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978-1-107-00183-1 - Trait-Mediated Indirect Interactions: Ecological and Evolutionary Perspectives

Edited by Takayuki Ohgushi, Oswald J. Schmitz and Robert D. Holt

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Trait-Mediated Indirect Interactions

Ecological and Evolutionary Perspectives

There is increasing evidence that the structure and functioning of ecological communities and ecosystems are strongly influenced by flexible traits of individuals within species. A deep understanding of how trait flexibility alters direct and indirect species interactions is crucial for addressing key issues in basic and applied ecology. This book provides an integrated perspective on the ecological and evolutionary consequences of interactions mediated by flexible species traits across a wide range of systems. It is the first volume synthesizing the rapidly expanding research field of trait-mediated indirect effects, and highlights how the conceptual framework of these effects can aid the understanding of evolutionary processes, population dynamics, community structure and stability, and ecosystem function. It not only brings out the importance of this emerging field for basic ecological questions, but also explores the implications of trait-mediated interactions for the conservation of biodiversity and the response of ecosystems to anthropogenic environmental changes.

TAKAYUKI OHGUSHI is a Professor at the Center for Ecological Research at Kyoto University. His research focuses on the population biology of insect herbivores, plant-herbivore interactions, multitrophic interactions and the linkage from gene to ecosystem. In particular, he is interested in how trait-mediated indirect effects create ecological communities and biodiversity.

OSWALD J. SCHMITZ is the Oastler Professor of Population and Community Ecology in the Yale University School of Forestry and Environmental Studies. He studies the linkage between two important components of natural systems: biodiversity and ecosystem services, using field experimentation guided by formal mathematical theory of trait-based species interactions.

ROBERT D. HOLT is Arthur R. Marshall Jr. Chair in Ecology and Eminent Scholar in the Department of Biology at the University of Florida. He is an evolutionary and community ecologist whose contributions are principally theoretical, but always tied to concrete processes in the natural world. He has received the International Ecology Institute Prize in Terrestrial Ecology and the Sewall Wright Award from the American Society of Naturalists.

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Edited by

TAKAYUKI OHGUSHI

Kyoto University, Japan

OSWALD J. SCHMITZ

Yale University, USA

ROBERT D. HOLT

University of Florida, USA



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[More information](#)

Contributors

GERARD J. ALLAN

Department of Biological Sciences,
Northern Arizona University,
Flagstaff, USA
gery.allan@nau.edu

PETTER ANDERSSON

Department of Botany, Stockholm
University, Stockholm, Sweden
petter.andersson@botan.su.se

ERIK T. ASCHEHOUG

Division of Biological Sciences,
University of Montana, Missoula, USA
erik.aschehoug@mso.umt.edu

JOSEPH K. BAILEY

Department of Ecology and
Evolutionary Biology, University of
Tennessee, Knoxville, USA
Joe.Bailey@utk.edu

MICHAEL BARFIELD

Department of Biology, University of
Florida, Gainesville, USA
mjb01@ufl.edu

CRAIG W. BENKMAN

Department of Zoology and
Physiology, University of Wyoming,
Laramie, USA
cbenkman@uwyo.edu

BENJAMIN M. BOLKER

Department of Mathematics and
Statistics and Department of
Biology, McMaster University,
Hamilton, Canada
bolker@mcmaster.ca

TIBOR BUKOVINSZKY

Department of Terrestrial
Ecology, Netherlands Institute of
Ecology, Wageningen,
The Netherlands
t.bukovinszky@nioo.knaw.nl

RAGAN M. CALLAWAY

Division of Biological Sciences,
University of Montana, Missoula,
USA
ray.callaway@mso.umt.edu

KEITH CLAY

Department of Biology,
Indiana University,
Bloomington, USA
clay@indiana.edu

TIMOTHY P. CRAIG

Department of Biology,
University of Minnesota, Duluth,
USA
tcraig@d.umn.edu

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[More information](#)

CLAYTON E. CRESSLER
Department of Ecology and
Evolutionary Biology, University
of Michigan, Ann Arbor, USA
cressler@umich.edu

DAVID W. CROWDER
Department of Entomology,
Washington State University,
Pullman, USA
dcrowder@wsu.edu

MICHAEL DIXON
US Fish and Wildlife Service,
Lakewood, USA
Michael_D_Dixon@fws.gov

DYLAN G. FISCHER
Environmental Studies Program, The
Evergreen State College, Olympia,
USA
fischerd@evergreen.edu

