INSECT BIODIVERSITY

SCIENCE AND SOCIETY

Edited by Robert G. Foottit and Peter H. Adler

Foreword by Tim New

WILEY-BLACKWELL

INSECT BIODIVERSITY

SCIENCE AND SOCIETY

Edited by Robert G. Foottit and Peter H. Adler

WILEY-BLACKWELL
A John Wiley & Sons, Ltd., Publication

This edition first published 2009, © 2009 by Blackwell Publishing Ltd

Blackwell Publishing was acquired by John Wiley & Sons in February 2007. Blackwell's publishing program has been merged with Wiley's global Scientific, Technical and Medical business to form Wiley-Blackwell.

Registered office: John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

Editorial Offices: 9600 Garsington Road, Oxford, OX4 2DQ, UK
The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK
111 River Street, Hoboken, NJ 07030-5774, USA

For details of our global editorial offices, for customer services and for information about how to apply for permission to reuse the copyright material in this books please see our website at www.wiley.com/wiley-blackwell

The right of the author to be identified as the author of this work has been asserted in accordance with the Copyright, Designs and Patents Act 1988.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, except as permitted by the UK Copyright, Designs and Patents Act 1988, without the prior permission of the publisher.

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic books.

Designations used by companies to distinguish their products are often claimed as trademarks. All brand names and product names used in this book are trade names, service marks, trademarks or registered trademarks of their respective owners. The publisher is not associated with any product or vendor mentioned in this book. This publication is designed to provide accurate and authoritative information in regard to the subject matter covered. It is sold on the understanding that the publisher is not engaged in rendering professional services. If professional advice or other expert assistance is required, the services of a competent professional should be sought.

Library of Congress Cataloging-in-Publication Data

Insect biodiversity : science and society / edited by Robert G. Foottit and Peter H. Adler.
p. cm.
Includes bibliographical references and index.
ISBN 978-1-4051-5142-9 (hardcover : alk. paper) 1. Insects–Variation. 2. Insects–Evolution. I. Foottit, R. (Robert G.) II. Adler, Peter H. (Peter Holdridge)
QL463.I65 2009
595.717–dc22

2008042545

ISBN: 9781405151429

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

Set in 9/11 Photina by Laserwords Pvt Ltd, Chennai, India

Printed and bound in the UK

1 2009

INSECT BIODIVERSITY

CONTRIBUTORS

PETER H. ADLER *Department of Entomology, Soils & Plant Sciences, Clemson University, Box 340315, 114 Long Hall, Clemson, South Carolina 29634-0315 USA* (padler@clemson.edu)

MAY R. BERENBAUM *Department of Entomology, University of Illinois, 505 S. Goodwin Ave., Urbana, Illinois 61801-3707 USA* (maybe@uiuc.edu)

PATRICE BOUCHARD *Environmental Health National Program (Biodiversity), Agriculture and Agri-Food Canada, K. W. Neatby Bldg., 960 Carling Ave., Ottawa, Ontario K1A 0C6 CANADA* (patrice.bouchard@agr.gc.ca)

MICHAEL F. CLARIDGE *84 The Hollies, Quakers Yard, Treharris, Wales CF46 5PP UK* (claridge@cardiff.ac.uk)

GREGORY W. COURTNEY *Department of Entomology, 432 Science II, Iowa State University, Ames, Iowa 50011-3222 USA* (gwcourt@iastate.edu)

PETER S. CRANSTON *Department of Entomology, University of California at Davis, Davis, California 95616 USA* (pscranston@ucdavis.edu)

HUGH V. DANKS *Biological Survey of Canada, Canadian Museum of Nature, P.O. Box 3443 Station D., Ottawa, Ontario K1P 6P4 CANADA* (hughdanks@yahoo.ca)

HUME DOUGLAS *Canadian Food Inspection Agency, Canadian National Collection of Insects, Arachnids and Nematodes, 960 Carling Avenue, Ottawa, Ontario K1A 0C6 CANADA* (douglash@inspection.gc.ca)

TERRY L. ERWIN *Smithsonian Institution, Department of Entomology, National Museum of Natural History, Mrc-187, Washington, DC 20560-0001 USA* (ErwinT@si.edu)

ROBIN M. FLOYD *Biodiversity Institute of Ontario and Department of Integrative Biology, University of Guelph, Guelph, Ontario N1G 2W1 CANADA* (rfloyd@uoguelph.ca)

