

Contents

Section I Introduction

1	The Various Effects of Insects on Ecosystem Functioning	3
	W.W. WEISSER and E. SIEMANN	
1.1	Summary	3
1.2	Introduction	3
1.3	A Brief Overview of Insect Effects on Ecosystem Function .	8
1.3.1	Insect Effects on Ecosystem Function Via Interactions with Plants	8
1.3.1.1	Herbivory	8
1.3.1.2	Plant–Insect Mutualisms	14
1.3.2	Other Direct and Indirect Effects of Insects on Ecosystem Function	14
1.4	The Aim and Structure of this Book	15
	References	19

Section II Insects and the Belowground System

2	Insect Herbivores, Nutrient Cycling and Plant Productivity	27
	S.E. HARTLEY and T. H. JONES	
2.1	Summary	27
2.2	Introduction	28
2.3	Decomposition	28
2.3.1	The Resources Available	28
2.3.2	Effects of Insect Herbivory on Decomposition	31

2.3.2.1 Herbivory and Litter Quality 31

2.3.2.2 Herbivory, Root Exudation and Root Biomass 32

2.4 Nutrient Cycling and Plant Productivity 33

2.4.1 Effects on Carbon and Nitrogen Cycling 34

2.4.1.1 Methane and Carbon Dioxide 34

2.4.1.2 Nitrogen and Phosphorus 35

2.4.1.3 Inputs from Aboveground Herbivores 36

2.4.1.4 The Importance of Belowground Biota: Evidence
 from Controlled Environment Studies 39

2.4.1.5 Insect Herbivory and Spatial Variation
 in Nutrient Availability 40

2.4.2 Herbivory and Plant Biomass 41

2.5 Conclusions 45

References 46

**3 Indirect Effects of Invertebrate Herbivory
 on the Decomposer Subsystem 53**
D.A. WARDLE and R.D. BARDGETT

3.1 Summary 53

3.2 Introduction 54

3.3 Mechanistic Bases of Invertebrate Herbivore Effects 54

3.3.1 Immediate Effects on Resource Quantity 56

3.3.2 Longer-Term Effects on Resource Quantity 56

3.3.3 Effects of Changed Litter Quality 57

3.3.4 Return of Invertebrate Waste Products 58

3.3.5 Effects of Changes in Vegetation Composition 59

3.3.6 Feedbacks and Aboveground Consequences 61

3.4 Significance of Invertebrate Herbivore Outbreaks 61

3.5 Multiple Species Herbivore Communities 62

3.6 Comparisons of Ecosystems 64

3.7 Conclusions 65

References 66

**4 Biotic Interactions in the Rhizosphere:
 Effects on Plant Growth and Herbivore Development 71**
M. BONKOWSKI and S. SCHEU

4.1 Summary 71

4.2 The Rhizosphere – Interface of Intense Microbial
 and Faunal Interactions 72

Contents	IX
----------	----

4.2.1	Plants as Drivers of Rhizosphere Interactions	73
4.3	Belowground Interactions and the Herbivore System	74
4.3.1	Effects of Mycorrhiza and Rhizobacteria on Aboveground Herbivores	76
4.3.2	Interactions with the Micro-Decomposer Food Web	77
4.3.2.1	The Bacterial Loop and Herbivore Performance	78
4.3.2.2	The Fungal Food Chain and Herbivore Performance	79
4.3.2.3	Ecosystem Engineers and Herbivore Performance	81
4.4	Top-Down Effects by Subsidizing Generalist Predators . . .	83
References	. . . . .	85

5	Belowground Herbivores and Ecosystem Processes	93
	G.J. MASTERS	
5.1	Summary	93
5.2	Introduction	94
5.3	Experimenting with Belowground Insect Herbivores	94
5.4	Belowground Herbivory and Plant Productivity: Allocation and Biomass	97
5.5	Implications of Belowground Herbivory for Nutrient Cycling	101
5.6	Implications of Belowground Herbivory for Multitrophic Interactions	104
5.7	Conclusion	109
References	. . . . .	109

Section III Plant–Insect Interactions and Ecosystem Processes

6	Bottom-Up Effects and Feedbacks in Simple and Diverse Experimental Grassland Communities	115
	J. JOSHI, S.J. OTWAY, J. KORICHEVA, A.B. PFISTERER, J. ALPHEI, B.A. ROY, M. SCHERER-LORENZEN, B. SCHMID, E. SPEHN and A. HECTOR	
6.1	Summary	115
6.2	Introduction	116
6.3	Effects of Plant Diversity on Herbivorous Insects Feeding Above Ground	117