CHRISTOPHER J. FROST
Warnell School of Forest Resources,
University of Georgia, Athens, USA
cfrost@warnell.uga.edu

H. CHARLES J. GODFRAY
Department of Zoology, University of
Oxford, Oxford, UK
charles.godfray@zoo.ox.ac.uk

ALEXANDRA GOUDARD
Lycée Champollion, Grenoble,
France
alexandra.goudard@ac-grenoble.fr

MYRA C. HALL
Georgia Perimeter College, Decatur,
USA
myra.hall@gpc.edu

PETER A. HAMBÄCK
Department of Botany, Stockholm
University, Stockholm, Sweden
Peter.Hambäck@botan.su.se

TERRY R. HAMS
Golder Associates, Saskatoon, Canada
hams0005@d.umn.edu

STEPHEN C. HART
School of Natural Sciences and Sierra
Nevada Research Institute, University
of California, Merced, USA
shart4@ucmerced.edu

MARK E. HAY
School of Biology, Georgia Institute of
Technology, Atlanta, USA
mark.hay@biology.gatech.edu

ROBERT D. HOLT
Department of Biology, University of
Florida, Gainesville, USA
rdholt@ufl.edu

MARK D. HUNTER
Department of Ecology and
Evolutionary Biology, University of
Michigan, Ann Arbor, USA
mdhunter@umich.edu

REBECCA E. IRWIN
Biology Department,
Dartmouth College, Hanover,
USA
Rebecca.E.Irwin@Dartmouth.edu

JOANNE K. ITAMI
Department of Biology,
University
of Minnesota-Duluth, USA
jitami@d.umn.edu

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X LIST OF CONTRIBUTORS

- RANDA JABBOUR
Department of Plant, Soil, and
Environmental Sciences,
University of Maine,
Orono, USA
Randa.jabbour@maine.edu
- ARNE JANSSEN
Section Population Biology, Institute
for Biodiversity and Ecosystem
Dynamics, University of Amsterdam,
Amsterdam, The Netherlands
A.R.M.Janssen@uva.nl
- ARTHUR KEITH
Department of Biological Sciences,
Northern Arizona University,
Flagstaff, USA
Arthur.Keith@nau.edu
- JEFFREY T. KERBY
Department of Biology,
Pennsylvania State University,
University Park, USA
jtkerb@gmail.com
- JENNIFER A. LAU
W.K. Kellogg Biological Station and
Department of Plant Biology,
Michigan State University, East
Lansing, USA
jenlau@msu.edu
- CARRI J. LEROY
Environmental Studies Program,
The Evergreen State College, Olympia,
USA
leroyc@evergreen.edu
- IZABELA LESNA
Section Population Biology, Institute
for Biodiversity and Ecosystem
Dynamics, University of Amsterdam,
Amsterdam, The Netherlands
i.k.a.lesna@uva.nl
- JEREMY D. LONG
Department of Biology and Coastal
Marine Institute Laboratory, San
Diego State University, San Diego,
USA
jlong@sciences.sdsu.edu
- MICHEL LOREAU
Station d'Ecologie Expérimentale du
CNRS, Moulis, France
michel.loreau@ecoex-moulis.cnrs.fr
- NASHELLY MENESES
Department of Biological Sciences,
Northern Arizona University,
Flagstaff, USA
nm49@nau.edu
- KAILEN A. MOONEY
Department of Ecology and
Evolutionary Biology, University of
California, Irvine, USA
mooneyk@uci.edu
- TOBIN D. NORTHFIELD
Department of Zoology, University of
Wisconsin, Madison, USA
northfield@wisc.edu
- SCOTT L. NUISMER
Department of Biological Sciences,
University of Idaho, Moscow, USA
snuismer@uidaho.edu
- TAKAYUKI OHGUSHI
Center for Ecological Research, Kyoto
University, Otsu, Japan
ohgushi@ecology.kyoto-u.ac.jp

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[More information](#)

TOSHINORI OKUYAMA
Department of Entomology,
National Taiwan University, Taipei,
Taiwan
okuyama@ntu.edu.tw

SCOTT D. PEACOR
Department of Fisheries and
Wildlife, Michigan State University,
East Lansing, USA
peacor@msu.edu

ERIC POST
Department of Biology,
Pennsylvania State University,
University Park, USA
esp10@psu.edu

PETER W. PRICE
Department of Biological Sciences,
Northern Arizona University,
Flagstaff, USA
peter.price@nau.edu

