

Preface to the Fourth Edition	xix
Preface to Volume I	xxi
Acknowledgment	xxiii
Contributors to Volume I	xxv

Section I Introduction

1. Introduction to Invertebrates of Inland Waters

*James H. Thorp, D. Christopher Rogers,
Walter W. Dimmick*

Introduction	3
Species and Phylogenies	4
Species and Concepts of Species	4
The Role of Phylogenies in Studies of Ecology and Behavior	7
Phylogenetic Trees	8
Using Systematics and Taxonomy to Classify Organisms	9
Taxonomic Keys to Invertebrates of Inland Waters	10
Key to Freshwater Invertebrates	11
Mollusca Classes	11
Annelid Groups	12
Arthropod Subphyla	12
References	21

2. Overview of Inland Water Habitats

James H. Thorp, Alan P. Covich

Introduction	23
Global Variations in Aquatic Habitats	24
Polar Zones and Alpine Habitats	24
Temperate Zones	25
Tropical Zone	25
Oceanic Islands	26
Australia—A Unique Biogeographic Region	28
Lotic Ecosystems: Rivers, Streams, and Springbrooks	28

Introduction to Lotic Systems	28
The Structure of Rivers at Different Spatial Scales	29
Intermittent Streams	32
Springs and Headwaters	34
Rivers	35
Hydrology and Hydraulics	36
Substrates	37
Chemical and Thermal Milieu	38
General Human Impacts on Lotic Communities	40
Subterranean Habitats	41
Hyporheic and Phreatic Zones	41
Aquatic Habitats in Caves and Other Karst Topography	42
Lentic Ecosystems: Lakes, Ponds, Wetlands, and Phytotelmata	43
Lakes	43
Reservoirs: Artificial Lakes	46
Wetlands	46
Hypersaline Lakes and Pools	48
Phytotelmata	49
General Human Impacts on Lentic Communities	49
References	50

3. Collecting, Preserving, and Culturing Invertebrates

D. Christopher Rogers, James H. Thorp

Introduction	57
Collecting Legally	57
Collecting Safely	58
Collecting Conservatively	58
Collecting and Sampling	58
Obtaining Benthic Invertebrates	59
Obtaining Planktonic Invertebrates	60
Record-Keeping	61
Preserving and Fixing Specimens	61
Culturing Invertebrates	62

Section II General Ecology and Human Impacts

4. Functional Relationships of Freshwater Invertebrates

James H. Thorp

Introduction	65
Distribution in Space	65
Physical and Ecological Characteristics of Lotic Ecosystems	66
Physical and Ecological Characteristics of Lentic Ecosystems	68
Aquatic–Terrestrial Ecotones	70
Acquiring Energy	71
Biodiversity Traits and Functional Feeding Groups	71
Aquatic Food Webs	72
Regulating Populations and Communities	75
Density-Dependent Control: Top-Down and Bottom-Up	76
Density-Independent Control: Environmental Variability	77
Acknowledgment	79
References	79

5. Ecology of Invasive Alien Invertebrates

Anthony Ricciardi

Rates and Global Extent of Freshwater Invertebrate Invasions	83
Human Vectors of Dispersal	84
Traits Conferring Invasion Success	86
Ecological Impacts	86
Can the Impacts of Alien Invertebrates be Predicted?	88
Management of Invasive Aquatic Invertebrates	88
References	89

6. Economic Aspects of Freshwater Invertebrates

Vincent H. Resh, David M. Rosenberg

Freshwater Invertebrates in Commerce	93
Aquaculture	93
Human Diets: The Invertebrate–Fish Connection	94
Freshwater Pearls and Insect Jewelry	95
Biomonitoring	97
Nuisance Aquatic Insects	98
Trichoptera	98
Ephemeroptera	98

Diptera	98
Benefits or Damages Caused by Introduced or Invasive Species	100
Direct Market Economic Benefits and Damages	100
Indirect Nonmarket Economic Benefits and Damages	102
Medicinal Leeches	103
Stresses to Livestock and Wildlife from Biting Flies	104
Diseases Vectored by Freshwater Invertebrates	104
Incidence	104
Habitats of Human Disease Vectors	105
Insect Vectors of Human Disease	106
Snails as Intermediate Hosts of Human Disease	106
Crustaceans as Intermediate Hosts of Human Disease	107
Acknowledgments	107
References	107

Section III Protozoa to Tardigrada

7. Free-Living Protozoa

Genoveva F. Esteban, Bland J. Finlay, Alan Warren

Introduction	113
The Nature of Protozoa as a Group	113
The Nature of Protozoan “Species”	114
Structure and Function of the Protozoan Cell	115
General Characteristics	115
Locomotion	115
Food Intake	116
Structural Elements	116
Reproduction	116
Biological Diversity of Free-Living Protozoa	116
Functional Groups of Free-Living Protozoa	116
Amoeboid Protozoa	118
Flagellated Protozoa	120
Ciliated Protozoa	122
Other Types of Protozoa	125
General Ecology of Protozoa	126
Functional Roles of Free-Living Protozoa	126
Symbiotic Associations	127
Protozoa and Ecosystem Function	127
Life in Low-Oxygen Environments	128
Groundwater Protozoa	128
Collecting and Culturing Protozoa	129
Collecting Protozoa and Assessing Diversity	129

