Annual Review of Entomology Vol. 50, 2005. May R. Berenbaum *et al.* (eds). Annual Reviews, 4139 El Camino Way, Palo Alto, CA 94306, USA. 2005. 631 pp. Price not mentioned.

Annual Reviews are of prime importance in bringing together the efforts of diverse groups of researchers working in allied areas, usually by pioneers in the respective field. This not only gives shape to the current understanding of concepts and paradigms and to predict the future directions, but also brings about the necessary focus on the shortcomings. On these lines, the *Annual Review Entomology* (*ARE*), celebrating its Golden Jubilee year, has brought out an assortment of 23 reviews covering topics like insect behaviour, systematics, biodiversity, physiology, chemical and biological control strategies for pests, integrated pest management, ecological roles of insects, silkworm genomics, insects as models to study immunity and ageing, etc.

In the review on insect pest management in North America, Coyle *et al.* address the issues concerning increasing demand for wood and wood products, and its impact on traditional forest production areas, leading to long-term economic and environmental concerns. To overcome this, intensively managed hardwood forest systems (IMHFS), grown using conventional agricultural as well as forestry methods, can help alleviate potential problems in natural forest production area. The substantial inherent challenges associated with pest management in the monoculture environments created by IMHFS are reviewed. The authors also suggest ways to design IMHFS that may reduce their susceptibility to pests, increase their growth and productivity potential, and create a more sustainable environment. They have also reviewed the major arthropod pests in the most important IMHFS and have provided current information on IPM strategies.

Wu and Guo describe pre- and post-*Bt* (*Bacillus thuringiensis*) scenario of pest management in China. Though the review concentrates on cotton boll-worm (*Heliothis armigera*), influence of *Bt*-cotton on other target and non-target insect populations and their management post-*Bt* cotton have also been brought out. Influence of different agro-ecological production regions on IPM, including regional differences in economic threshold (ET) have been highlighted. Post-*Bt*, since expression of ET in terms of egg density becomes inaccurate, as *Bt* is active against only larvae, China has fixed 13 larvae/plant as the new ET. India will benefit immensely in emulating China in carrying out studies on the above lines. The authors suggest the development of non-*Bt*, insect-resistant transgenics to decelerate resistance development. The authors conclude by hailing positive effects brought about by *Bt*-transgenic cotton in IPM of cotton.

Pates and Curtis have analysed the endophilic and exophilic behaviour of mosquitoes as a consequence of house-spraying. This behaviour has also been analysed in relation to time of biting, which is different for different malarial vectors. The authors have also suggested how these behavioural studies (like choice of oviposition site, larvivorous fishes and insects, etc.) can be used for mosquito control. They have explained the genetic control of mosquitoes by Sterile Insect Technique (SIT) or by generating transgenic mosquitoes harmless to humans. Success of these strategies will depend on the competitive mating behaviour, which in turn will depend on dispersal/migration and monogamous/polygamous behaviour of the female mosquito.

Abe *et al.* bring to light the importance and indispensability of the domesticated silkworm, *Bombyx mori*, as an insect model alongside *Drosophila*. A long history of domestication is definitely an advantage, as there are a large number of mutants and inbred lines available for extensive genetic analysis and gene discovery projects. Dense molecular linkage maps have enhanced attempts at positional cloning and marker-assisted selection. Also, physical maps are not far from realization with the available BAC sequences and whole genome shotgun sequences integrated onto the linkage maps. The biology of the unique female-heterogametic sex system and the sex chromosomes are rightly given a special focus in this review. The strongly or perhaps solely female-determining nature of the W-chromosome composed largely of nested full-length long-terminal repeat retrotransposons along with the Z-chromosome, which lacks dosage compensation, are interesting evolutionary milestones. Except for the downstream sex differentiation gene, *doublesex*, nothing is known about the sex-determination pathway. The other recent developments in silkworm research, generation of expressed sequence tags (ESTs), full-length cDNA libraries, which are important resources to discover Lepidoptera-specific genes, evidence for horizontal gene transfer, and availability of microarrays are discussed. The authors also observe that germline transformation and transient expression systems are well established and available for functional studies, high-level protein expression and gene silencing via RNA interference.