BARBARA C. REYNOLDS
Department of Environmental
Studies, University of North
Carolina-Asheville, Asheville, USA
kreynolds@unca.edu

BENJAMIN J. RIDENHOUR
Department of Biological Sciences,
University of Notre Dame, South
Bend, USA
Benjamin.Ridenhour.1@nd.edu

JENNIFER A. RUDGERS
Department of Biology, University of
New Mexico, Albuquerque,
USA
jrudgers@unm.edu

VOLKER H. W. RUDOLF
Department of Ecology and
Evolutionary Biology, Rice
University, Houston, USA
volker.rudolf@rice.edu

MAURICE W. SABELIS
Section Population Biology,
Institute for Biodiversity and
Ecosystem Dynamics, University of
Amsterdam, Amsterdam, The
Netherlands
M.W.Sabelis@uva.nl

OSWALD J. SCHMITZ
School of Forestry and
Environmental Studies,
Yale University, New Haven,
USA
oswald.schmitz@yale.edu

THOMAS W. SCHOENER
Department of Evolution and
Ecology and Center for
Population Biology,
University of California,
Davis, USA
twschoener@ucdavis.edu

JENNIFER A. SCHWEITZER
Department of Ecology and
Evolutionary Biology,
University of Tennessee,
Knoxville, USA
Jen.Schweitzer@utk.edu

STEPHEN M. SHUSTER
Department of Biological Sciences,
Northern Arizona University,
Flagstaff, USA
stephen.shuster@nau.edu

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xii LIST OF CONTRIBUTORS

ADAM M. SIEPIELSKI
 Department of Biology,
 University of San Diego, San Diego,
 USA
 adamsiepielski@sandiego.edu

MICHAEL S. SINGER
 Department of Biology,
 Wesleyan University, Middletown,
 USA
 msinger@wesleyan.edu

JULIE W. SMITH
 Department of Biology,
 Pacific Lutheran University,
 Tacoma, USA
 smith@plu.edu

WILLIAM E. SNYDER
 Department of Entomology,
 Washington State University,
 Pullman, USA
 wesnyder@wsu.edu

DAVID A. SPILLER
 Department of Evolution and
 Ecology and Center for Population
 Biology, University of California,
 Davis, USA
 daspiller@ucdavis.edu

GEOFFREY C. TRUSSELL
 Marine Science Center and
 Department of Biology,

Northeastern University,
 Boston, USA
 g.trussell@neu.edu

F. J. FRANK VAN VEEN
 Centre for Ecology and Conservation,
 College of Life and Environmental
 Sciences, University of Exeter,
 Penryn, UK
 f.j.f.van-veen@exeter.ac.uk

FAITH WALKER
 Department of Biological Sciences,
 Northern Arizona University,
 Flagstaff, USA
 Faith.Walker@nau.edu

THOMAS G. WHITHAM
 Department of Biological Sciences,
 Northern Arizona University,
 Flagstaff, USA
 thomas.whitham@nau.edu

CHRISTOPHER C. WILMERS
 Environmental Studies Department,
 University of California,
 Santa Cruz, USA
 cwilmers@ucsc.edu

SCOTT WOOLBRIGHT
 The Institute for Genomic Biology,
 University of Illinois,
 Urbana, USA
 sawg@illinois.edu

Foreword

PETER W. PRICE

The word ‘ubiquitous’ crops up repeatedly in this book in relation to trait-mediated indirect interactions (TMIs) in ecology, where one species alters the interchange between two other species. Indeed, the subject of this book has a pervasive relationship with all of ecology, providing a theme and a concept that enmeshes all levels of organization, from individuals to populations, communities, ecosystems and global phenomena. Another term used frequently is ‘strong effect’ for the influence of such indirect interactions in communities and ecosystems. If we are dealing with ever-present and major impacts in ecology, then certainly these kinds of interactions deserve much attention. In fact, the volume of literature in this field appears to be undergoing exponential growth. Therefore, this volume is a timely reminder that the field is expanding rapidly, and a guide on how it can grow along new routes of research and application with time. TMIs as a category of interchanges in ecology are worthy of attention from all ecologists and those in related fields such as agriculture, forestry, conservation, epidemiology, parasitology and animal husbandry.

