Annual Review of Entomology, Vol. 51, M. R. Berenbaum, R. T. Cardé and G. E. Robinson (eds), Annual Reviews, 4139, El Camino Way, Palo Alto, California 94306, USA. 2006. 739 pp. Price: US $80.

Reading a 700-page book from cover to cover may be considered an onerous task, and it certainly could be. However, a superabundance of riches in this book, made me dip in again and again, without regret, each time emerging refreshed. I quote from Felix Sperling (Member of the *Annual Review* Editorial Committee) in his preface: 'I'd also like to address an awkward issue that applies to all publications, but especially to reviews like *ARE* [*Annual Review of Entomology*]. It is the tension between taking the time to try to do something that will stand the test of time and the relentless pressure on most of us to produce ever more – but not necessarily better – publications … . So why strive to produce a polished, elegant, insightful review, as our authors clearly do? The answer is that the *Annual Review of Entomology* is not Google … I love such search engines for their breathtaking speed, their serendipitous results, and their unquestionable effectiveness in finding factoids. But they just do not produce reliable roadmaps for efficiently traversing complex conceptual topography. Nor do they filter junk from jewels.' Well said. There are too many jewels in this book to place all on display but I will review a few favourites and leave the interested reader to browse through the rest.

Biology is becoming increasingly interdisciplinary in nature. An integrated science of entomology should also reflect this trend, which is precisely what most of the articles in this volume achieve. Potential editorial conflicts as to whether certain articles belong in an *Annual Review of Ecology, Evolution and Systematics*, or in one of *Genetics* or even in one of *Phytopathology*, are apparent. This is good for the science, because it encourages crosstalk between the practitioners of various disciplines, and creates a common meeting ground.

An *Annual Review* is naturally influenced by topicality, and what could be more topical than globalization? Invasive species are of particular concern today because of globalization. Thrips are especially problematical because they are small, laying tiny eggs within plant tissues that would not be detected by standard phytosanitary screening procedures. Some statistics from the review on the impact and prevalence of thrips are worth mentioning here (Morse and Hoddle: Invasion biology of thrips). Twenty per cent of cuttings and 12% of plants imported into Switzerland were infested with thrips. International trade in flowers such as orchids and gladioli bulbs is a major source of thrips invasions. Thirty-four per cent of unpowdered, dried, food herb samples (e.g. sage, thyme) taken from 56 locations around the US contained thrips. Fragments of thrips were, however, difficult to identify in powdered samples of these same herbs, calling into question the 'vegetarian' nature of powdered herbs. Thrips have resulted in worldwide crop failures (up to 13% loss of Swedish rye and 100% of tea in Kenya). Food historians even believe that the Romans may have been responsible for the movement of *Thrips tabaci* within onion and garlic supplies for their legions (an ancient example of globalization). The fact that many thrip species are parthenogenetic also contributes to their invasive properties; furthermore, the rapidity of modes of travel, e.g. airplane flight, enables even normally short-lived species (and especially short-lived males of these species) to survive and establish in areas that are at considerable distances from their original homes. A most pertinent point made in this paper is how sociology and current political affairs could influence or create an arena in which thrips can continue to invade without check. In the author's opinion, the current focus of the US on homeland security as compared to other types of security has resulted in a shift in emphasis from traditional types of screening procedures that would have detected a greater proportion of thrips-contaminated consignments. There is now serious discussion on the use of imaging techniques and also methods such as infra-red spectroscopy to detect thrips in processed as well as unprocessed biological material entering countries. The review bemoans the fact that with the decline of systematists worldwide, the problem of identifying local versus exotic thrips species will increase, and this could have serious consequences for understanding and managing thrips outbreaks. Another related review in this volume is on current approaches to phytosanitation (Follett and Neven: Current trends in quarantine entomology). Such a review is timely considering that, for example, the annual loss due to exotic insects and mites in the US is ≥ $ 17 billion. Continuing in this vein of insect pest management is the extremely lucid review on trap-cropping (Shelton and Badenes-Perez: Concepts and applications of trap-cropping in pest management). Trap cropping is the cultivation of plants to trap insect pests and divert them from adjacent target crops owing to the greater preference in insect pests for such plants. An extremely important point being made in this piece is that although this pest-management practice is ecologically sound and also 'green', it demands much greater specific knowledge of individual pest species ecology, as opposed to the generic knowledge required for pesticide development. Trap-cropping is apparently being used effectively via the planting of alfalfa as a trap crop to protect adjacent cotton in the US, or also in India by the plantation of castor, millet and soybean to protect groundnut crops from leafminers. The authors quite rightly discuss the future of trap-cropping, and whether it will ever be adopted as a general pest management tool, especially since it requires the setting aside of arable land for the plantation of trap crops, which may not be economically viable in countries where individual land holdings are small. Trap-cropping also requires cooperation and coordination between adjacent farmers because of potential interactions between plants that can serve either as sources or sinks of pests.