Culturing Protozoa	130	10. Phylum Platyhelminthes	
Acknowledgment	131	<i>Carolina Noreña, Cristina Damborenea,</i>	
References	131	<i>Francisco Brusa</i>	
8. Phylum Porifera		Introduction	181
<i>Renata Manconi, Roberto Pronzato</i>		General Systematic	181
Introduction	133	Phylogenetic Relationships	184
General Systematics	133	Distribution and Diversity	184
Evolution and Phylogenetics	134	General Biology	186
Biogeography and Diversity	135	Body Wall, Epidermis, and Sensory	
General Biology	138	Structures	186
Body Bauplan	138	Parenchyma	188
Life History Changes in Morphology	140	Regeneration	190
Anatomy and Physiology	140	Neural System	191
Life History, Life Cycle, and		Digestive Tract	192
Reproduction	143	Osmoregulatory and Excretory Systems	194
General Ecology and Behavior	145	Reproductive System and Development	194
Habitat Selection	145	General Ecology and Behavior	197
Feeding Behavior	146	Habitat Selection	197
Other Behavioral Adaptive Traits	147	Food Web Role in the Ecosystem	197
Competition and Cooperation	148	Ectosymbiosis	198
Sponges as a Natural Resource	149	Physiological Constraints	199
Collecting, Rearing, and Preparation for		Collecting, Culturing, and Specimen	
Identification	149	Preparation	199
References	151	Collecting	199
		Culturing	200
		Specimen Preparation	200
		Acknowledgment	200
		References	200
9. Phylum Cnidaria		11. Phylum Nemertea	
<i>Nadine C. Folino-Rorem</i>		<i>Malin Strand, Per Sundberg</i>	
Introduction	159	Introduction	205
General Features of the Phylum	159	General Systematics	205
General Systematics	159	Phylogenetic Relationships	206
Phylogenetic Relationships	161	Distribution and Diversity	206
Distribution and Diversity	162	General Biology	207
General Biology	164	External Anatomy	207
External Anatomy	164	Internal Anatomy and Physiology	207
Internal Anatomy	166	Reproduction and Development	208
Physiology	166	General Ecology and Behavior	208
Reproduction and Life History	168	Collecting, Culturing, and Specimen	
General Ecology and Behavior	171	Preparation	209
Habitat Selection	171	Collecting and Culturing	209
Physiological Constraints	172	Specimen Preparation	209
Feeding Behavior	172	References	209
Predators	173		
Other Ecological Aspects of Cnidaria	173	12. Phylum Gastrotricha	
<i>Hydra</i> as a Model Organism	175	<i>Tobias Kanneby, Rick Hochberg</i>	
Collecting, Culturing, and Specimen		Introduction	211
Preparation	175	General Systematics	211
Collecting	175		
Culturing	176		
Specimen Preparation	176		
References	177		

Phylogenetic Relationships	212	Predators and Parasites of Freshwater	
Distribution and Diversity	214	Nematodes	291
General Biology	214	Freshwater Stages of Invertebrate and	
External Anatomy	214	Vertebrate Parasitic Nematodes	292
Internal Anatomy and Physiology	216	Collecting, Rearing, and Preparing Specimens	297
Reproduction	217	Sampling Methods	297
General Ecology and Behavior	218	Extraction	298
Habitat Selection	218	Fixing and Mounting	299
Physiological Constraints	218	Culturing	300
Feeding Behavior	220	References	300
Predators and Parasites	220		
Collecting, Culturing, and Specimen			
Preservation	220		
References	221		
13. Phylum Rotifera		15. Phylum Nematomorpha	
<i>Robert L. Wallace, Terry W. Snell,</i>		<i>Matthew G. Bolek, Andreas Schmidt-Rhaesa,</i>	
<i>Hilary A. Smith</i>		<i>L. Cristina De Villalobos, Ben Hanelt</i>	
Introduction to Rotifera	225	Introduction to Nematomorpha	303
General Characteristics	225	General Introduction	303
Biogeography	228	General Systematics	304
Evolutionary Relationships	230	Phylogenetic Relationships	304
General Biology	231	Distribution and Diversity	304
External Morphology	231	General Biology	305
Organ System Structure and Function	232	External Anatomy	305
Environmental Physiology	238	Internal Anatomy	306
Ecology and Evolution	242	Physiology	308
Diversity and Distribution	242	Reproduction and Life Cycle	308
Reproduction and Life History	249	General Ecology and Behavior	316
Ecological Interactions	258	Host Specificity	316
Collecting, Culturing, and Preparation for		Sex Ratios	317
Identification	265	Habitat Selection	318
Collecting	265	Physiological Constraints	319
Culturing	266	Effects of Pesticides	319
Preparation for Identification	268	Feeding Behavior	319
References	269	Predation, Parasitism, and Commensals	319
		Collecting, Culturing, and Preparing	
		Specimens	321
		Collecting	321
		Culturing	321
		Specimen Preparation	322
		Acknowledgment	323
		References	323
14. Phylum Nemata		16. Phyla Ectoprocta and Entoprocta	
<i>George O. Poinar Jr</i>		(Bryozoans)	
Introduction	273	<i>Timothy S. Wood</i>	
Evolution and Phylogenetic Relationships	273	Introduction	327
Biogeography and Diversity	274	Origin and Evolutionary Development of	
General Biology	275	Ectoprocta	328
External Anatomy	275	General Biology of Ectoprocta	328
Internal Anatomy	278	External and Internal Anatomy	328
Growth and Reproduction	284	Food, Feeding, and Digestion	331
General Ecology and Behavior	286	Reproduction	332
Habitat Selection	286	General Ecology and Behavior of Ectoprocta	336
Physiological Constraints	286	Habitats	336
Feeding Behavior and Sites	288		
Extreme and Specialized Habitats	288		
Dispersal	291		