We should not be surprised by the pervasive and robust influences of TMIs. One example: as with humans, all plants and animals produce body odours, but more so than with humans, the body odours in nature have strong effects on other species, both direct and indirect. A phytochemical may have a direct impact on a herbivore, as well as an indirect effect by acting as an attractant to the enemy of the herbivore. In a community of plants, herbivores, parasitoids and predators there is therefore a rich blend of aromas wafting around, mediating the interactions of a multitude of species. These are not necessarily feeding links that would enter into a food web, but they would become important components of an interaction web, far richer than the conventional food web. Similar increases in interaction richness and complexity are observed when we compare direct feeding links on plants versus indirect interactions emanating from herbivores altering plant traits, which provide new resources for other species. Interactions may more than triple in number when trait-mediated interchanges are recognized.

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In the equation resulting in great biodiversity there is also the role of plant genotype, which influences all trophic levels above and below ground, community structure and ecosystem processes. Therefore, genotypic diversity within populations and species, and their hybrids, has wide-ranging indirect effects, many of them surprisingly strong.

Then we should reflect upon the effects of geographic adjustment of species ranges resulting from climate change, invasive species and species introductions by humans, say, for biological control purposes. All involve animals and plants which influence residents, including in many indirect ways, creating non-analogue communities – never seen before – and a mismatch between consumers and resources. The cohesiveness of communities is disrupted in many indirect ways, such as in diffuse coevolutionary processes.

Part of the wonder and amazement that we enjoy in this literature is derived from our naturalist's fascination with nature. The subject of this book depends on the keen observer, a witness to behavioural interactions; the accomplished chemist who can unravel unseen, cryptic relationships and the formerly mysterious world of molecular processes; and the experimenter who can support or dispel notions and hypotheses on the natural world.

All these topics and many more are discussed in this book, which has become a compendium of the large literature on the vast array of interactions under the umbrella of trait-mediated indirect effects. Theory, concept, hypothesis, modelling, empirical results, predictions and applications to practical environmental problems are blended into this volume. The recognition of indirect effects enriches ecology by an order of magnitude.

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Preface

Ecologists have long found the complexity of ecological systems, brought about by the diversity of species and the myriad direct and indirect interactions among them, to be a source of awe. Such complexity represents a formidable scientific challenge as ecologists struggle to identify the fundamental mechanisms that make sense of the web of interactions that drive ecological functioning and sustainability. The most fundamental mechanism driving complexity is the process of evolution by natural selection, a process that requires variation in phenotypic traits among members of a species. One dimension of this variation is the propensity for organisms to show adaptive shifts in phenotypes to meet challenges imposed by changing environmental conditions. But this fundamental evolutionary mechanism seems somewhat forgotten in modern analyses of community and ecosystem dynamics, where conceptualizations and empirical approaches typically treat organisms (and entire species) as having a fixed set of phenotypic traits, invariant to changes in environmental contexts. Ecologists have largely ignored the community and ecosystem consequences of phenotypic adjustment to environmental conditions, and thereby effectively have overlooked the potential to explain much of context-dependency (and hence variation) in species interactions. Taking into account such flexibility in individual traits will, we believe, enhance the power of our field to explain ecological patterns and to predict the consequences of environmental change.

This volume grew from a symposium entitled ‘Trait-mediated indirect effects in insect communities’, held in Durban, South Africa, at the International Congress of Entomology meeting in July 2008. The symposium brought together a collection of international contributors uniquely qualified to evaluate and expand our understanding of how trait-mediated indirect effects structure insect communities. To offer a broader view of the field, we invited additional authors working in a wide range of ecological systems to contribute chapters. We intend to provide ecologists with insight into the ‘state-of-the-art’ of research focused on trait-based effects, an approach which can link in novel ways individual, population, community and ecosystem

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xvi PREFACE

ecology. Our goal is to foster research on trait-mediated interactions and thereby stimulate ecologists to address more systematically how trait-based effects can modify expectations based on classical approaches that view traits as invariant across environments. This volume reveals in many ways how the conceptual framework of trait-mediated indirect interactions can greatly improve our understanding of evolutionary processes, population dynamics, community structure and stability, and ecosystem properties and functions.

We are very grateful to the British Ecological Society for including this volume in the series titled *Ecological Reviews*. We thank the authors for their hard work in helping us put this volume together, and the many colleagues who kindly reviewed the chapters. Finally, we particularly thank commissioning editor Dominic Lewis, assistant editor Lynette Talbot and production editor Caroline Mowatt for their assistance with the production of this volume. It has been greatly rewarding for us to be involved in crafting a book focused on this emerging, important research area.