

OXFORD  
BIOLOGY

# Insect Conservation

*A Handbook of Approaches and Methods*

MICHAEL J. SAMWAYS  
MELODIE A. McGEOCH  
TIM R. NEW

*Techniques in Ecology & Conservation Series*

# Contents

## Introduction

xiii

<b>1</b>	<b>Introducing insect conservation</b>	<b>1</b>
1.1	The challenge: the relevance of sampling insects	1
1.2	An historical perspective	2
1.3	Ethics of insect conservation	3
1.4	Ethics of collecting insects	6
1.5	Ecological and evolutionary timescales	10
1.6	The taxonomic challenge	13
1.7	Summary	15
<b>2</b>	<b>Taxonomy and curation of insects</b>	<b>17</b>
2.1	Introduction: essential planning	17
2.2	Selection of insect groups for study	19
2.3	Taxonomic knowledge	21
2.4	Taxonomic resolution	25
2.5	Morphospecies and parataxonomists	27
2.5.1	<i>The morphospecies approach</i>	27
2.5.2	<i>Parataxonomists</i>	29
2.5.3	<i>Voucher collections</i>	30
2.6	Bioinformatics	31
2.6.1	<i>Virtual voucher collections</i>	33
2.6.2	<i>Sample tracking</i>	33
2.6.3	<i>Taxonomy using barcoding</i>	34
2.7	Specimen treatment	35
2.7.1	<i>Sequence of steps for treating insect samples</i>	38
2.7.1.1	Preservation	38
2.7.1.2	Mounting	46
2.7.1.3	Storage	53
2.8	Summary	57
<b>3</b>	<b>Designing sampling protocols for insect conservation</b>	<b>59</b>
3.1	Introduction	59
3.2	Defining the conservation question	60
3.2.1	<i>Broad objectives in insect conservation</i>	61
3.2.2	<i>Refining the objective</i>	63
3.2.3	<i>Hypothesis formulation</i>	64
3.3	Designing a sampling protocol	65
3.3.1	<i>Sample grain</i>	66

3.3.2	<i>Sample extent</i>	67
3.3.3	<i>Sample number</i>	68
3.3.4	<i>Sample independence</i>	70
3.3.5	<i>Spatial autocorrelation</i>	73
3.3.6	<i>Sample placement</i>	76
3.3.7	<i>Sampling coverage and intensity</i>	79
3.3.8	<i>Controls</i>	79
3.4	<i>Pilot studies</i>	80
3.5	<i>Coping with the unexpected</i>	81
3.6	<i>Data management</i>	82
3.7	<i>Summary</i>	82
<b>4</b>	<b>Collecting and recording insects</b>	<b>85</b>
4.1	<i>Introduction: What do you really need to collect?</i>	85
4.2	<i>Named and nameless approaches to data portrayal</i>	87
4.3	<i>High-canopy insects</i>	92
4.4	<i>Low-canopy insects</i>	96
4.5	<i>Grass/herbaceous layer</i>	99
4.6	<i>Sampling flying insects</i>	101
4.7	<i>Sampling insects on the ground</i>	116
4.8	<i>Sampling insects in the leaf litter and soil</i>	121
4.9	<i>Sampling aquatic insects</i>	124
4.10	<i>Sound recording</i>	127
4.11	<i>Summary</i>	129
<b>5</b>	<b>Measuring environmental variables</b>	<b>131</b>
5.1	<i>Introduction: selection of variables</i>	131
5.2	<i>Conceptualizing environmental variable data</i>	134
5.3	<i>Choosing the environmental variables</i>	135
5.4	<i>Measuring air and soil environmental variables</i>	146
5.5	<i>Measuring vegetation characteristics</i>	153
5.6	<i>Aquatic environmental variables</i>	156
5.7	<i>Summary</i>	159
<b>6</b>	<b>Estimating population size and condition</b>	<b>161</b>
6.1	<i>Introduction: the relevance of populations</i>	161
6.2	<i>Assessing changes in population levels</i>	163
6.3	<i>Significance of surveys</i>	166
6.4	<i>Evaluating population structure</i>	168
6.5	<i>Measuring population size</i>	171
6.5.1	<i>Some underlying principles</i>	171
6.5.2	<i>Temporal considerations</i>	173
6.5.3	<i>Spatial considerations and differences between sexes</i>	177
6.5.4	<i>Accuracy of estimates relative to feasibility</i>	177



