Insects at Low Temperature

Richard E. Lee, Jr., and David L. Denlinger
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THIS BOOK DESCRIBES the current state of knowledge, and suggests areas for future studies, in the rapidly growing field of insect adaptations to low temperature. This monograph pulls together many facets of low-temperature research that are not readily accessible to those with an interest in the topic. Although entomologists know the importance of low-temperature adaptations in the evolutionary success of insects, they have not had a good single reference available on the subject. The publication of this volume rectifies this shortcoming.

The timing of this monograph is right because rapid advances are being made in identifying mechanisms of freezing tolerance; characterizing multicryoprotectant systems, nucleating agents, and thermal hysteresis proteins; and investigating mechanisms of rapid cold hardening and vitrification. Insect cold-hardening studies have expanded rapidly in the last two decades and considerable comparative information has become available. The taxonomic index of more than 300 species of arthropods amply demonstrates this point.

The genesis of the monograph was an Entomological Society of America symposium on insect cold-hardiness and cryopreservation held in Louisville, Kentucky in 1988 and four international symposia on cryobiology held from 1982 to 1990. This volume contains the contributions of thirty-nine leading investigators in insect cryobiology and related topics from six countries. The twenty chapters are grouped into four sections: physiology of cold tolerance (five papers); effect on development and survival (four papers); species adaptations (six papers); and practical applications (five papers). This grouping represents a logical organization of the wide-ranging text. However, an overview of the topics covered would have been useful at the beginning of each section. Also, there was some inconsistency about the inclusion of the valuable statement on future research directions at the end of each chapter.

The first section pays tribute to the pioneering work in insect cold hardiness of R. W. Salt and discusses the principles and terminology of the field. Of special note are a review of physiological mechanisms for seasonal adjustments in body water, an account of the seasonal metabolism of cryoprotectants, and a review of thermal hysteresis-producing antifreeze proteins and ice-nucleating proteins.

The second section focuses on the effect of low temperature on insect development. A more comprehensive understanding of this relationship is beginning to emerge through investigations of cold shock and heat shock in the flesh fly, the effect of suboptimal temperatures on insect morphogenesis,the relationship between cold hardiness and diapause, and the effects of thermoperiod on insect seasonal biology.

The third section presents examples of the complex ecological relationships that contribute to overwintering survival. Apparently through convergent evolution, many different physiological, biochemical, and ecological adaptations contribute to insect cold-tolerance. However, ecological studies into insect cold-tolerance have not kept pace with physiological and biochemical studies. For example, much additional research is needed into the role of microhabitat in overwintering success. Fascinating reading is provided about the overwintering biology of the goldenrod gall fly, and about the seasonal adaptations of a freeze-tolerant arctic Lymantrid moth with a fourteen-year life cycle. A comparative approach is taken in chapters dealing with mechanisms of freezing tolerance among insects and intertidal invertebrates, adaptations of arthropods to alpine and polar environments, and mechanisms freshwater benthic invertebrates use to overwinter.

The last section provides a valuable review of current and potentially practical applications of insect low-temperature science, and demonstrates a clear need to integrate laboratory and field studies in insect cold-har-

Mosquito Nannies

diness. Methods for the cryopreservation of insects are described, followed by examples of research progress in the use of cryopreservation to maintain some of the 50,000 genetic lines of *D. melanogaster*, and a year-round supply of silkworm cocoons. The social basis of overwintering in honey bees by the hoarding of food and colony thermoregulation is described. A review of data about insect cold-hardiness that is useful in developing predictive models for integrated pest management rounds out the volume.

In summary, this volume presents a comprehensive and up-to-date review of the state of knowledge in insect low, temperature science. It provides a valuable source book for cryobiology researchers and entomologists working in such diverse fields as metabolic regulation, insect seasonality, apiculture, and biological control. Because of the breadth of topics covered, the text will make useful supplementary reading in several basic and applied courses in entomology, and it could serve as a primary source for an advanced seminar on insect cryobiology.

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Agroecology

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THERE ARE VERY FEW BOOKS available devoted to the important subject of agroecology, and there has been great philosophical divergence between agriculturalists and agronomists with respect to the subject. Agriculture, over the last fifty years, has been likened to industrial production with considerable increases in productivity. However, some of these successes have been achieved at the expense of considerable deterioration of the natural resource base in terms of soil erosion, water contamination, use of fossil fuel based resources, and even in some cases, food safety. A general appreciation is developing that this process can be reversed only by developing farming systems based on sound ecological principles. Agricultural education has been essentially of a disciplinary nature whereas ecology is basically an interdisciplinary process.

This book, which addresses these issues, is divided into four parts. First there is a general background to agroecology, which overviews the history of agriculture, its social aspects, technological change, and ecological impacts. The second part addresses the ecological background to agroecology in terms of plant, physiological, and population ecology, disease dynamics, beneficial insects, and the agroecosystem as a complex ecological community. This is followed by a part that discusses management issues, including nitrogen cycling, integrated pest management, ecological genetics, human nutritional needs, intercropping, and promotion of genetic diversity. Finally, agricultural research is discussed in terms of traditional agriculture, research in developed nations, research in the third world, and the political and economic aspects of agricultural research.

These topics vary considerably in content and treatment, ranging from theoretical discussions to pragmatic approaches. The twenty-three chapters are written by thirty-two contributors with widely ranging backgrounds and approaches.

The authors do not define the audience to which the book is intended. Many agricultural scientists, students, and farmers will find much of interest. Entomologists will have particular interest in the chapters on herbivorous insects in agroecosystems, beneficial insects, integrated pest management, and the relationship of integrated pest management to ecological genetics. Workers in environmental entomology will find many things of interest in a large part of the book.

This is a large and relatively expensive book, but it should find a place in most agricultural and biological libraries. The volume will stimulate interest in the extremely important but greatly neglected subject of agroecology.

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