MEETING REPORT

Future dimensions in entomology research*

A series of discussion meetings highlighting the advances in the area of entomological research involving an interdisciplinary approach have been planned by T. N. Ananthakrishnan (formerly Director of the Entomology Research Institute, Chennai). The first in the series was on the 'Molecular modalities in the biological control of insects', held in July 2001, was organized at the COSTED. Inaugurating the second discussion meeting recently, K. V. Peter, (Vice-Chancellor, Kerala Agricultural University) stressed the need for deliberation on the ways and measures to prevent accidental introduction of exotic pests through adequate quarantine measures. Recent introduction of the coconut eriophyid mite, the spiralling whitefly, the coffee berry borer and the American serpentine leaf miner was emphasized in relation to their impact on crop production. Mention was made of insecticide resistance and insect resurgence and the need to go organic.

Delivering the keynote address, T. M. Manjunath (Director, Monsanto Research Centre, Bangalore) emphasized that biotechnology in the form of insect-resistant transgenic plants entered the history of crop protection at such a crucial time, when an effective technology was badly needed to save our crops from the ravages of insect pests. Transgenic plants, he observed, were the first biotechnological products to emerge from the pipeline for commercialization owing to the availability of a large gene pool of *Bt* (*Bacillus thuringiensis*) insecticidal proteins of diverse host range. Potential ecological benefits by way of reduced insecticidal usage also gave a thrust to this technology. Besides, *Bt* research, work on other potentially insecticidal gene products such as protease and amylase inhibitors, lectins and enzymes is also in progress. He further emphasized that in addition to developing insect-resistant transgenic plants, genetic engineering can also be applied to enhance the efficiency of insect natural enemies and also to develop natural enemies or plants with genes for pesticidal resistance.

Initiating the trend of discussion, T. N. Ananthakrishnan emphasized the significance of induced defence in the dynamics of host-plant resistance, in view of their increased relevance in biotechnology. The role of methyl jasmonate in the induction of protease inhibitors and the utility of these in the development of transgenics has been a continuing exercise, he said. He also indicated the relevance of biological restructuring of agroecosystems for increased biodiversity, with increased crop diversity adding to the volatile chemical profiles which attract natural enemies of insects in large numbers. The capability of plants to change their biosynthetic pathways to produce newer secondary compounds resistant to insects, has now become the basis of 'pathway engineering'. He also indicated that it is possible to stabilize insect communities in agroecosystems, by designing and restructuring vegetational architecture which supports population of insect natural enemies. He also emphasized the role of chemo-orientation in insect behaviour, besides a better understanding of the genetics of insect behaviour.

Raghavendra Gadagkar (Indian Institute of Science, Bangalore) discussing the behavioural genetics and sociogenomics of social insects, indicated that social insects have been in the forefront of behavioural genetic studies. He emphasized that even a small of number of genes can control complex events such as the genetic behaviour of honey bees, studies on which have indicated clear evidence for genetic determination of complex behaviour. Intra-colony genetic variability is now known to be one of the factors giving rise to age polytheism and task specialization. More recently, honey bees (*Apis florea*) have provided sufficient evidence for the role of differential gene expression during development in caste determination in bees.

R. S. Annadurai (Vittal Mallya Research Foundation, Bangalore) suggested that while greater emphasis is given for Integrated Pest Management (IPM) in crop protection, the impact of transgenics on the natural enemy complex at the ecosystem level needs to be addressed. Different cultivars/geneotypes of crop plants are known to have varied nutritional values related to their infestation patterns. The same law applies to transgenic plants, the nutritional status of which will have an impact on the concerned pest species. The *Arabidopsis* model can be exploited as a tool to address the impact of transgenics on insect–plant relations. Long-term benefits of transgenics and impact on pests should be researched for several generations using model systems. Current indications are that there will be nearly twenty transgenic plants introduced by early next year in India, which will open up exciting areas for research in the future.

G. Suresh (SPIC Science Foundation, Chennai) discussed the application of isobolographic analysis to constitutive chemistry of plants and interaction among the constitutive plant defences. The biosynthetic capability of any one species/genus to produce an array of compounds that are subtly different from each other and synthesized from a basic skeleton, results in enormous structural diversity, he said. Classical examples would include cyanohydrin diversity of the Passifloreaceae, limonoid diversity of the Rutales and cardenolides and pyrolizzidine alkaloids diversity in the Asclepiadaceae and Apocynaceae. A closer look at such elaboration of select groups of constitutive chemistry within a given genus/species and the interacting diverse insect species, brings forth the important compound interactions (synergy, additivity and antagonism) as components in the decision-making process for successful host plant selection or rejection by insect herbivores. The isobolographic analysis, an intuitive method applied in pharmacology, has been successfully applied to study interactions among plant defence compounds, wherein it was suggested that the large body of published ecological information can be utilized for application of this null model in order to investigate and to derive meaningful conclusions on chemical interactions and herbivory.