Furthermore, with a touch of realism, if not cynicism, the authors state that although trap-cropping may be ecologically viable, it will not receive funding for research because its development does not entail a 'product' that can be marketed, such as *Bt*-cotton. The review on natural insecticides (Isman: Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world) revisits the same theme of globalization, economics and the future of non-synthetic chemical formulations, e.g. pyrethrum, neem and essential oils. The review concludes with the opinion that while the role of such natural insecticides may be commercially viable only for the production of 'organic food' in industrialized countries, they could play a much larger role in developing countries and research on such botanicals should therefore not be neglected. Considering the amount of research that has been conducted on defeating agricultural pests, one wonders where this will end; or, as Peter Kareiva

declared[1], will we have to acknowledge that victory in some co-evolutionary arms races may not be possible, and that substantial losses of crops may simply be unavoidable?

It is indisputable that economic interest has driven fascinating research in insect ecology as the review on aphid ecology amply demonstrates (Powell, Tosh, and Hardie: Host plant selection by aphids: behavioral, evolutionary, and applied perspectives). This is applied entomology at its best and I recommend this particular review as an example of how applied research could be simultaneously challenging and fascinating. Aphids constitute a plant grower's worst nightmare, especially since they have both dispersive winged and sedentary non-winged forms, and they also go through parthenogenetic reproductive cycles when they could produce numerous offspring without sexual reproduction. Furthermore, the winged females could begin the process of parturition to produce offspring as soon as they insert their needle-shaped mouthparts into a suitable host-plant. But how does an aphid make this decision about host-plant suitability? The review is focused on the step-wise process of host-plant selection by aphids. In a sense, this article celebrates the work of Freddy Tjallingii who developed the EPG (Electrical Penetration Graph) technique at Wageningen University, because without this technique, aphid feeding ecology would not have advanced. Aphids are phloem-feeders, and using piercing mouthparts called stylets, they penetrate plant tissue to reach the phloem sieve tubes. However, on the way into their phloem, they have to prevent the wounding response of plants and the consequent accumulation of coagulating plant proteins that would block the stylar conduit, preventing the suction of phloem contents. Using the stylar conduit, aphids can suck out phloem contents for hours on end. They keep the conduit open by secreting a watery saliva into it, whose effect is to prevent the effectiveness of the plant wounding response[2]. The EPG technique uses a DC-based recording system which measures voltage changes as the stylet penetrates through various types of cells with different membrane properties and ion concentrations. With this technique, it is now known that aphids can decide upon the suitability of a plant within a few seconds of probing with the stylet, and that the decision about plant unsuitability leading to stylar withdrawal could even be made after probing just xylem or other peripheral tissues without reaching the phloem. Such work on the aphid system is a true demonstration of fabulous science made possible by the development of technology.