6.3.1	Hypotheses Predicting the Response of Herbivores to Higher Plant Diversity	117
6.3.2	Responses of Specialist and Generalist Herbivores in Plant Diversity Experiments	119
6.3.3	Concomitant Responses of Natural Enemies of Herbivores	123
6.3.4	Insect Herbivores as Drivers of Ecosystem Processes	124
6.4	Effects of Plant Diversity on Pathogens	125
6.5	Belowground Food Web	126
6.5.1	Plant Biomass and Microbial Response	126
6.5.2	Soil Animals that Feed on Microbes	128
6.6	Conclusions	129
	References	130

7 **The Potential of Phytophagous Insects in Restoring Invaded Ecosystems: Examples from Biological Weed Control** 135

H. ZWÖLFER and H. ZIMMERMANN

7.1	Summary	135
7.2	Introduction	136
7.3	Success Rates and Successes in Biological Weed Control	137
7.4	Weed Characteristics and Positive Traits of Insects in Biological Control	138
7.4.1	Weed Species	139
7.4.2	Insect Species	139
7.5	Three Examples of Successful Weed Control	140
7.5.1	<i>Rhinocyllus conicus</i> on <i>Carduus nutans</i>	140
7.5.2	Interactions Between Three Weevil Species in the Biocontrol of the Invader <i>Sesbania punicea</i> in South Africa	143
7.5.2.1	The Seed-Destroying Agents: <i>Trichapion lativentre</i> and <i>Rhyssomatus marginatus</i>	144
7.5.2.2	The Stem-Borer: <i>Neodiplogrammus quadrivittatus</i>	145
7.5.3	Aquatic Weeds	146
7.6	Discussion and Conclusions	147
	References	150

8 **Plant-Insect-Pathogen Interactions on Local and Regional Scales** 155

A. KRUESS, S. EBER, S. KLUTH and T. TSCHARNTKE

8.1	Summary	155
8.2	Introduction	156

8.3	Biological Weed Control, Interactions and Ecosystem Processes	157
8.3.1	Classical Biological Control	157
8.3.2	Plant–Pathogen–Herbivore Interactions	158
8.4	Creeping Thistle, Insects, Pathogens and Processes	160
8.4.1	The Creeping Thistle (<i>Cirsium arvense</i>)	160
8.4.2	Interactions Between Pathogens and Insect Vectors on a Local Scale	161
8.4.3	Regional Dynamics of <i>Cirsium arvense</i> and an Associated Herbivore	163
8.4.4	The Influence of Landscape Context at Different Spatial Scales	165
8.5	Conclusions and Future Outlook	168
	References	169
 9	 Food Web Interactions and Ecosystem Processes	 175
	A. JANSSEN and M.W. SABELIS	
9.1	Summary	175
9.2	Introduction	175
9.3	Interactions Among Entire Trophic Levels	178
9.4	Effects of Diversity Within Trophic Levels	179
9.4.1	Apparent Competition	180
9.4.2	Omnivory	180
9.4.3	Intraguild Predation	181
9.4.4	Plant-Mediated Indirect Interactions Between Herbivores	181
9.4.5	Indirect Plant Defences	182
9.4.6	Interactions Among Plants	183
9.4.7	Behavioural Effects	184
9.5	Conclusions and Perspectives	184
	References	186
 10	 A General Rule for Predicting When Insects Will Have Strong Top-Down Effects on Plant Communities: On the Relationship Between Insect Outbreaks and Host Concentration	 193
	W.P. CARSON, J. PATRICK CRONIN and Z.T. LONG	
10.1	Summary	193
10.2	Introduction	193
10.3	The Significance of Insect Outbreaks	194

10.3.1 Insect Outbreaks Are Common
in Numerous Community-Types Worldwide 195

10.3.2 Insect Outbreaks Are More Common and More
Devastating per Host in Large, Dense and
Continuous Host Stands 199

10.3.3 Native Outbreacking Insects Function as Keystone Species
by Reducing the Abundance of the Dominant Species
and Increasing Diversity 200