New thrust in IPM of horticultural crops was provided by N. K. Krishna Kumar (Indian Institute of Horticultural

*A report on the second of a series of discussion meetings on advances in entomological research organized by T. N. Ananthakrishnan at the COSTED Auditorium, Chennai on 19 January 2002.

Research, Bangalore). He indicated that transformation of Indian agriculture from sustenance to commercial farming has changed the mosaic and cropping pattern in rural India. Decreased acreage under millets, oil seeds and increased area under horticulture crops, resulted in specialized peri-urban cropping pattern. Production of fruits and vegetables targeting export market, commercial cultivation of floriculture under protected cultivation are some of the examples of this changing scenario. In order to realize higher economic returns, a shift towards cultivation of hybrids/improved varieties (increased input of fertilizer, irrigation and pesticides), off-season production characterize such farming. Perhaps the greatest threat to future vegetable production is from the newly emerging viruses and vectors. It is an extremely complex field necessitating a multidisciplinary approach. The emerging insect pest scenario under protected cultivation is challenging and requires a new dimension of IPM.

The role of trap crops to manage pests of vegetables and the possible influence of volatile chemicals in the attraction of pests and of other natural enemies was discussed by K. Srinivasan (Tractor and Farm Equipments, Chennai). He emphasized that IPM technologies with trap crops as an important component and their limitation, possible role of volatile chemicals in trap crops to attract pests and beneficial insects are important aspects. Scope for future research from the lead obtained from these researches was also indicated.

Speaking on the future inputs in pheromone-related insect behaviour, S. Narasimhan (SPIC Science Foundation, Chennai) indicated that the inputs in pheromone technology have undergone a change in view of the increasing failure of lures to catch insects. These can be classified as (a) bio-informatics and modelling involving development of prediction models based on the knowledge of the biology and ecology of insects which could be used for pest control, and (b) experimental study of insect behaviour requiring detailed study of the response of insects to chemicals (kairomones) using wind tunnel and electroantennogram techniques which could be used to control pests.

V. V. Ramamurthy (Indian Agricultural Research Institute, New Delhi) discussed the orientation to insect biosystematic studies and drew attention to increased revival of interest in systematics due to increasing demands in biodiversity, especially on its bioinformatics component. It will be of paramount importance in economically important insects relating to agricultural, forestry and health aspects of human life, to not only accumulate the taxonomic information of the above kind, but also develop efficient means of quick information retrieval. It is equally relevant that all the available information of significance for utilization, manipulation and management of insect biodiversity must be compiled, comprehended, classified, processed and made available in the form of bioinformatic tools. This will envisage integration of information technology in a large way, especially towards easy, quick and authentic field-level diagnostics of pests, parasites and predators and exploitation of the biological knowledge associated with them.

B. Subramaniam (Indian Agricultural Research Institute, New Delhi) indicated that natural products from a wide range of ecosystems have been studied to identify molecules of biological activity in the past fifty years. Though several hundreds of molecules are known, only a few reached the final stage of registration and field acceptance. This presentation also dealt with the newer insecticides and their efficacy, botanicals, bio-pesticides, feeding deterrents, pheromones and their potential in IPM, transgenic crops and recombinant baculoviruses as components of pest management.

R. J. Rabindra (Tamil Nadu Agricultural University, Coimbatore) suggested that in order to increase the uptake of microbial pesticides, future research should focus on genetic improvement of these microbials for increased virulence, field persistence, storage stability and amenability for mass production at reduced cost. Many earlier attempts at mass production have been at laboratory or pilot-scale levels. On long-term basis, sustained efforts should be focused on exploiting recombinant DNA technology in increasing the potency and insecticidal activity of microbial pathogens. While substantial developments have taken place in producing genetically superior strains of *Bt* at competitive cost by fermentation technology, no indigenous products have been developed. There is an urgent need to isolate genetically superior strains of *Bt* to target specific pest groups and develop indigenous fermentation technology for commercial scale production of baculoviral, fungal and entomopathogenic nematode pathogens.

D. Muraleedharan (University of Kerala, Trivandrum) speaking on the biotechnological approaches to allatomodulator neuropeptides indicated that during the last decade, a large body of information started accumulating for both the allatomodulatory neuropeptides – allatostatins (inhibitory) and allatotropins (stimulatory). Recent advances in peptide chemistry and biotechnology have suggested new ways of manipulating neuroendocrine system for insect control. Identification of these neuropeptides together with their cDNA opens up new avenues for the practical use of these neuropeptides to disturb JH biosynthesis. By combining recombinant DNA techniques with information about the amino acid sequence of these insect-specific microorganisms and of the genome of crop plants, disruption of the physiological endocrine balance in insects is possible.

Speaking on entomo-detritivores and litter decompositon in the tropics, Vikram Reddy (Kakatiya University, Warangal) stressed the fact that very few studies have been conducted in this area and that these detritivores play a pivotal role in transporting and inoculating saprophytic microorganisms and in stimulating their activity in the decay of litter.