6.5.5	<i>Special considerations for threatened species</i>	178
6.5.6	<i>Direct counts</i>	179
6.5.7	<i>Transect counts</i>	183
6.5.7.1	<i>Line transects</i>	183
6.5.7.2	<i>Point transects</i>	187
6.5.7.3	<i>Belt transects</i>	187
6.5.8	<i>Quadrat counts</i>	188
6.6	Populations and conservation status	189
6.6.1	<i>Conservation status</i>	189
6.6.2	<i>Level of threat</i>	191
6.7	Population distinctiveness	202
6.8	Population condition	204
6.9	Population modelling	205
6.10	Summary	206
<b>7</b>	<b>The population and the landscape</b>	<b>209</b>
7.1	Introduction: the relevance of landscapes	209
7.2	Effects of landscape structure	211
7.3	Resources and landscape geometry: the insect's habitat	217
7.4	Insect movements and MRR methods	218
7.4.1	<i>MRR process</i>	226
7.4.2	<i>Capture</i>	228
7.4.3	<i>Marking</i>	229
7.4.4	<i>Release</i>	232
7.4.5	<i>Recapture</i>	232
7.4.6	<i>Outcomes from MRR studies</i>	233
7.5	Landscape geometry and insect populations	235
7.6	Dispersal and dispersion (aggregation)	240
7.6.1	<i>Activity patterns</i>	243
7.6.2	<i>Recording activity and abundance</i>	244
7.7	Summary	245
<b>8</b>	<b>Ex-situ conservation: captive rearing and reintroduction programmes</b>	<b>247</b>
8.1	Introduction: conservation objectives	247
8.2	Farming or ranching insects for conservation	252
8.3	Process	253
8.3.1	<i>Capture</i>	257
8.3.2	<i>Transport</i>	258
8.3.3	<i>Maintenance</i>	259
8.3.4	<i>Breeding</i>	260
8.3.5	<i>Release</i>	264
8.4	Practical outcomes	268
8.5	Summary	271

<b>9 Biodiversity and assemblage studies</b>	<b>273</b>
9.1 Introduction: defining biodiversity in space and time	273
9.2 The assemblage matrix	275
9.3 The relational matrix	278
9.4 Estimating sampling adequacy	278
9.4.1 <i>Taxon sampling (accumulation and rarefaction) curves</i>	280
9.5 Species richness	282
9.5.1 <i>Comparisons of species richness</i>	282
9.5.2 <i>Estimating species richness</i>	282
9.5.3 <i>Choosing a richness estimator</i>	283
9.6 Species abundance and density	284
9.7 Species range and distribution	287
9.7.1 <i>Biodiversity mapping</i>	288
9.8 Diversity indices	292
9.8.1 <i>Species richness, evenness and dominance</i>	292
9.8.2 <i>Beta diversity</i>	295
9.8.3 <i>Functional diversity</i>	298
9.8.4 <i>Taxonomic diversity</i>	300
9.9 Phylogenetic comparative methods	302
9.10 Summary	303
<b>10 Studying insects in the changing environment</b>	<b>305</b>
10.1 Introduction: drivers and methodology	305
10.2 Environmental change in context	305
10.3 Approaches to studying environmental change	306
10.3.1 <i>Methodological approaches</i>	306
10.3.2 <i>Modelling</i>	307
10.4 Bioindicators	310
10.4.1 <i>Bioindication terminology and development</i>	311
10.4.2 <i>Taxa that make good bioindicators</i>	312
10.4.3 <i>Quantifying the indicator value of a species</i>	318
10.4.4 <i>Testing the proposed bioindicator and developing the bioindicator system</i>	321
10.5 Biodiversity assessment	322
10.6 Biodiversity mapping	325
10.7 Summary	331
<b>11 Key questions for insect conservation in an era of global change</b>	<b>333</b>
11.1 Forms of environmental change	333
11.1.1 <i>Habitat loss, fragmentation, and isolation</i>	333
11.1.2 <i>Disturbance, decline in habitat quality and the loss of critical resources</i>	335
11.1.3 <i>Impact of invasive alien species</i>	336

11.1.4	<i>Climate change</i>	337
11.1.5	<i>Biotechnology, biological control, and sustainable harvesting</i>	346
11.1.5.1	<i>Biotechnology</i>	346
11.1.5.2	<i>Biological control</i>	351
11.1.5.3	<i>Sustainable harvesting</i>	352
11.1.6	<i>Aquatic and terrestrial systems contamination</i>	353
11.2	<i>Consequences of species loss for ecosystem function</i>	354
11.2.1	<i>Importance of diversity</i>	354
11.2.2	<i>Temporal perspectives, adverse synergisms and discontinuities</i>	354
11.2.3	<i>Species numbers, rarity and ecosystem function</i>	355
11.2.4	<i>The importance of food web connectance</i>	357
11.2.5	<i>Rare and threatened species as flagships</i>	358
11.3	<i>Lessons learned from diversity value: towards a synthetic management approach</i>	359
11.4	<i>Triage and restoration</i>	364
11.5	<i>Ecological monitoring</i>	365
11.6	<i>Engaging citizen scientists in insect conservation</i>	368
11.7	<i>Summary</i>	371
	<i>Software</i>	373
	<i>References</i>	375
	<i>Glossary</i>	405
	<i>Index</i>	425