Insect predator–prey dynamics

Much of our understanding about insect predator–prey dynamics derives from studies on insect parasitoids. But do true predators such as ladybird beetles really operate in a similar way and how does this affect their use in biological control? The extensive literature on ladybirds as biocontrol agents shows that their size and rate of development is very dependent on the nature of their prey. This volume explores the basic biology of ladybirds, their association with their prey and its effect on development rate and body size. Optimal foraging theory, field observations and laboratory experiments are used to illustrate how ladybird larvae maximize their rate of energy intake, and ladybird adults their fitness. The interdependence of these life-history parameters is then used to develop a simple predator–prey model, which with an analysis of the literature highlights the specific attributes of potentially successful biocontrol agents for all those interested in predator–prey dynamics.

A.F.G. Dixon is an Emeritus Professor in the School of Biological Sciences at the University of East Anglia. He has written over 200 papers on aphids and their natural enemies in scientific journals, and has written or edited nine other books. In 1992, he was awarded the Gregor Mendel Gold Medal by the Czech Academy of Science.
Insect predator–prey dynamics

Ladybird beetles and biological control

A. F. G. DIXON

University of East Anglia
Insect predator–prey dynamics: ladybird beetles and biological control
A. F. G. Dixon

Cambridge University Press
The Edinburgh Building, Cambridge CB2 2RU, UK

Published in the United States of America by Cambridge University Press, New York

www.cambridge.org

Information on this title: www.cambridge.org/9780521622035

© Cambridge University Press 2000

This book is in copyright. Subject to statutory exception and to the provisions of relevant collective licensing agreements, no reproduction of any part may take place without the written permission of Cambridge University Press.

First published 2000
This digitally printed first paperback version 2005

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

Library of Congress Cataloguing in Publication data
Dixon, A. F. G. (Anthony Frederick George)
   Insect predator–prey dynamics : ladybird beetles and biological control /
   A. F. G. Dixon.
   p. cm.
   Includes bibliographical references (p. ).
   ISBN 0 521 62203 4
   1. Ladybugs. 2. Predation (Biology) 3. Insect pests–Biological control. I. Title.
   QL596.C65 D58 2000
   595.76/9  99-045440

ISBN-10  0-521-62203-4 hardback
ISBN-10  0-521-01770-X paperback
Contents

Preface ix
1 Introduction 1
2 Basic biology and structure 6
   Introduction 6
   Life cycle 8
   Morphology 10
      Mouthparts 12
      Alimentary canal 14
      Legs 14
   Development 15
   Survival 17
   Reproduction 18
      Fecundity and longevity 18
      Effect of food supply on egg and cluster size 21
      Interspecific relationships 23
   Overwintering 27
   Defence 29
3 Body size 36
   Introduction 36
   Intraspecific plasticity in size 36
   Sex and size 42
   Sexual size dimorphism 44
   Protandry 46
   Gonadal constraint 50
   Fecundity advantage 52
   Time and energy constraint 52
   Body size distribution 55
      Theory 55
      Empirical data 57
4 Slow–fast continuum in life history parameters
   Introduction
   Speed of movement
   Developmental time and metabolic rate
   Fecundity and longevity
   Trade-off

5 Foraging behaviour
   Introduction
   Functional response
   Prey recognition
   Relative risk as a determinant of diet breadth
   Prey specificity
   Switching
   Adult foraging behaviour
      Location of prey
      Patch quality
   Egg distribution
   Larval foraging behaviour
      Location of prey
   Survival
   Ladybird abundance

6 Cannibalism
   Introduction
   Theory
   Cannibalism by adults
   Cannibalism by larvae
      Fitness
      Currency
   Model
   Empirical data
   Avoidance of cannibalism
      Eggs
      Pupae
   Cannibalism as a means of harvesting prey – the icebox hypothesis

7 Theory of predator–prey interactions
   Introduction
Preface

Ladybird beetles are familiar and popular insects and therefore need no introducing. The objective of this book is to give university students and research workers a better understanding of predation by insects than is to be found in most current ecological texts.

As stated in the Introduction the foundations of this book were built upon the enthusiasm for and understanding of ladybirds of my colleagues and students. In addition Jean-Louis Hemptinne kindly read and commented on the whole manuscript, and Pavel Kindlmann, on Chapter 7. Other people too have helped in the preparation of the book. I am especially grateful to CSIRO Entomology and Veronica Brancatini for supplying, with permission to use, the photograph of *Rodolia cardinalis* that is on the back cover, and to CAB International and Roger Booth for permission to reproduce the habitus drawing of *Hyperaspis pantherina* in Chapter 9.

I also wish to express special thanks to Diane Alden for preparing the figures and to Karen Harris for typing some of the manuscript.

I dedicate this book to June.

Tony Dixon