R. V. Varma (Kerala Forest Research Institute, Peechi) discussing the future trends in forest-pest management, indicated that the prevention of forest insect-pest outbreaks requires an understanding of the causation of population increase, stable populations, populations showing regular cycles of abundance and populations which erupt occasionally and spread to large areas. Most herbivorous insects seen in forests belong to the first category. However, there are many examples such as the teak defoliator, *Hyblaea puera*, the mahogany shoot borer *Hypsipyla robusta*, the pentatomid bug, *Udonga montana* associated with gregarious flowering of bamboo, etc. wherein the outbreak occurs due to environmental favourability. Thus, an insight into the causation of insect outbreaks is essential to determine whether they can be prevented.

Navarajan Paul (Indian Agricultural Research Institute, New Delhi) indicated that a clear understanding of the favourable hydrocarbon profiles of popular crop

varieties of important crops in relation to the key natural enemies will help to enhance the naturally occurring entomophages by growing favourable cultivars. This will also help to support the natural enemy activity in augmentative releases. Semiochemicals could also be used to enhance the activity of natural enemies by direct application of synthetic kairomones or by using crude extracts from favourable host plants and host insects or their by-products. Searching ability of natural enemies could be enhanced by exposing them to kairomonal cues before releases. These semiochemicals could also be employed in mass production of natural enemies with factitious hosts, to enhance the level of parasitism by treating them with favourable kairomonal/synomonal extracts. Application of kairomonal/synomonal formulations in release areas could intensify the searching behaviour of the natural enemies and thereby enhance their potential as biocontrol agents.

B. Vasantharaj David (Sun Agro Biotech Research Centre, Chennai) discussed the present and future dimensions in the use of insecticides, outlined the important insecticides, acaricides and nematicides used in crop protection in India, the new molecules that have been registered in recent years, and molecules under development and their spectrum of activity. The combination products for control of pest complex of cotton, rice, etc. that have been introduced in the recent years and those under evaluation/development were elaborated. The status of fumigants in control of storage pests and the development of magnesium phosphide was also discussed.

Presiding over the plenary session, S. Chelliah (M.S. Swaminathan Research Foundation, Chennai), while extolling the diversity of areas covered in the meeting, emphasized the following: (a) in using combination pesticides in insect control, the long-term implications in development of cross-resistance by insects are to be taken care of; (b) as GM crops are likely to be made available for cultivation, IPM strategy on GM crop base is to be worked out soon to avoid loss of time; (c) in pursuing research on plant products as pesticides, commercial feasibility, stability and safety to non-target organisms are to be addressed; and (d) cropping systems suggested for pest management should have a broader perspective of increased income, ecological compatibility and easy marketability, besides imparting best suppression/repellence. The systems should be acceptable to agronomists and farmers at large.

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RESEARCH NEWS

Mantle convection results from plate tectonics – Fresh hypothesis reverses current views

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Plate tectonic theory, which has revolutionized earth science, grew around the original concept of continental drift proposed in 1912 by Alfred Wegner, and ideas of sea-floor spreading advanced by Arthur Holmes in 1928. Subsequent work by British, American, Canadian and French scientists led to a full-fledged plate tectonic theory in 1968. According to this theory, the outer layer of the earth is divided into small segments or plates, which move relative to each other. It is believed that their movements are brought about by convection currents in the 2900 km thick mantle lying below and driven by radiogenic heating, hot upwellings from deep mantle and cooling of earth. Over the years, geologists invoked plate tectonism to explain global tectonics, volcanism, mantle geochemistry and a host of other geological phenomena. But, some basic features of this theory have remained unresolved even today. For example, why did plate tectonics develop on our planet, while it is presently absent in other terrestrial planets? What forces are responsible for driving the plates? Is mantle a homogeneous mixture or a set of two or more separately convecting systems? Scientists' answers to these could not explain satisfactorily the conflicting geochemical and geophysical observations about mantle dynamics and chemistry though their efforts have enhanced our knowledge about the earth's mantle.

The simple plate tectonic model is based broadly on the analogy of a boiling fluid of uniform viscosity. The thermal convection currents generated in such a fluid are characterized by a symmetrical pattern of 'cells' with similar width and depth. This convection pattern is known as Rayleigh–Bènard model, so named after these two scientists who had conducted studies on such a medium (see Box 1). As in the case of a boiling fluid, convection cells ascending from the depths of mantle are supposed to be responsible for movements of the earth's plates, since the latter are literally floating on top of the fluid mantle or the asthenosphere. However, unlike symmetrical cells developed in a boiling fluid, the earth's plates are asymmetrical and unequal, the viscosity in the mantle is non-uniform, the chemical composition heterogeneous and some of the physicochemical characteristics of plate–mantle dynamics do not conform to Rayleigh–Bènard model. These factors led to the development of new ideas about the mechanism of convection in the earth's mantle.

Presently, two modes of mantle convection are competing for recognition. One of them, the 'layered-mantle convection mode', regards earth's mantle to be stratified into two or more convecting layers, while the second or the 'whole-