Preface

The spatial dimension of ecology, until recently rather unfashionable, is currently the subject of a surge of interest that appears to have arisen independently in a number of fields. Spatial heterogeneity and the spatiotemporal processes of dispersal and migration, and invasion and colonisation, are now receiving attention not only from 'island biogeographers' but also from population ecologists and geneticists, evolutionary biologists and applied ecologists. A recent editorial in the journal *Ecology* declared spatial dynamics to be 'the final frontier for ecological theory' (Kareiva, 1994). Geographers have established a new subdiscipline, 'landscape ecology', to integrate the biological, economic and cultural aspects of environmental heterogeneity. Technical advances in remote sensing (of both habitats and migratory movements), geographic information systems, geostatistics, biotelemetry, meteorology and climatology have spurred and sustained all of these approaches.

Central to any consideration of spatial dynamics in ecology must be the processes by which organisms move, or are moved, from one habitat location to another. Migration has been studied in many taxa, but work on insects has been particularly intense and productive, primarily because several of the world's most damaging pests are migratory, but also because insects' short life cycles make the inter-relations of migration with life history and the seasonal cycle especially evident and accessible to study.

Progress in understanding insect migration, and indeed animal migration in general, has been hampered for many years by confusion, in both concepts and terminology, about what constitutes 'migration'. This obstacle was finally removed by the late Professor J. S. Kennedy FRS, who first made clear the distinction between the behavioural and ecological meanings of this term. For many species, changes in the spatial

distribution of populations are the result of no more than the day-to-day movements associated with foraging, together with the occasional and unpredictable adventitious displacements that occur when station-keeping behaviour is overwhelmed by disruptive forces such as high winds, storms, floods, or human intervention. However, in migratory species, specialised behaviour has evolved that enables individuals to leave the current habitat patch and find and colonise other patches that have arisen elsewhere. Kennedy (1985) proposed the following definition of this specialised behaviour:

> Migratory behaviour is persistent and straightened-out movement effected by the animal's own locomotory exertions or by its active embarkation on a vehicle. It depends on some temporary inhibition of station-keeping responses but promotes their eventual disinhibition and recurrence.

This behavioural characterisation of migration, and the distinction between the process of migration and its ecological consequences that it has fostered, form one of the cornerstones of the conceptual framework underlying contemporary approaches to migration studies.

Professor Kennedy died in 1993. We dedicate this volume to his memory, in recognition of his pivotal contribution to the emergence, over the last 40 years, of the study of insect migration from its origins in natural history to its present status as a modern, interdisciplinary branch of biology, incorporating biogeographic, ecological, behavioural, physiological and genetic dimensions.

This book had its origins in a symposium entitled *Insect Migration: Physical Factors and Physiological Mechanisms* held during the 1992 XIX International Congress of Entomology (ICE) in Beijing (Frontispiece). The symposium, organised by Alistair Drake, Gavin Gatehouse and Professor X.-X. Zhang (Nanjing Agricultural University), focussed on three areas in which significant progress had been achieved during the 1980s: the relation of migration to weather and climate, physiological adaptations for migration, and forecasting of migrant pests. After the symposium, the participants were commissioned to develop the material they had presented orally into the broader treatments that appear in this book. A slight geographical bias towards East Asia and Australia has been deliberately retained, to counterbalance a tendency in previous reviews and books on this topic to focus on Africa and North America. (It is worth noting that South America is unrepresented in this or earlier reviews: little seems to be known of insect migration in that continent.)

The book concludes with an overview chapter, in which we attempt a synthesis of current knowledge of insect migration within the framework of a single, comprehensive conceptual model.

We would like to thank the XIX ICE Programme Committee (Chairman Professor Y.-Q. Liu) and Professor X.-X. Zhang for their support of the Beijing Symposium, and all our chapter authors for responding positively and creatively to our proposals on the scope of their contributions and to our sometimes vigorous and critical editing. We are most grateful to H. Dingle, R.A. Farrow, P.C. Gregg, G. McDonald, D.E. Pedgley, D.R. Reynolds and K. Wilson for reading and commenting so constructively and promptly on various chapter drafts.

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October 1994

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