ROBERT G. FOOTTIT *Environmental Health National Program (Biodiversity), Agriculture and Agri-Food Canada, K. W. Neatby Bldg., 960 Carling Ave., Ottawa, Ontario K1A 0C6 CANADA* (robert.foottit@agr.gc.ca)

CHRISTY J. GERACI *Smithsonian Institution, Department of Entomology, National Museum of Natural History, Mrc-187, Washington, DC 20560-0001 USA* (GeraciC@si.edu)

VASILY V. GREBENNIKOV *Canadian Food Inspection Agency, Canadian National Collection of Insects, Arachnids and Nematodes, 960 Carling Avenue, Ottawa, Ontario K1A 0C6 CANADA* (GrebennikovV@inspection.gc.ca)

PAUL D. N. HEBERT *Biodiversity Institute of Ontario and Department of Integrative Biology, University of Guelph, Guelph, Ontario N1G 2W1 CANADA* (phebert@uoguelph.ca)

THOMAS J. HENRY *Systematic Entomology Laboratory, PSI, Agriculture Research Service, U. S. Department of Agriculture, c/o Smithsonian Institution, Washington DC 20013-7012 USA* (Thomas.henry@ars.usda.gov)

JOHN M. HERATY *Department of Entomology, University of California, Riverside, California 92521 USA* (john.heraty@ucr.edu)

此为试读,需要完整PDF请访问: www.ertongbook.com

E. RICHARD HOEBEKE *Department of Entomology, Cornell University, Ithaca, New York 14853-2601 USA* (erh2@cornell.edu)

JOHN T. HUBER *Canadian Forestry Service, K. W. Neatby Bldg., 960 Carling Ave., Ottawa, Ontario K1A 0C6 CANADA* (john.huber@agr.gc.ca)

NORMAN F. JOHNSON *Department of Entomology, Ohio State University, 1315 Kinnear Road, Columbus, Ohio 43212 USA* (johnson.2@osu.edu)

KE CHUNG KIM *Frost Entomological Museum, Department of Entomology, Pennsylvania State University, University Park, Pennsylvania 16802 USA* (kck@psu.edu)

ALEXANDER S. KONSTANTINOV *Systematic Entomology Laboratory, PSI, Agricultural Research Service, U. S. Department of Agriculture, Smithsonian Institution, P. O. Box 37012, National Museum of Natural History, Rm. CE-709, MRC–168, Washington, DC 20560-0168 USA* (alex.konstantinov@ars.usda.gov)

BORIS A. KOROTYAEV *Zoological Institute, Russian Academy of Sciences, Universitetskaya nab. 1, St. Petersburg 199034 RUSSIA* (baris@zin.ru)

MERVYN W. MANSELL *ARC – Plant Protection Research Institute, Biosystematics Division, Private Bag X134, Pretoria 0001 SOUTH AFRICA* (vrehmwm@plant5.agric.za)

GARY L. MILLER *Systematic Entomology Laboratory, PSI, Agricultural Research Service, U.S. Department of Agriculture, Bldg. 005, BARC-West, Beltsville, Maryland 20705 USA* (Gary.Miller@ars.usda.gov)

JOHN C. MORSE *Department of Entomology, Soils & Plant Sciences, Clemson University, Box 340315, 114 Long Hall, Clemson, South Carolina 29634-0315 USA* (jmorse@clemson.edu)

THOMAS PAPE *Natural History Museum of Denmark, Zoological Museum, Universitetsparken 15, DK-2100 Copenhagen, DENMARK* (tpape@snm.ku.dk)

MICHAEL G. POGUE *Systematic Entomology Laboratory, PSI, Agricultural Research Service, U. S. Department of Agriculture, Smithsonian Institution, P. O. Box 37012, National Museum of Natural History Museum, MRC-168, Washington, DC 20560-0168 USA* (michael.pogue@ars.usda.gov)

AMANDA D. ROE *Department of Biological Sciences, CW 405a Biological Sciences Centre, University of Alberta, Edmonton, Alberta T6G 2E9 CANADA* (adroe@hotmail.com)

MICHAEL J. SAMWAYS *Department of Entomology and Centre for Agricultural Biodiversity, University of Stellenbosch, Private Bag X1, 7602 Matieland, SOUTH AFRICA* (samways@sun.ac.za)

CLARKE H. SCHOLTZ *Department of Zoology and Entomology, University of Pretoria, Pretoria 002, SOUTH AFRICA* (chscholtz@zoology.up.ac.za)