The test of a good review is that it should not only provide updated information on the field but that it should stimulate the reader to new ideas and new ways of approaching problems. From this perspective, the review by van Veen, Morris and Godfray (Apparent competition, quantitative food webs, and the structure of phytophagous insect communities) makes the grade because it captures the complexity of insect community ecology while also bringing newer concepts onto centre stage. These concepts include apparent competition, apparent mutualism and trait-mediated interactions, in contrast to competition and mutualism viewed in the traditional sense. This review focuses on the fact that different prey species could share natural enemies and thus coupled predator–prey dynamics could create indirect negative (apparent competition) or positive (apparent mutualism) effects between prey species. Trait-mediated interactions focus on those that arise from phenotypic plasticity, wherein a prey species may exhibit different behavioural, morphological or physiological traits in the presence of the predator compared to when the predator is absent. The presence of such inducible traits (which may reduce prey capture by functioning in defence) in only one prey species in the case of sympatric prey species that share predators, may thus influence the interactions between species in the community. The authors call for a move from describing insect community patterns towards understanding the processes that structure these communities, and urge greater quantification, keeping these newer processes in mind. They also suggest selection of model systems that are large enough to be interesting but small enough to be tractable to experimentation. I recommend this particular review to young graduate students who are looking for ideas for their research careers. A coupled review in this compendium is the one on insect developmental biology (Pennacchio and Strand: Evolution of developmental strategies in parasitic Hymenoptera). This review should be read together with the one previously described, since it provides a comprehensive treatment of parasitoid life history strategies which would need to be taken together with prey dynamics in order to understand insect community structure. Parasitoids could attack eggs, larvae, pupae or adults of an insect host–prey species. They could be idiobionts: those that arrest the development of their hosts, or koinobionts: those in which the hosts continue to develop alongside the developing parasitoid embryo. They could also be ectoparasitic or endoparasitic, and thus exemplify a huge diversity of developmental options. Furthermore, successful parasitism, especially in the case of internally developing parasitoids, involves host immunosupression, and regulation of host development particularly in the case of koinobionts. The review, therefore, also discusses the evolution and phylogeny of parasitoid virulence genes; some immunosupression and avoidance of host defence systems is actually achieved via the presence of symbiotic polydnaviruses (e.g. bracoviruses in the cases of braconid parasitoids, and ichnoviruses in the case of ichneumonids). The importance of such viral genes in parasitoid virulence has therefore led to some viral genomes being completely sequenced[3] and the authors call for more work on genomics and gene expression in this extremely interesting group of insects.

Boaz Yuval has done a splendid job of reviewing mating systems in blood-feeding flies. There has always been interest in this group and funding has also not been a constraint for research on these flies because they constitute some of the worst pest and disease-carrying scourges of humans and domesticated animals. Black flies, biting midges, mosquitoes, phlebotomine sandflies, tabanid horse flies, muscid stable flies and tsetse flies are some members of this gallery of rogues. This review traces the evolutionary history of mating systems in this group. The ancestral mating system apparently constituted an aerial mating swarm, in which species recognition was by auditory means using wing beat frequency. In such a system, females had no opportunity for direct pre-copulatory mate choice, owing to rapid copulation resulting from high swarm densities. However, later evolved species exhibit transitions from this type of system to those which rely more on visual and chemical cues for species recognition, and in which mating could be substrate-based (i.e. on particular plants) or occur in certain physical locations where males may either hold

territories or display in leks. The review outlines fascinating evolutionary scenarios for the role of male accessory gland secretions (MAGS) that are transferred to the female during mating. According to the author, MAGS may have been originally intended as nuptial gifts to influence female mate choice, and might, for example, have been important in early culicine mosquitoes, in which monogamy was the norm, and in which egg production was still autogenic (i.e. without a blood meal). In such species, MAGS would have been important. However, as sugar feeding and subsequently blood feeding also evolved, females were less dependent on MAGS for egg development. According to the author, this feeding transition was accompanied by the development of polyandry and the presence of multiple spermathecae in the female to store sperm from multiple matings. At this point MAGS did not serve any nutritional function to influence female choice; males now used MAGS as a means to curtail multiple matings by females by inhibiting female receptivity after the first mating. This is certainly an exciting and plausible hypothesis and it would be interesting to see how this reasoning holds up to further scrutiny and evidence.

