CAMBRIDGE

Cambridge University Press
0521440009 - Insect Migration: Tracking Resources through Space and Time
Edited by V. A. Drake and A. G. Gatehouse
Frontmatter
More information

Migration is a key process in the population dynamics of many insects, including some of the most damaging pests. Multidisciplinary research over the last three decades has produced a series of important new insights. This book reviews current understanding of the ecological, behavioural, physiological and genetic bases of insect migration. The first part describes migration systems in Europe, Asia, Africa, Australia and America, with an emphasis on the role of regional weather and climate. The second part considers how insects are adapted for migration; it covers aerodynamics and energetics, the integration of migration in insect life cycles, environmental and genetic regulation of migratory potential and the evolutionary implications of habitat heterogeneity and variability. The third part addresses the application of this knowledge to operational pest forecasting. The book concludes with a comprehensive overview of insect migration, written from an evolutionary perspective.

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
0521440009 - Insect Migration: Tracking Resources through Space and Time
Edited by V. A. Drake and A. G. Gatehouse
Frontmatter
More information

INSECT MIGRATION:

tracking resources through space and time

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
0521440009 - Insect Migration: Tracking Resources through Space and Time
Edited by V. A. Drake and A. G. Gatehouse
Frontmatter
More information

Participants in the symposium *Insect Migration: Physical Factors and Physiological Mechanisms* at the XIX International Congress of Entomology, Beijing, 29–30 June 1992. Left to right, *back row:* G.M. Tatchell, C.-S. Ma, J. Colvin, K. Wilson, T.P. Robinson, J.D. Knight, T. Watanabe, X.-N. Cheng, K. Hirai, J.-H. Lee, K.-B. Uhm, M. Lecoq, G. McDonald, J.I. Magor, Y.-J. Sun, T. Wada, K. Sogawa. *Front row:* S.J. Johnson, R.-L. Chen, P.C. Gregg, R. Kisimoto, M. Ishii, V.A. Drake, X.-X. Zhang, A.G. Gatehouse, R.A. Farrow, K.J. Walden, J.N. McNeil, D.E. Pedgley.

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
0521440009 - Insect Migration: Tracking Resources through Space and Time
Edited by V. A. Drake and A. G. Gatehouse
Frontmatter
More information

INSECT MIGRATION:

tracking resources through space and time

Edited by

V.A. DRAKE
University of New South Wales, Australia

and

A.G. GATEHOUSE
University of Wales, Bangor

CAMBRIDGE
UNIVERSITY PRESS

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
0521440009 - Insect Migration: Tracking Resources through Space and Time
Edited by V. A. Drake and A. G. Gatehouse
Frontmatter
More information

Published by the Press Syndicate of the University of Cambridge
The Pitt Building, Trumpington Street, Cambridge CB2 1RP
40 West 20th Street, New York, NY 10011–4211, USA
10 Stamford Road, Oakleigh, Melbourne 3166, Australia

www.cambridge.org
Information on this title: www.cambridge.org/9780521440004

© Cambridge University Press 1995

First published 1995

A catalogue record for this book is available from the British Library

Library of Congress cataloguing in publication data

Insect migration : tracking resources through space and time / edited by V. A. Drake and A. G. Gatehouse.
p. cm.
Includes bibliographical references and index.
ISBN 0 521 44000 9 (hardback)
1. Insects – Migration. 2. Insect pests – Migration. I. Drake. V. A. II. Gatehouse, A. G.
QL496.2.147 1995
595.7052'5 – dc20 94–49434 CIP

ISBN-13 978-0-521-44000-4 hardback
ISBN-10 0-521-44000-9 hardback

Transferred to digital printing 2005

RO

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
0521440009 - Insect Migration: Tracking Resources through Space and Time
Edited by V. A. Drake and A. G. Gatehouse
Frontmatter
More information

This book is dedicated to
the memory of
John S. Kennedy FRS
1912–1993

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
0521440009 - Insect Migration: Tracking Resources through Space and Time
Edited by V. A. Drake and A. G. Gatehouse
Frontmatter
More information

Contents

List of contributors *page* xi
Preface xv
Part one: Insect migration in relation to weather and climate 1
1 Long-range insect migration in relation to climate and weather: Africa and Europe *D.E. Pedgley, D.R. Reynolds and G.M. Tatchell* 3
2 Insect migration in North America: synoptic-scale transport in a highly seasonal environment *S.J. Johnson* 31
3 Migration of the Brown Planthopper *Nilaparvata lugens* and the White-backed Planthopper *Sogatella furcifera* in East Asia: the role of weather and climate *R. Kisimoto and K. Sogawa* 67
4 Migration of the Oriental Armyworm *Mythimna separata* in East Asia in relation to weather and climate. I. Northeastern China *R.-L. Chen, Y.-J. Sun, S.-Y. Wang, B.-P. Zhai and X.-Y. Bao* 93
5 Migration of the Oriental Armyworm *Mythimna separata* in East Asia in relation to weather and climate. II. Korea *J.-H. Lee and K.-B. Uhm* 105
6 Migration of the Oriental Armyworm *Mythimna separata* in East Asia in relation to weather and climate. III. Japan *K. Hirai* 117
7 Insect migration in an arid continent. I. The Common Armyworm *Mythimna convecta* in eastern Australia *G. McDonald* 131
8 Insect migration in an arid continent. II. *Helicoverpa* spp. in eastern Australia *P.C. Gregg, G.P. Fitt, M.P. Zalucki and D.A.H. Murray* 151

