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Low temperature biology of insects

Edited by David L. Denlinger & Richard E. Lee Jr.
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There have been several predecessors to this book including *Insects at Low Temperatures* (R.E. Lee Jr & D.L. Denlinger 1991) and works by Davenport (1992), Leather *et al*. (1993) and Sømme (1995). All have brought together information on the affects of environmental temperature on the ecology, physiology and biochemistry of animals with a particular bias towards insects. As the authors state in the preface to their present volume "It is the goal of this book to outline the mechanisms used by insects to survive and respond to low temperature, then to reflect upon how these adaptations are expressed in a broader ecological and evolutionary context, particularly with respect to global climate change, and finally to examine practical applications that can be derived from low-temperature studies of insects."

The 14 chapters (from 29 contributors) are grouped into three parts: physiological and molecular responses, ecological and evolutionary responses, and practical applications. Physiological and molecular responses (Part I) contribute the largest part of the volume beginning with a informative primer on insect cold tolerance for those new to the field (Lee), followed by authoritative reviews of rapid cold-hardening (Lee & Denlinger) and antifreeze and ice-nucleator proteins (Duman *et al*.). It is clear that understanding the mechanism promoting rapid cold-hardening in insects and knowledge of the structure of nucleators are fundamental to their use in pest control and other applications. The chapter on -omics (genomics, proteomics and metabolomics) (Michaud & Denlinger) highlights the need to identify the main molecular players in low temperature insect biology as currently results mainly fulfil a hypothesis-generating role in the field. The last three chapters in the first part of the book are on cell structure (Koštál), oxygen (Storey & Storey) and desiccation interactions (Holmstrup *et al*.), and are comprehensive reviews of these important areas.

Part II on the ecological and evolutionary responses contains a mixed bag of chapters ranging from the macrophysiology of insect cold-hardiness (Chown & Sinclair), through the evolutionary physiology of cold adaptation (Huey) and climate change effects (Bradshaw & Holzapfel) to evolution of cold tolerance (Overgaard *et al*.) and life-history adaptations (Convey). I have had misgivings about the use of the macro approach in insect cold tolerance, but this chapter by Chown & Sinclair goes some way to dispelling them. It is essential, if we are to understand how insects respond to environmental changes, that their physiological responses are investigated at multiple spatial and temporal scales - an approach which has been somewhat neglected hitherto by ecophysiologists. The next chapter (Huey) adopts a refreshingly global approach to the physiology of insect cold adaptation and is a good example of how the macro approach can help, whilst Bradshaw & Holzapfel examine the consequences of climate change on temperate zone species. Genetic variability is discussed in relation to the evolution of insect cold-tolerance and the paucity of research in this area by Overgaard *et al*. The final chapter (Convey) in Part II explores the life history features of terrestrial invertebrates living in cold regions in terms of strategies and concludes that flexibility is the most dominant feature, which underpins their success in low temperature habitats.

Part III, practical applications, contains only two chapters. The first outlines a template for insect cryopreservation (Leopold & Rinehart), whilst Bale reviews the implications of cold tolerance for pest management. Both are excellent attempts in pointing the way forward into areas which insect ecophysiologists have rarely explored and which, in the long-term I feel sure, will provide results to benefit human kind and the planet on which we live. However, the paucity of activity on the practical applications of insect low temperature biology is disappointing. I would have expected much more progress in this area since the 1991 volume. An important way forward is to use genomic tools to probe cryoprotection and the nature of cold injury, helping us to answer some of the fundamental questions on the evolution of freezing tolerance and freezing susceptibility, the interrelationship between insect cold tolerance, desiccation and anoxia, and the limits of chilling and freezing tolerance. With an increased understanding of the underlying physiology of low temperature tolerance from a large diversity of species, it should be possible to extrapolate its significance through population dynamics to global changes in climate. However, a more robust understanding requires continued and extended integration of research at the ecological, organismal and molecular levels. This volume forms a sound basis for future development in the field of low temperature biology of insects.

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