GEOFFREY G. E. SCUDDER *Department of Zoology, University of British Columbia, 7270 University Boulevard, Vancouver, British Columbia V6T 1Z4 CANADA* (scudder@zoology.ubc.ca)

BRADLEY J. SINCLAIR *Entomology - Ontario Plant Laboratories, Canadian Food Inspection Agency, K.W. Neatby Building, 960 Carling Avenue, Ottawa, Ontario K1A 0C6 CANADA* (sinclairb@inspection.gc.ca)

JEFFREY H. SKEVINGTON *Agriculture and Agri-Food Canada (AAFC), Canadian National Collection of Insects, Arachnids and Nematodes, K.W. Neatby Building, 960 Carling Avenue, Ottawa, Ontario K1A 0C6 CANADA* (jeffrey.skevington@agr.gc.ca)

ANDREW B. T. SMITH *Research Division, Canadian Museum of Nature, P.O. Box 3443, Station 'D', Ottawa, Ontario K1P 6P4 CANADA* (asmith@mus-nature.ca)

FELIX A. H. SPERLING *Department of Biological Sciences, CW 405a Biological Sciences Centre, University of Alberta, Edmonton, Alberta T6G 2E9 CANADA* (felix.sperling@ualberta.ca)

MARK G. VOLKOVITSH *Zoological Institute, Russian Academy of Sciences, Universitetskaya nab. 1, St. Petersburg 199034 RUSSIA* (polycest@zin.ru)

ALFRED G. WHEELER, JR. *Department of Entomology, Soils & Plant Sciences, Clemson University,*

Box 340315, 114 Long Hall, Clemson, South Carolina 29634-0315 USA (awhlr@clemson.edu)

QUENTIN D. WHEELER *International Institute for Species Exploration, Arizona State University, P.O. Box 876505, Tempe, AZ 85287-6505 USA* (Quentin.Wheeler@asu.edu)

JOHN J. WILSON *Biodiversity Institute of Ontario and Department of Integrative Biology, University of Guelph, Guelph, Ontario, N1G 2W1 CANADA* (jwilso04@uoguelph.ca)

PREFACE

Insects are the world's most diverse group of animals, making up more than 58% of the known global biodiversity. They inhabit all habitat types and play major roles in the function and stability of terrestrial and aquatic ecosystems. Insects are closely associated with our lives and affect the welfare of humanity in diverse ways. At the same time, large numbers of insect species, including those not known to science, continue to become extinct or extirpated from local habitats worldwide. Our knowledge of insect biodiversity is far from complete; for example, barely 65% of the North American insect fauna has been described. Only a relatively few species of insects have been studied in depth. We urgently need to explore and describe insect biodiversity and to better understand the biology and ecology of insects if ecosystems are to be managed sustainably and if the effect of global environment change is to be mitigated.

The scientific study of insect biodiversity is at a precarious point. Resources for the support of taxonomy are tenuous worldwide. The number of taxonomists is declining and the output of taxonomic research has slowed. Many taxonomists are reaching retirement age and will not be replaced with trained scientists, which will result in a lack of taxonomic expertise for many groups of insects. These trends contrast with an increasing need for taxonomic information and services in our society, particularly for biodiversity assessment, ecosystem management, conservation, sustainable development, management of climate-change effects, and pest management. In light of these contrasting trends, the scientific community and its leadership must increase their understanding of the science of insect biodiversity and taxonomy and ensure that policy makers are informed of the importance of biodiversity for a sustainable future for humanity.

We have attended and contributed to many scientific meetings and management and policy gatherings where the future, the resource needs, and importance of insect taxonomy and biodiversity have been debated. In fact, discussion of the future of taxonomy is a favorite pastime of taxonomists; there is no shortage of "taxonomic opinion." Considerable discussion has focused on the daunting task of describing the diversity of insect life and how many undescribed species are out there. However, we felt that there was a need for an up-to-date, quantitative assessment of what insect biodiversity entails, and to connect what we know and do not know about insect biodiversity with its impact on human society.

Our approach was to ask authors to develop accounts of biodiversity in certain orders of insects and geographic regions and along selected subject lines. In all categories, we were limited by the availability of willing contributors and their time and resources. Many insect groups, geographic regions, and scientific and societal issues could not be treated in a single volume. It also was apparent to us, sometimes painfully so, that many taxonomists are wildly over-committed. This situation can be seen as part of the so-called taxonomic impediment – the lack of available taxonomic expertise is compounded by an overburdened community of present-day taxonomists with too much work and perhaps too much unrealistic enthusiasm.