10.3.4 Insect Outbreaks Are Common Relative
to Host Life Span Yet May Often Go Unnoticed 201

10.3.5 Chrysomelid Beetles and Lepidoptera Seem
to be Responsible for the Majority of Outbreaks 201

10.4 The Host Concentration Model May Predict Insect Impact
on Plant Communities at Multiple Spatial Scales Better
Than Resource Supply Theory 202

10.4.1 Resource Supply Theory 202

10.4.2 The Host Concentration Model (HCM) 203

10.4.3 Distinguishing Between the Two Models 204

10.5 Relationship to Other Related Processes Proposed
to Promote Diversity 204

10.5.1 Does Pathogen Impact Increase with Host Concentration? . 205

References 205

11 The Ecology Driving Nutrient Fluxes in Forests 213
B. STADLER, E. MÜHLENBERG and B. MICHALZIK

11.1 Summary 213

11.2 Introduction 214

11.3 Life Histories of Canopy Insects 215

11.3.1 Aphids 215

11.3.2 Scale Insects 215

11.3.3 Lepidopterous Larvae 216

11.4 Population Ecological Background of Nutrient Fluxes 217

11.4.1 Sites and Experimental Setup 219

11.4.2 Results 220

11.5 Trophic Effects and Organic Pathways 224

11.6 Herbivore-Mediated Changes in Quality
and Quantity of Nutrient Fluxes 226

11.7 Synthesis and Conclusions 230

11.7.1 Understanding the Temporal Dynamics
of Energy and Nutrient Fluxes 230

11.7.2 Understanding the Spatial Variability in Fluxes 231

11.7.3	Understanding the Mechanics that Regulate Fluxes	232
11.7.4	Generating Testable Hypotheses	233
References	. . . . .	235

Section IV **Methods: Reducing, Enhancing and Simulating Insect Herbivory**

12	Simulating Herbivory: Problems and Possibilities	243
	J. HJÄLTÉN	
12.1	Summary	243
12.2	Introduction to the Problem	244
12.3	Advantages of Simulated Herbivory	245
12.4	Disadvantages of Simulated Herbivory	247
12.4.1	Simple Biotic Interactions	247
12.4.2	Complex Biotic Interactions	249
12.4.3	Basic Ecosystem Processes	250
12.5	Conclusions and Suggestions for the Future	251
References	. . . . .	253
 13	 The Use and Usefulness of Artificial Herbivory in Plant–Herbivore Studies	 257
	K. LEHTILÄ and E. BOALT	
13.1	Summary	257
13.2	Introduction	258
13.3	Material and Methods	258
13.4	Commonness of Differences Between Natural and Artificial Herbivory	260
13.5	Strength of the Effect of Natural and Artificial Damage . . .	266
13.6	Responses of Different Types of Response Traits to Artificial and Natural Damage	267
13.7	Simulations of Mammalian and Invertebrate Herbivory . . .	269
13.8	Attempts of Exact Simulation	270
13.9	Conclusions	271
References	. . . . .	273

14	From Mesocosms to the Field: The Role and Value of Cage Experiments in Understanding Top-Down Effects in Ecosystems	277
	O.J. SCHMITZ	
14.1	Summary	277
14.2	Introduction	278
14.3	Research Approach	281
14.4	<i>In</i> -Ecosystem Investigation Using Enclosure Experiments	282
14.4.1	Natural History: Knowing the Players in the System	282
14.4.2	Enclosure Cages: Design and Biophysical Properties	285
14.4.3	Considerations for the Design of Cage Experiments	288
14.4.3.1	Artificial Complements of Populations or Communities in Enclosure Cages Are Not Realistic	288
14.4.3.2	Experimental Outcome Could Be an Artifact of the Venue	288
14.4.3.3	Enclosures Unrealistically Constrain Movement of Species	289
14.4.3.4	Time Scale of Enclosure Experiments Exclude or Distort Important Features of Communities and Ecosystems	290
14.4.4	Mechanistic Insights from Enclosure Cage Experiments	290
14.4.4	Identifying the Potential for Top-Down Control	291
14.4.5	<i>Of</i> -Ecosystem Studies: Testing the Reliability of Mechanistic Insights from Cage Experiments	297
14.4.5.1	Direct and Indirect Effects of Top Predators	299
14.4.5.2	Top Predator Effects on Plant Diversity and Productivity	300
	References	300
15	Reducing Herbivory Using Insecticides	303
	E. SIEMANN, W.P. CARSON, W.E. ROGERS and W.W. WEISSER	
15.1	Summary	303
15.2	Basic Concepts	303
15.3	Using Insecticides to Infer the Role of Herbivores	304
15.4	Ghost of Herbivory Past	307
15.5	Artifacts of Method May Masquerade as Release from Herbivory	308
15.5.1	What Types of Artifacts Are a Concern?	308
15.5.2	Overview of Published Studies	309
15.5.3	Quantification of Herbivore Damage	310
15.5.4	Phytotoxic Effects	311
15.5.5	Insecticides May Be Toxic to Several Groups of Insects	313
15.5.6	Effects of Insecticides on Non-Arthropods	314
15.5.7	Effects of Insecticides on Soil Organisms	314