Gooding and Krafsur who are among the pioneers in the field of tsetse biology, take stock of the current knowledge in different areas and bring to light the need for supporting research on tsetse genetics to understand gene flow among natural populations, relative strengths of selection, drift and dispersal in establishing the gene frequency patterns observed among tsetse populations. Tsetse fly, a haematophagous dipteran is the vector of African trypanosomes, which cause trypanosomiasis, commonly referred to as sleeping sickness in humans and as nagana, a lethal wasting in cattle. The major epidemics of human and cattle trypanosomiasis causes enormous economic losses. The authors enlist low fecundity and long reproductive period, surprising chromosomal diversity among different groups, a high level of population structuring from different geographical areas as difficulties in doing tsetse genetics.

Floate *et al.* discuss the 'non-target' effects of residual parasiticides that remain in the faeces of animals treated with them. These faecal residues containing parasiticides are harmful to coprophilous insects, most of which are beneficial and help in the dung-decomposition processes. Different parasiticides affect differently based on their mode of application, route of excretion, persistence, etc. and determine the 'level of environmental safety' of these chemicals. The experience gained in the application of parasiticides has prompted The Veterinary International Cooperation on Harmonisation (VICH), to set up a two-phase assessment of parasiticides before marketing.

The 'mevalonate pathway', which Belle *et al.* describe, is unique in insects as the end-product is juvenile hormone (JH), and not cholesterol as in vertebrates. Importance of this pathway is highlighted by the fact that the JH regulates embryonic development, represses metamorphosis and induces vitellogenin synthesis and pheromone production in insects. Resear-

ches carried out in *Drosophila melanogaster*, *Anopheles gambiae* and *Bombyx mori* have led to the molecular characterization of the enzymes involved in the mevalonate pathway. Experimental data suggest that JH itself regulates the pathway. The authors postulate that the advent of advanced techniques like RNAi and microarrays will expedite the research to fill up the gaps in the regulation of the mevalonate pathway.

While all other articles have focused on arthropods, pests or parasites, Fountain and Hopkin have discussed a soil insect, *Folsomia candida*, which is also used as a pollution indicator. The other less studied but equally important use of this insect is its utility as a model for studying cold tolerance and prey quality. Thus this review dwells on the ecotoxicological importance of this insect.

Hassanali *et al.* have presented an overview on the role of chemical compounds on ecology and population dynamics of locusts. The sexual maturation in the solitarious desert locust coincides with the bud burst of certain desert shrubs (Bosewellia and Commiphora) just before onset of the rainy season, suggesting that solitary acridids may use changing physiology of food and nonfood plants as a source of dependable cues to synchronize their reproductive activities. Oviposition studies in locusts appear to have focused on the gregarious phase, which show communal egg-laying behaviour. Solitary females prefer to oviposit adjacent to the plants Heliotropium and bulrush millet, while gregarious females prefer moist sand without any plant. Adults emit pheromone, which is mainly composed of aliphatic aldehydes and alcohols and induces/enhances maturation in males. In gregarious-phase acridids the ketonic compounds emitted by females during oviposition act as gregarizing factor for developing embryos. They also point out a better understanding of reproductive diapause and its termination, mating, and oviposition pattern in solitaria in relation to weather and vegetation patterns, and provide the groundwork for developing population and gregarization models for predicting potential outbreaks.

O'Callaghan *et al.* review effects of insect-resistant GM plants on predators and parasites of target species, and on soil biota. It is concluded that any effects observed have been due to changed nutritional characteristics (C : N ratio, lignin content, carbohydrate content) of GM plants, rather than due to the transgene. The authors point out the absence of substantial data on long-term sub-lethal effects of GM plants. Studies reviewed show no effect on earthworms, isopods, microarthropods and soil nematodes (let alone other transgenes, even anti-nematode cystatin expressing transgenics had no effects). However, lack of studies on density and diversity of collembolans and soil protozoans, and soil processes is a major limitation as pointed out by the reviewers.

Bactrocera, recently evolved tropical polyphagous fruit flies, are pests on fruits, but their pest status is not clear, which is the subject matter of this review. Clarke *et al.* have discussed their taxonomic distribution, highlighting the importance of their phylogenetic status, which is an important parameter in evolutionary and ecological studies. Mating behaviours of these annutigenous fruit flies are unique in that they depend on plants for sugars and phylloplane bacteria and bird faeces for proteins. Phenylpropanoids, plant products, affect their mating behaviour which seems to be unique to this class of fruit flies.