In Chapter 1, we introduce the ongoing challenge to document insect biodiversity and develop its services. Chapter 2 provides a comprehensive overview of the importance and value of insects to humans. The next two sections deal with regional treatments and ordinal-level accounts of insect biodiversity. These approaches were a serious challenge to the contributors who had to compile information from a wide array of sources or, alternatively, deal with situations in which accurate information simply is insufficient. In Part III, we document some of the tools and approaches to the science of taxonomy and its applications. Perspective is provided on the past, present, and future of the science of insect taxonomy and the all-important influence of species concepts and their operational treatment on taxonomic science and insect biodiversity. Contributions

on the increasing role of informatics and molecular approaches are provided, areas with ongoing controversy and differences of opinion. These chapters are followed by contributions on the applications of taxonomic science for which biodiversity information is fundamental, including the increasing impact of adventive insects, pest detection and management, human medical concerns, and the management and conservation of biodiversity. The book ends with an historical view of the continuing attempts to document the extent of world insect biodiversity.

Robert G. Foottit
Ottawa, Ontario

Peter H. Adler
Clemson, South Carolina

FOREWORD

Insects are the most exuberant manifestation of Earth's many and varied life forms. To me, one of their greatest fascinations is how a rather simple basic unifying body plan has become modified and adapted to produce an enormous variety of species, able to exploit virtually all terrestrial and freshwater environments on the planet while, as a paradox debated extensively a few decades ago, not becoming equally predominant in the seas and oceans. Features such as possession of wings and the complete metamorphosis of many species have been cited frequently as fostering this massive diversity. However, the 'success' of insects can be measured by many parameters: their long-term persistence and stability of their basic patterns, the variety of higher groups (with almost 30 orders commonly recognized) and, as emphasized in this book, the wealth of species and similar entities. Each of these species has its individual biological peculiarities, ecological role, distribution, and interactions within the local community. And each may differ in habit and appearance both from its closest relatives and also across its range to reflect local influences and conditions. Every species is thus a mosaic of physical variety and genetic constitution that can lead to both taxonomic and ecological ambiguity in interpreting its integrity and the ways in which it may evolve and persist.

Entomologists will continue to debate the number of insect 'species' that exist and the levels of past and likely future extinctions. Documenting and cataloging insect biodiversity as a major component of Earth's life is a natural quest of human inquiry but is not an end in itself and, importantly, is not synonymous with conserving insects or a necessary prerequisite to assuring their well-being. Despite many ambiguities in projecting the actual numbers of insect species, no one would query that there are a lot and that the various ecological processes that sustain ecosystems depend heavily on insect activity. Indeed, 'ecological services' such as pollination, recycling of materials, and the economically important activities of predators and parasitoids are signaled increasingly as part of the rationale for insect conservation because these values can be appreciated easily through direct economic impacts. All these themes are dealt with in this book, centered on questions related to our ignorance of the fundamental matters of 'how many are there?' and 'how important are they?' to which the broad answers of 'millions and 'massive' may incorporate considerable uncertainty; this uncertainty, however, is reduced by many of the chapters here.

In any investigations of insect biodiversity, the role of inventory tends to be emphasized. Documenting numbers of species (however they are delimited or defined) gives us foci for conservation advocacy and is pivotal in helping to elucidate patterns of evolution and distribution. Recognizing and naming species allow us to transfer information, but high proportions of undescribed or unrecognizable species necessitate the use of terms such as 'morphospecies' in much ecological interpretation of diversity. Nevertheless, other than in some temperate regions, particularly in the Northern Hemisphere, many estimates of insect species richness and naming the species present are highly incomplete. Much of the tropics, for example, harbors few resident entomologists other than those involved with pressing problems of human welfare, and more basic and sustained documentation almost inevitably depends on assistance from elsewhere. Some insects, of course, have been explored much more comprehensively than others, so that selected taxonomic groups (such as butterflies, larger beetles, and dragonflies) and ecological groups ('pests') have received much more attention than many less charismatic or less economically important groups. Indeed, when collecting Psocoptera in parts of the tropics, I have occasionally been asked by local people why I am not collecting birdwing butterflies, stag beetles, or other 'popular' (or commercially desirable!) insects, and my responses have done little to change their opinions of my insanity! In short, many gaps in knowledge of insect diversity persist,

