s flowers and has a single opening, ostiole. Volatile organic compounds (VOCs) produced by syconium attract fig wasp pollinators to pollinate flowers and oviposit into selected pollinated flowers producing galls. Pollinator offspring mature and mate with the anthesis of male flowers within syconia. Male offspring eclose first, mate with and release females

Fig. 1. Fig–fig wasp interaction system: untwining complex relationships (Ghara et al., 2011)
from their galls. Female pollinators exit the syconia laden with pollen from male flowers in search of a pollen-receptive female phase syconium within which they can continue life cycle. She said that the fig–fig wasp mutualism is also subjected to parasitism by galling fig wasps and parasitoids of the early parasitic gallers and pollinators. The innermost ovules far from the syconial wall are preferred by pollinators to escape the reach of the ovipositors of parasitoids (Ghara et al., 2011). VOCs produced by fig mediate the attraction of parasitoids to syconia besides pollinators and non-pollinating fig wasp (NPFW) gallers. She opined that successful parasitism of fig–fig wasp mutualism is a challenging task and biology of NPFWs needs to be studied to understand the complex interactions existing in the fig ecosystem. In conclusion, there is variability in fig–fig wasp system; all syconia in a tree may not fully endure to all the players in the food web. This variation existing in natural ecosystems is important for regeneration of the fig system. Similarly for pest management in agroecosystems, if ecology is understood in depth, one can decide upon the kind (chemical/biological mechanism), time (phenophase) and frequency of such interventions.

To illustrate how important it is to understand ecology, Dr. Borges discussed on ant–plant interaction system. She mentioned that ants provide protection to their host plants against herbivores and supply nitrogen. In turn, plants reward them either in the form of food (extra floral nectar rich in lipids and proteins) or nesting spaces (domatia) like hollow internodes, thorns or tubers. While there are many ant-plants and several genera of plant-ants, there are few obligate/specialized mutualists in such interactions. For e.g. in an Indian ant-plant, Humboldtia brunonis, the domatia are non-specifically occupied not only by protective and non-protective ants but also by interlopers like arboreal earthworms; these non-specific domatia occupants contribute to the nitrogen budget of the plant. She mentioned that only larvae of the mutualistic ant species having proteases that are insensitive to proteinase inhibitors present in the food bodies of acacias consume the plant food and thus plants prevent the consumption of food bodies by opportunistic, exploitative ants (Borges, 2015). Larvae of non-adapted ant species, whose digestive enzymes be inhibited by these compounds, would acquire nutrition at a slower rate; consequently, colonies of such non-adapted ants would grow at slower rates, and thus lose out in a competition with mutualists. This appears to be a biochemical filter that can prevent undue exploitation of the mutualism. She mentioned that such a mechanism is believed to help stabilize the ant–plant relationship.

Dr. Raghavendra Gadagkar spoke on the importance of understanding the principles behind insect behavioural experiments in applied entomology. He opined that experimental principles are of great interest than observations alone and have relevant value practically. Nature does not unveil the behavioural secrets of its biotic component unless we disturb, observe and then gather an understanding of the normal state of behaviour (e.g. creating temporary mutation). To understand the significance of behavioural experiments, he described some of the important experiments on wasps, honeybees and ants. He explained an experiment carried out by Nobel laureate, Niko Tinbergen on how the digger wasp recognized its own nest marked with a ring of pinecones. He stated Tinbergen’s experiment suggested that digger wasps used visual landmarks to locate their nests. Gadagkar described an elegant experiment performed by Nobel laureate, Karl Von Frisch on the colour sense of the honey bees using coloured cardboard paper in order to illustrate that trained bees discriminate colour through classical and operant conditioning.

Karl von Frisch correlated the runs and turns of the bee dance to the distance and direction of the food source from the hive (von Frisch, 1967). Successful foraging bees perform a waggle dance on their return to the hive, indicating that food is farther away, while the round dance indicates that food is nearby. This was thought to attract the attention of other bees. To determine distance flown by gauging the extent to which the image of the environment moves in the eye as honey bees fly toward their destination, Gadagkar described an experiment to illustrate the properties of this visually driven odometer. By training bees to fly to a feeder in a tunnel lined with a range of different visual patterns, and analyzing their dances when they return to the hive, he was able to prove that the odometric signal is relatively unaffected by variations in the contrast and spatial frequency content of the patterns (Srinivasan et al., 2000). He mentioned that honey bees are believed to assess feeder distances by the energy spent on foraging flights and based on recent research as well as the critical review on energy hypothesis it was proved incorrect. He emphasized on an ‘optical flow hypothesis’ in which bees use the speed of retinal image motion perceived from the ground to estimate the distance flown. He opined that flight altitude

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is important to estimate the distance by retinal image flow, because objects move faster and farther across the retina when the bee flies closer to the ground (Esch and Burns, 1996).

Dr. Gadagkar described an experiment to substantiate the striking feature of hymenopteran societies in which male workers are generally absent. In eusocial wasp, Ropalidia marginata, ability of males to feed their larvae was investigated by providing excess food and by removing the females. Males were able to feed larvae with probabilities and rates comparable to those of females (Sen and Gadagkar, 2006). This suggested that lack of pre-adaptation to feed larvae does not explain the absence of male workers in social Hymenoptera. However, males were not as efficient as females at feeding larvae; they seemed capable of doing enough for natural selection to have promoted the evolution of male workers if there were no other factors preventing them. From his experiment he stated that it was surprising that at least in species in which males stay on their natal nests for substantial periods of time; natural selection has not evolved feeding larvae by males into common and efficient behaviour (Gadagkar, 2016).

In conclusion, it is significant to have an inclusion and exclusion of variables in the experiments that focus on the ecological and behavioural aspects of insects to gather a comprehensive knowledge. For instance fig–fig wasp system. Many times under compulsion from the government linkage departments to find quick fix solutions to burning pest problems, several basic questions on biology and behavior remain unanswered. This eventually results in prescription of ineffective management practices that lead to eventual control failures. In spite of exhaustive research on tomato fruit borer, Helicoverpa armigera, a catholic polyphagous pest, researchers are unable to manage it. An ability to metabolise/detoxify the toxins especially Bt by using its enzyme systems has enabled it to thrive as devastating pest. A clear understanding of insect ecology and behaviour is important for effective management of notorious insect pests and environmental integrity. Thus, it is essential to conduct experiments in natural ecosystems specific to pest, crop and region.

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