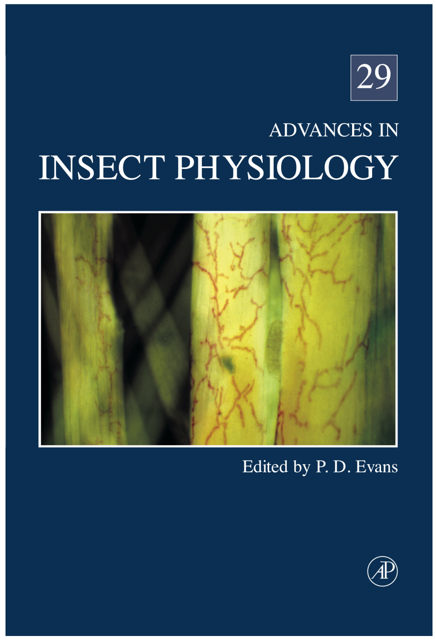
Book Review

SO MANY INSECTS, SO MANY SIGNALS



Advances in Insect Physiology, Volume 29

Edited by P. D. Evans

London: Academic Press (2002)
428p. ISBN 012024229X
£89.95 hardback.

Reviews published in *Advances in Insect Physiology* are typically comprehensive treatments of an area by renowned experts in the field, and volume 29 is no exception! Hallmarked by their longevity as references, many reviews written 1–3 decades ago are still frequently cited in peer-reviewed literature and textbooks, and the new edition seems set to go the same way. The collection of reviews in volume 29 deals with aspects of signaling in insects, either by second messengers, sound, neurotransmitters or hormones. As each article is in keeping with the 'Advances' tradition, the authors are to be congratulated on producing readable and insightful treatments of their topics.

The opening chapter, written by David Morton and Martin Hudson, focuses on cyclic guanosine monophosphate (cGMP) regulation and function in insects. They describe the roles of this intracellular signalling molecule in multiple functions, including ecdysis, sensory physiology, neuronal development, food-search behaviour and Malpighian tubule ion transport. The authors point out that cyclic GMP-dependent protein kinase and nitric oxide-insensitive soluble guanylate cyclases were first demonstrated as signalling molecules using invertebrate tissues (from lobsters and tobacco hornworms, respectively) and that insects continue to be valuable models for analysis of cyclic GMP regulation. The chapter includes detailed discussions of the variety of receptor and soluble guanylyl cyclases, cyclic GMP-dependent phosphodiesterases, cyclic GMP protein kinases, and cyclic GMP-gated ion channels. The authors have done a good job in comparing the major functions of cyclic GMP in tissues of vertebrates versus invertebrates. Overall, the chapter provides a welcome review of this rapidly changing area of cell signalling.

Neurotransmitter transporters are also important in signalling physiology, as they terminate the chemical signals carried by neurotransmitters within the nervous system. In their review of insect neurotransmitter transporters, Stanley Caveney and Cameron Donly dedicate major sections to describing transporters for glutamate and other excitatory amino acids, Na^+/Cl^--dependent transporters for γ-amino butyric acid, monoamines (serotonin, dopamine, octopamine) and choline, as well as Na^+-dependent histamine transporters. Their hierarchical and comparative approach for each neurotransmitter permits comparisons of structure, function and regulation for the various transporters across species.

In a section on applications of insect neurophysiological studies to pest control, Caveney and Donly remind us that screening and identification of insecticides has usually followed a 'shot-gun/fishing-expedition approach'. The fortuitous discovery of natural pesticides such as avermectin or synthetic organics lead to revealing studies of how the insect central nervous system (CNS) works, rather than *vice versa*. Robot-based high-throughput screening approaches now promise to reveal blockers of new molecular targets in the insect CNS. About 90% of the current market for insect control measures is in 'hard' commercial insecticides that act on the CNS or muscle. The number of targets, including the voltage-dependent sodium channel, acetyl cholinesterase and octopamine receptors, is quite small, with the not surprising result that there is now widespread resistance to organophosphate and carbamate insecticides. The authors suggest that neurotransmitter transporters may in the future prove to be practical, rather than hypothetical, targets for new insecticides.

In the review of sound signalling in Orthoptera, by David Robinson and Marion Hall, they note that ears and organs of sound production have arisen multiple times during the evolution of crickets and grasshoppers. Orthoptera are therefore a rich group for studies of sound signalling diversity. Divergence of sound signalling among orthoptera is such that it may play an important role in speciation, and Robinson and Hall describe many adapations that have allowed insects to take advantage of sound for signalling, despite their lack of stature. For example, the small size of insects leads to problems as small animals are less efficient radiators of low-frequency sound. So orthopterans are faced with a trade-off between low-frequency sounds, which travel further, and high frequency sounds, which are produced more efficiently. Moreover, where an animal is shorter than the wavelength of an incoming sound, the sound pressure difference across the tympana is too small to permit directional hearing. Yet sound arrives at both external and internal surfaces of the ear at different times, producing differences between the two ears that are sufficient to be interpreted by the nervous system and provide directional information about the source.

Robinson and Hall discuss how an orthopteran trying to obtain a mate using acoustic signals must provide information about its species, location and suitability as a mate. Many species use modulation of amplitude and/or, frequency as well as changes in temporal patterning (pulse length, interpulse interval, bout length of pulse series) to provide the listener with important information. Sound signals may also be modulated so as to minimize eavesdropping by predators, parasitoids or conspecific competitors. The chapter summarizes recent advances in auditory neurobiology and in recording and analysis of sound signals. It also provides some fascinating insights into the evolution of predator avoidance mechanisms in orthopterans. For the most part, however, we know very little about sites and basis for decision making following sound reception, and the authors point out that investigation of the brain may be the most important area of research in sound signalling in the future.

A highly efficient excretory system has been of cardinal importance to the phenomenal success of insects in colonising the terrestrial environment, so it should come as no suprise that sophisticated hormonal signalling systems are involved in the control of excretion. The concluding review, by Geoffrey Coast, Ian Orchard, John Phillips and David Schooley, begins with a discussion of the physiology of insect excretion and the functions of diuretic and antidiuretic hormones. Useful summary diagrams on ion transport and signalling pathways in the Malpighian tubules and hindgut broaden the review's appeal to vertebrate renal and comparative physiologists. Subsequent sections describe the isolation and structural characterisation of the active hormones, their cellular actions and their distribution in the neuroendocrine system. Some of the peptides described have been studied with a view to their potential role as safe and specific insecticides. Somewhat unexpectedly, mortality from such compounds may result less from impairment of osmoregulation and more from effects on feeding behaviour, sensory phenomena and gut motility. This chapter, as with those on cyclic GMP regulation and neurotransmitter transporters, also documents how useful the *Drosophila* genome has become to insect physiologists.

Reviews published in *Advances in Insect Physiology* in decades past still form useful introductions to sub-disciplines in insect physiology, prior to the explosive growth in information through recent advances in molecular biology, genetics, electronics and analytical chemistry. The four chapters in this volume provide us with brief overviews of the early literature and critical analyses of cutting-edge research in four important areas of insect physiology. The volume will be of most use to researchers with interests in insect and/or comparative physiology, but all chapters are understandable by upper-level biology undergraduates as well. I predict a long run of favourable citations for all four chapters.

10.1242/jeb.00665

Michael O'Donnell
Department of Biology,
McMaster University,
Hamilton,
Ontario,
Canada L8S 4B7
e-mail: odonnell@mcmaster.ca