and seem unlikely to be redressed effectively in the near future, other than by 'guesstimates' extrapolating from sometimes rather dubious foundations. However, sufficient knowledge does exist to endorse the practical need to protect natural habitats effectively from continued despoliation and, as far as practicable, from the effects of climate changes. Citations of impressively large numbers of insect species can become valuable advocacy in helping to conserve areas with largely unheralded wealth of biodiversity. Presence of unusual lineages of insects, of narrow range endemics, as well as highly localized radiations and distributional idiosyncrasies (such as isolated populations beyond the main range of the taxon) are all commonplace scenarios and may in various ways help us to designate priorities for allocating the limited conservation resources available. Many such examples from selected insect groups are revealed in this book – but evaluating the richness and ecological importance of the so-called meek inheritors, that vast majority of insects that do not intrude notably on human intelligence and welfare, remains a major challenge. Many such taxa receive attention from only a handful of entomologists at any time, and some are essentially 'orphaned' for considerable periods. Progress with their documentation is inevitably slow and sporadic. In addition, some hyperdiverse orders and families of insects exhibit daunting complexity of form and biology, as 'black hole groups' whose elucidation is among the major challenges that face us.

Insect conservation has drawn heavily on issues relevant to biodiversity and appreciation of the vast richness of insects – not only of easily recognizable 'species' but also of the occurrence of subspecies and other infraspecific variants such as significant populations, collectively 'evolutionarily significant units'. This more complex dimension of insect biodiversity is receiving considerable attention as new molecular tools (such as DNA analysis) enable us to probe characters in ways undreamed of only a decade or so ago to augment the perspectives provided by morphological interpretation. The vast arrays of cryptic species gradually being revealed suggest that even our most up-to-date estimates of species numbers based on morphological data may be woefully inadequate. Insect diversity equates to 'variety', but the subtleties of interpopulation variations in genetic constitution and ecological performance are difficult to appraise and to categorize formally – and perhaps even more difficult to communicate to non-entomologists whose powers may determine the future of the systems in which those insects participate. Education and communication, based on the soundest available information, are essential components of insect conservation. This book is a significant contribution to this endeavor, through indicating how we may come to interpret and understand insect biodiversity more effectively. In addition to providing a range of opinions and facts on insect richness in a variety of taxonomic, geographical, and methodological contexts, it helps to emphasize the importance of accurate species recognition. Failure to recognize adventive alien species may have dire economic or ecological consequences, for example, or confusion between biotypes or cryptic species may invalidate expensive management programs for their suppression or conservation.

A new generation of skilled insect systematists – whose visions encompass the wider ramifications of insect biodiversity, its importance in understanding the natural world and the accelerating impacts of humans upon it – is an urgent need. They enter an exciting and challenging field of endeavor, and the perspectives included in this volume are essential background to their future contributions. This book is thus both a foundation and a stimulating working tool toward that end, and I expect many of the chapters to be key references as we progressively refine and enlarge the bases of our understanding of insects and their activities in the modern world.

T.R. New,
Department of Zoology,
La Trobe University,
Victoria 3086, Australia

此为试读,需要完整PDF请访问: www.ertongbook.com

ACKNOWLEDGMENTS

We asked external reviewers to give us perspective on each chapter, and we are grateful for their efforts and appreciative of the time they took from their busy schedules. We would like to thank the following individuals who reviewed one or more chapters: P. Bouchard, C. E. Carlton, M. F. Claridge, P. S. Cranston, T. L. Erwin, C. J. Geraci, D. R. Gillespie, P. W. Hall, R. E. Harbach, J. D. Lafontaine, J. D. Lozier, P. G. Mason, H. E. L. Maw, J. C. Morse, L. A. Mound, G. R. Mullen, T. R. New, J. E. O'Hara, V. H. Resh, M. D. Schwartz, G. G. E. Scudder, D. S. Simberloff, A. Smetana, A. B. T. Smith, J. Sóberon, L. Speers, F. A. H. Sperling, I. C. Stocks, M. W. Turnbull, C. D. von Dohlen, D. L. Wagner, G. Watson, A. G. Wheeler, Jr., Q. D. Wheeler, B. M. Wiegmann, D. K. Yeates, and P. Zwick. We extend our gratitude to Eric Maw for his tremendous efforts in generating the taxonomic indices.

Finally, we acknowledge the encouragement and support, both moral and technical, of the staff at Wiley-Blackwell, particularly Ward Cooper, Delia Sandford, and Rosie Hayden.

CONTENTS

DETAILED CONTENTS

此为试读,需要完整PDF请访问: www.ertongbook.com