Ecological and spatiotemporal behaviours of animals are affected by aggregation, which is controlled by visual, auditory or chemical communication. There are enough resources on mechanistic and cost-benefit ratio of aggregation pheromones, but their evolutionary and ecological aspects have remained untouched. This aspect has been highlighted in the review by Wertheim *et al.* The authors have explained how these pheromones affect ecological interactions. They have succeeded in their efforts to hammer the ecological aspects of these hormones, which can be exploited for novel strategies for biological control of insects.

Egg-dumping, in the avian literature, refers to the behaviour of females that regularly or occasionally parasitize the maternal behaviour of other females by laying eggs in their nests. For centuries, egg-dumping was considered a behaviour peculiar to birds, even when it was reported for other vertebrates such as salamanders and fish. This reveals remarkable parallels between the behaviours of insects and birds facing similar parental constraints. Tallamy enumerates the adaptative benefits associated with placing eggs in other nests and argues that this behaviour in insects is hardly a mistake or last-ditch effort to release eggs. He discusses the known cases of insect egg-dumping and the hypotheses that have been advanced to explain the evolution of egg-dumping. He also proposes that, despite similarities in the ultimate motivation of egg-dumpers, it is fundamental differences in the reproductive physiology and behaviour of egg recipients that control the ecological and evolutionary consequences of receiving conspecific eggs and thus the evolution of parasitic, mutualistic, or kin-selected egg-dumping. He has analysed physiological regulation of oogenesis, kin selection, parental risks, fecundity, iteroparity and rapid indeterminate egg production, access to host, eggs clutch size, larval dependency and predation, as factors to test this hypothesis.

Insects have evolved a mechanism to use hydrocarbons as guard against desiccation, barrier to microbes apart from other ecological, physiological and behavioural traits. Howard and Blomquist have indicated that future studies will dwell on the role of chirality in hydrocarbon biochemistry and physiology. Many of the ecological and behavioural aspects like recognition of gender, nest mate and cues for mates and fertility are possibly decided by these hydrocarbons.

The chapter starts with A. M. Stuarts' famous statement, 'It is in sexual behaviour that all animals can be considered social'. This sets the right tone for the readers and the rest of the chapter keeps the reader engrossed. The key question asked is whether it is the male or female that determines the identity of successful mates. The answer is not simple and Boomsma *et al.* have provided enough conceptual matter that allows the reader to understand which/how male and female components of sexual selection operate in the social context. In largely monogamous animal groups like wasps and ants, sexual selection does not occur beyond premating partner choice and hence it is considered weak. But the sexually selected traits in these insects helped to understand the mode of sexual selection in polygamous insects, where sexual selection is relatively complex. The review also highlights the role of partner commitment, longevity, prolonged sperm survival, habitat selection, aggressive behaviours like lethal fighting and number of matings per male as sexually selected premating male traits. Male traits which are vital for post-mating sexual selection are sperm length, sperm number, sperm competition and cryptic female choice. Authors have given more impor-

tance to cryptic female choice over sexual conflicts. One important point raised in the review, which has been constantly overlooked, is the role of male genetalia in sexual selection in monogamous insects.

Senescence is a nearly universal feature of multicellualr organisms. It is defined as a decline in performance and fitness with advancing age. But why it occurs is a long-standing unsolved question in biology. Hughes and Reynolds have presented with elegance both evolutionary and mechanistic models of aging. They have described evolutionary theory in the light of mutation accumulation, antagonistic pleiotropy and disposable soma versions of the evolutionary model. The mechanistic theory has been explained according to the models of oxidative stress response, cellular signalling and dietary inhibition mechanisms. They have explained that the mechanistic model has led to identification of genes with large phenotypic effects and natural selection might have removed variation in such genes (both inter- and intra-species). But this approach does not answer two related questions: (i) which of the mechanisms that can increase lifespan have been exploited by evolution to create naturally long-lived forms and (ii) which genes and pathways are responsible for the lifespan variation existing in the population? These questions are addressed by the evolutionary model which harps on finding aging genes based on markers segregating with lifespan phenotypes.