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
0521440009 - Insect Migration: Tracking Resources through Space and Time
Edited by V. A. Drake and A. G. Gatehouse
Frontmatter
More information

9 Insect migration in an arid continent. III. The Australian Plague Locust *Chortoicetes terminifera* and the Native Budworm *Helicoverpa punctigera* in Western Australia *K.J. Walden* 173

Part two: Adaptations for migration 191

10 Migratory potential in insects: variation in an uncertain environment *A.G. Gatehouse and X.-X. Zhang* 193

11 Insect migration in heterogeneous environments *K. Wilson* 243

12 The regulation of migration in *Helicoverpa armigera* *J. Colvin* 265

13 Physiological integration of migration in Lepidoptera *J.N. McNeil, M. Cusson, J. Delisle, I. Orchard and S.S. Tobe* 279

14 Aerodynamics, energetics and reproductive constraints of migratory flight in insects *R. Dudley* 303

Part three: Forecasting migrant pests 321

15 Operational aspects of forecasting migrant insect pests *R.K. Day and J.D. Knight* 323

16 Geographic information systems and remotely sensed data for determining the seasonal distribution of habitats of migrant insect pests *T.P. Robinson* 335

17 Forecasting systems for migrant pests. I. The Brown Planthopper *Nilaparvata lugens* in China *B.-H. Zhou, H.-K. Wang and X.-N. Cheng* 353

18 Forecasting systems for migrant pests. II. The rice planthoppers *Nilaparvata lugens* and *Sogatella furcifera* in Japan *T. Watanabe* 365

19 Forecasting systems for migrant pests. III. Locusts and grasshoppers in West Africa and Madagascar *M. Lecoq* 377

Part four: Overview and synthesis 397

20 Forecasting migrant insect pests *J.I. Magor* 399

21 Insect migration: a holistic conceptual model *V.A. Drake, A.G. Gatehouse and R.A. Farrow* 427

Index 459

Note added in proof:
Professor R.-L. Chen died 28/3/95. The author for correspondence for chapter 4 is now Ms Y.-J. Sun.

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
0521440009 - Insect Migration: Tracking Resources through Space and Time
Edited by V. A. Drake and A. G. Gatehouse
Frontmatter
More information

Contributors

Prof. X.-Z. Bao
Institute of Plant Protection, Jilin Academy of Agricultural Sciences, Gongzhuling, Jilin Province, 136100, China

Prof. R.-L. Chen
Institute of Plant Protection, Jilin Academy of Agricultural Sciences, Gongzhuling, Jilin Province, 136100, China

Prof. X.-N. Cheng
Department of Plant Protection, Nanjing Agricultural University, Nanjing 210014, China

Dr J. Colvin
Natural Resources Institute, Central Avenue, Chatham Maritime, Chatham, Kent ME4 4TB, UK

Dr M. Cusson
Laurentian Forestry Centre, 1055 PEPS, PO Box 3800, Ste Foy, PQ, G1V 4C7, Canada

Dr R.K. Day
International Institute for Biological Control, PO Box 30148, Nairobi, Kenya

Dr J. Delisle
Laurentian Forestry Centre, 1055 PEPS, PO Box 3800, Ste Foy, PQ, G1V 4C7, Canada

Dr V.A. Drake
Department of Physics, University College, University of New South Wales, Australian Defence Force Academy, Canberra, Australian Capital Territory 2600, Australia

Dr R. Dudley
Department of Zoology, University of Texas, Austin, TX 78712, USA

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
0521440009 - Insect Migration: Tracking Resources through Space and Time
Edited by V. A. Drake and A. G. Gatehouse
Frontmatter
More information

Dr R.A. Farrow
Division of Entomology, CSIRO, GPO Box 1700, Canberra, Australian Capital Territory 2601, Australia

Dr G.P. Fitt
Division of Entomology, CSIRO, PO Box 59, Narrabri, New South Wales 2390, Australia

Dr A.G. Gatehouse
School of Biological Sciences, University of Wales, Bangor, Gwynedd LL57 2UW, UK

Dr P.C. Gregg
Department of Agronomy and Soil Science, University of New England, Armidale, New South Wales 2351, Australia

Dr K. Hirai
National Agricultural Research Centre, Tsukuba, Ibaraki 305, Japan

Dr S.J. Johnson
Department of Entomology, Louisiana Agricultural Experiment Station, Louisiana State University Agricultural Center, Baton Rouge, LA 70803, USA