The evolution of social systems has always been an appealing topic probably because humans are also social animals. A review of conflict resolution in societies should, therefore, be even more appealing, and this comprehensive review of conflict resolution by Ratnieks, Foster and Wenseleers (Conflict resolution in insect societies) is timely as well as highly informative and well structured. In brief, the review centres around the fact that in haplodiploid hymenopteran societies, workers are related by 0.75 to their full sisters and by 0.25 to their brothers. Therefore, from the workers' perspective, the colony sex ratio should be 3 : 1 in favour of females. Natural selection should, however, favour any behaviour of queens which would counter this worker bias of colony sex ratio, since the colony ratio from the queen's perspective should be closer to 1 : 1 as a queen is related equally to her sons and daughters (relatedness factor of 0.5). However, since males do not usually perform colony-related tasks, factors that involve colony functioning could also influence colony sex ratio. The review divides colony conflict resolution into conflicts over sex allocation, queen rearing, male rearing, caste fate determination and also conflicts between totipotent females. An example should illustrate the types of conflicts outlined in this review. In honeybees, it has been found that although 7% of male eggs in a colony are laid by workers, only 0.1% of adult males in the colony is a worker's son. The phenomenon of worker policing, wherein workers destroy eggs laid by other workers, takes care of this conflict. However, in a comparative analysis of several Hymenoptera, the proportion of males in a colony that as a worker's son was 12% on average, with values ranging from 0 to as high as 85% or even more in some cases. Therefore conflict resolution varies widely in efficiency. The review discusses possible reasons for this variation within the framework of inclusive fitness theory.

Reading this collection of reviews gave me many new ideas, and left me intellectually energized. Several other topics feature here, e.g. cannibalism in spider populations (David Wise), a review which spans all the various hypotheses erected to explain this intriguing phenomenon; I also wonder whether the fact that extra-oral digestion occurs in spiders could contribute to the need in many spiders for high levels of certain amino acids (those occurring in the large quantities of enzymes secreted extra-orally), and whether this special need could contribute to the much higher nitrogen contents found in spiders compared to other arthropod predators and also to cannibalism. Predatory spiders are known to be able to regulate their diets to obtain appropriate mixes of essential amino acids[4]. It is possible that requirements for certain essential amino acids could be most easily met by cannibalism, and perhaps the link between extra-oral digestion and cannibalism should be explored further.

Overviews of the relationship between entomopathogenic fungi and their hosts, plant-mediated interactions between pathogenic microorganisms and arthropod herbivores, Dopa decarboxylase in insects, as well as of insect odour and taste receptors, are examples of other topics of broader general interest in this collection. Those on the Tachinidae, Latin American biogeography, or tallgrass prairie arthropods, may have a narrower audience. Yet, most articles are stimulating and enjoyable, all of which gives credence to Sperling's introductory remarks on the future of the *Annual Review* tradition. Sperling need not worry; there is absolutely no doubt about the outcome of a contest between this compendium of review articles and Google. Google would lose every time.

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3. Webb, B. A. and Strand, M. R., *Comprehensive Molecular Insect Science* (eds Gilbert, L. I. *et al.*), Elsevier, San Diego, 2005, pp. 323–360.
4. Greenstone, M. H., *Nature*, 1979, **282**, 501–503.

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Great Tsunami. Memoir 64, Geological Society of India, P.B. No. 1922 Gavipuram, Bangalore 560 019. 2005. 142 pp. Price: Rs 750.

This publication on the great tsunami of 26 December 2004 by the Geological Society of India in 2005 has been a timely one. The report was published in less than twelve months of the event and with more than twenty-one contributing organizations and other individuals pitching into this effort, this is no mean feat.

For once, a comprehensive publication has been produced in the country through an initiative of the Department of Science and Technology, New Delhi, which collates the surveys and studies of numerous scientific departments, institutes and individuals across India on a single event, the 26 December 2004 Sumatra earthquake and the consequential tsunami. This is a laudable effort and bodes well for the future of scientific collaborative studies in the country. The preface mentions that the 'detailed information available in this book shall be of immense help to researchers, planners and all concerned with the earthquake and tsunami risk and mitigation in India and elsewhere in the world'. One may thus infer that the report, while scientific in nature, is meant to be accessible to stakeholders and the general public. This perhaps may account for the slim and smart layout of the report.