Out of hundreds of chemicals, which control insect behaviour, two of them octopamine (OA) and tyramine (TA) stand out as major players. They are vertebrate equivalents of adrenergic transmitter and act through G Protein Coupled Receptors (GPCRs). OA acts as a modulator of peripheral and sense organs, thus controlling the response to external stimuli. These two also offer suitable targets for insecticides for which extensive studies will be required. Roeder suggests that this will give an insight into behaviour, learning, memory, regulation of immune response, etc.

Norris and Kogan review ecology of interactions between weeds and arthropods in intensely managed ecosystems. Noticeable impacts of weeds are on trophic relationships, altered habitat conditions and chemical ecology. In turn, arthropods play a role by direct herbivory on weeds or altering competitive interactions. Reviewers highlight various interactions – weeds as an alternate host to pest (direct herbivory on weed protects crops), weed as an alternate host to prey (provides food to parasitoids), weeds as alternate host to arthropod as well as pathogen (intense disease spread), weeds as an alternate host to arthropod (increased pest population) and weed as oviposition sites (for both pest and parasite). In conclusion, owing to multiplicity of interactions between weeds and arthropods, a comprehensive analysis of multi-pest impacts of weed-based enhanced biodiversity is required before weed-based IPM could be adopted by the growers.

This review by Gage and Kosay finds a place in this book owing to the important role played by the insect vectors – fleas, in the spread of disease. The causative agent of plague is a Gram-negative bacterium, *Yersinia pestis*. It exists in natural rodent hosts and is transmitted by fleas (insect vectors). Authors have elegantly compiled recent research on plague, highlighting the role of different factors like virulence of *Y. pestis* strains, host resistance, genetic make-up, populations, etc. in understanding the epidemiology of the disease. However, the authors also point out some drawbacks like some contradictory results and interpretations. They recommend multidisciplinary research leading to good management of plague.

The insect immune system, although primitive in nature, is quite complex in the sense that the immune strategy is bound by constraints and trade-offs between fitness-relevant traits like survival and reproduction. Though the study of such trade-offs is not possible by ignoring the ecology of an organism, the dynamics of population and genes or the processes of co-evolution with parasites, all of which affect the costs and benefits of a given immune response in the organism's environment. Schmid-Hempel has highlighted molecular evidences that suggest a similar immune response pathway between vertebrates and invertebrates. The same insight is now also being gained from functional analysis using the concepts and tools of evolutionary ecology. The growing molecular data will allow ecologists and evolutionary biologists to test the hypotheses and mathematical models by comparing details of immune defences in different species. Similarly, developing molecular markers for each such gene will allow researchers to trace the fate of genetic lines that differ in their immune responses in the wild. The author also foresees molecular biology and evolutionary ecology becoming sisters that will open unprecedented possibilities to see evolution in progress. This is truly an exciting time to study insect immunity.

The Hymenoptera, the most diverse ordinal-level group of organisms, is partitioned among three major groups: the aculeate wasps (including the stinging wasps, ants and bees), the sawflies (mostly phytophagous as larvae) and a number of groups collectively referred to as the parasitic Hymenoptera. Among the parasitic wasps, the Platygastroidea superfamily, which represents some 4460 described species worldwide, is found virtually in all habitats except for the polar regions and is particularly diverse and abundant in the wet forests of the tropics and subtropics. They parasitize a diverse array of insects as well as spiders. The review by Austin *et al.* focuses on the current phylogenetic status of the monophyletic superfamily called the Platygastroidea. The focus is mainly on their phylogeny, classification and taxonomy and related areas, namely species diversity, ovipositional behaviour, host relationships and their potential as model systems. Study of the biology of the Platygastroidea superfamily is timely, given its use as natural enemies to pest species, and also because of its importance as model systems in entomological ecology research. The review also includes kairomone research and studies on sex-ratio allocation, patch defence behaviour, competition and more theoretical aspects of biological control.

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Himalayan Orogen–Foreland Interaction. A. R. Bhattacharya and K. K. Agarwal (eds). Special Publication No. 2, The Palaeontological Society of India, Department of Geology, University of Lucknow, 2005, 302 pp. Price: Rs 750.

This edited volume is an outcome of a conference on the same theme held in Lucknow during 29–30 January 2003. It is sometimes difficult to review such a