Prof. R. Kisimoto
Faculty of Bioresources, Mie University, 1515 Kamihama, Tsu 514, Japan

Dr J.D. Knight
Silwood Centre for Pest Management, Department of Biology, Imperial College at Silwood Park, Ascot, Berks. SL5 7PY, UK

Dr M. Lecoq
CIRAD-PRIFAS, BP 5035, 34032 Montpellier, CEDEX 1, France

Dr J.-H. Lee
Division of Applied Entomology, Department of Agricultural Biology, College of Agriculture and Life Sciences, Seoul National University, Suwon, 441–744, Korea

Dr J.I. Magor
Natural Resources Institute, Central Avenue, Chatham Maritime, Chatham, Kent ME4 4TB, UK

Dr G. McDonald
Plant Sciences and Biotechnology, Agriculture Victoria, La Trobe University, Bundoora, Victoria 3083, Australia

Prof. J.N. McNeil
Département de biologie, Université Laval, Cité universitaire, Québec, PQ, G1K 7P4, Canada

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
0521440009 - Insect Migration: Tracking Resources through Space and Time
Edited by V. A. Drake and A. G. Gatehouse
Frontmatter
More information

Dr D.A.H. Murray
Department of Primary Industries, Toowoomba, Queensland 4350, Australia

Dr I. Orchard
Department of Zoology, University of Toronto, Ramsay Wright Zoological Laboratories, 25 Harbord Street, Toronto, Ontario M5S 1A1, Canada

Mr D.E. Pedgley
Natural Resources Institute, Central Avenue, Chatham Maritime, Kent ME4 4TB, UK

Dr D.R. Reynolds
Natural Resources Institute, Central Avenue, Chatham Maritime, Kent ME4 4TB, UK

Dr T.P. Robinson
c/o The Foreign and Commonwealth Office (Lusaka), King Charles Street, London SW1A 2AH, UK

Dr K. Sogawa
Kyushu National Agricultural Experiment Station, Nishigoshi, Kumamoto 861–11, Japan

Ms Y.-J. Sun
Institute of Plant Protection, Jilin Academy of Agricultural Sciences, Gongzhuling, Jilin Province, 136100, China

Dr G.M. Tatchell
Rothamsted Experimental Station, Harpenden, Herts. AL5 2JQ, UK

Prof. S.S. Tobe
Department of Zoology, University of Toronto, Ramsay Wright Zoological Laboratories, 25 Harbord Street, Toronto, Ontario M5S 1A1, Canada

Dr K.-B. Uhm
Department of Entomology, Agricultural Science Institute, Rural Development Administration, Suwon, 441–707, Korea

Mr K.J. Walden
Western Australian Department of Agriculture, PO Box 110, Geraldton, Western Australia 6530, Australia

Dr H.-K. Wang
Department of Plant Protection, Nanjing Agricultural University, Nanjing 210014, China

Ms S.-Y. Wang
Institute of Plant Protection, Jilin Academy of Agricultural Sciences, Gongzhuling, Jilin Province, 136100, China

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
0521440009 - Insect Migration: Tracking Resources through Space and Time
Edited by V. A. Drake and A. G. Gatehouse
Frontmatter
More information

Dr T. Watanabe
Laboratory of Pest Management Systems, Kyushu National Agricultural Experiment Station, Nishigoshi, Kumamoto, 861–11, Japan

Dr K. Wilson
Department of Zoology, University of Cambridge, Downing Street, Cambridge CB2 3EJ, UK

Dr M.P. Zalucki
Department of Entomology, University of Queensland, Brisbane, Queensland 4072, Australia

Dr B.-P. Zhai
Institute of Plant Protection, Jilin Academy of Agricultural Sciences, Gongzhuling, Jilin Province, 136100, China

Prof. X.-X. Zhang
Department of Plant Protection, Nanjing Agricultural University, Nanjing 210014, China

Prof. B.-H. Zhou
Department of Plant Protection, Nanjing Agricultural University, Nanjing 210014, China

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
0521440009 - Insect Migration: Tracking Resources through Space and Time
Edited by V. A. Drake and A. G. Gatehouse
Frontmatter
More information

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

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
0521440009 - Insect Migration: Tracking Resources through Space and Time
Edited by V. A. Drake and A. G. Gatehouse
Frontmatter
More information

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.)

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
0521440009 - Insect Migration: Tracking Resources through Space and Time
Edited by V. A. Drake and A. G. Gatehouse
Frontmatter
More information

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.

Alistair Drake, Canberra, Australia
Gavin Gatehouse, Bangor, North Wales, UK
October 1994

References

Kareiva, P. (1994). Space: the final frontier for ecological theory. *Ecology*, **75**, 1.

Kennedy, J.S. (1985). Migration, behavioural and ecological. In *Migration: Mechanisms and Adaptive Significance*, ed. M.A. Rankin, pp. 5–26. *Contributions in Marine Science*, vol. 27 (Suppl.). Port Aransas, Texas: Marine Science Institute, The University of Texas at Austin.

© Cambridge University Press www.cambridge.org