15.5.8	Nutrient Inputs May Facilitate Plant Growth	315
15.5.9	Insect-Vectored Diseases	317
15.5.10	Community-Level Artifacts	318
15.6	Are There Better Types of Insecticides?	318
15.7	Conclusions	319
	Appendix: Results of Surveyed Studies	320
	References	324

16	The Role of Herbivores in Exotic Plant Invasions: Insights Using a Combination of Methods to Enhance or Reduce Herbivory	329
	W.E. ROGERS and E. SIEMANN	

16.1	Summary	329
16.2	Introduction	329
16.3	The Role of Herbivores in Exotic Plant Invasions	330
16.4	Focal Plant Species	331
16.5	Experimental Methods for Assessing Herbivory Effects . . .	331
16.5.1	Common Garden/Reciprocal Transplant Studies	332
16.5.2	Reducing Herbivory on Target Plants Using Insecticide Sprays	336
16.5.3	Reducing Herbivory on Community Assemblages Using Insecticide Sprays	337
16.5.4	Factorial Manipulations of Herbivory, Resources and Competition	338
16.5.5	Simulating Herbivory Via Mechanical Leaf Damage	339
16.5.6	Simulating Herbivory Via Mechanical Root Damage	341
16.5.7	Simulating Herbivory Using Herbicide Sprays	342
16.5.8	Assessing Herbivore Damage Using Exclosures and Enclosures	344
16.6	Implications and Potential Significance	347
	References	349

17	Herbivore-Specific Transcriptional Responses and Their Research Potential for Ecosystem Studies	357
	C. VOELCKEL and I.T. BALDWIN	

17.1	Summary	357
17.2	The Subtle Effects of Insects on Ecosystem Function	357
17.3	Transcriptional Regulation of Plant Responses	358
17.4	Insect-Induced Transcriptional Changes	362

17.5 How a Molecular Understanding of Plant–Insect
 Interactions Can Help Elucidate Ecosystem Function 371

References 375

Section V Synthesis

18 Testing the Role of Insects in Ecosystem Functioning 383
 E. SIEMANN and W.W. WEISSER

18.1 Summary 383

18.2 Introduction 384

18.3 Simple Models of Niche Space 385

18.3.1 Reduced Vigour Model 385

18.3.2 Reduced Range of Tolerance Model 387

18.3.3 Specialist Herbivores 388

18.4 Effects of Herbivores in Resource Competition Models . . . 389

18.4.1 Specialist Herbivores in Resource Competition Models . . . 391

18.4.2 Generalist Herbivores in Resource Competition Models . . 395

18.5 Differential Impacts on Plants with Different Traits 396

18.6 Conclusions from the Modelling Work 396

18.7 Suggestions for Future Studies 397

18.7.1 Exploring Below- and Aboveground Interactions
 in More Detail 397

18.7.2 Measuring Herbivory Effects at Nominal Levels
 as Well as in Outbreak Situations 398

18.7.3 Quantifying the Effects of Plant Resource Allocation
 Under Herbivory for Ecosystem Functioning 399

18.7.4 Combining Various Methodologies to Achieve
 an Understanding of Insect Effects on Ecosystem Function . 399

References 400

Subject Index 403

Taxonomic Index 409



<http://www.springer.com/978-3-540-74003-2>

Insects and Ecosystem Function
Weisser, W.W.; Siemann, E. (Eds.)
2008, XXI, 415 p., Softcover
ISBN: 978-3-540-74003-2