Dispersal	337	Diversity	383
Life History	337	General Systematics and Phylogenetic Relationships of Mollusca	384
Ecological Interactions	338	Mollusc Anatomy and Physiology	384
Ecology of Selected Species of Ectoproct Bryozoans	339	Freshwater Members of the Class	
Ectoprocta	340	Gastropoda	388
Collecting, Culturing, and Specimen Preparation	341	General Systematics and Phylogenetic Relationships	389
Collecting	341	Distribution and Diversity	392
Culturing	342	Reproduction and Life History	397
Specimen Preparation	342	General Ecology and Behavior	399
References	343	Habitat and Food Selection and Effects on Producers	399
17. Phylum Tardigrada		Population Regulation	402
<i>Diane R. Nelson, Roberto Guidetti, Lorena Rebecchi</i>		Ecological Determinants of Distribution and Assemblage Structure	404
Introduction	347	Conservation Ecology	408
General Features of the Phylum	347	Collecting, Culturing, and Specimen Preparation	412
Biogeography	349	Collecting	412
General Systematics and Phylogenetic Relationships	350	Specimen Preparation and Identification	413
Major Morphological Characters of Taxonomic Importance	351	References	413
General Biology	359	19. Class Bivalvia	
Internal Anatomy	359	<i>Kevin S. Cummings, Daniel L. Graf</i>	
Latent States	360	Introduction	424
Reproduction and Development	363	Introduction to the Class Bivalvia	424
Life History, Molting, and Cyclomorphosis	368	General Phylogenetic Relationships	424
General Ecology and Behavior	369	Evolution and Phylogenetics	425
Habitats	369	Diversity of the Nearctic Unionoidea	426
Population Dynamics	370	Diversity of the North American Sphaeriidae	431
Trophic Relationships	375	Diversity of <i>Corbicula</i> and <i>Dreissena</i> in North America	434
Dispersal	375	General Biology	434
Collection, Culturing, and Specimen Preparation	376	External and Internal Anatomy	434
Collection and Extraction	376	Feeding Structures and Mechanisms	441
Preparing Tardigrades for Light and Electron Microscopy	376	Foot and Locomotion	449
Culturing	377	Physiology	451
Phylogeny Determination and Species Identification	377	Reproductive Anatomy	454
References	378	General Ecology	460
Section IV		Life Cycles	460
Phylum Mollusca		Age and Growth	467
18. Introduction to Mollusca and the Class Gastropoda		Population Demography	468
<i>Mark Pyron, Kenneth M. Brown</i>		Biotic Interactions	468
Introduction to Freshwater Members of the Phylum Mollusca	383	Ecosystem Processes	471
		Habitat and Abiotic Interactions	472
		Changes in Hydrology	476
		Pollution and Freshwater Bivalves as Biomonitors	478
		Endangered Species and Conservation	481
		Consumptive and Commercial Impacts	482

Invasive Bivalves (<i>Corbicula</i> , <i>Dreissena</i> , and Sphaeriids)	483
Zebra Mussels and Benthic Invertebrate Interactions	484
Collecting, Curation, and Rearing	484
Collecting	484
Curation	486
Culture, Propagation, and Rearing	486
References	490

Section V Phylum Annelida

20. Introduction to Annelida and the Class Polychaeta

Piet F.M. Verdonshot

Introduction to Inland Water Annelida	509
General Systematics	510
Phylogenetic Relationships	511
Distribution and Diversity	512
General Biology	514
External Anatomy	514
Internal Anatomy	515
Physiology	516
Reproduction	516
General Ecology and Behavior	517
Distribution and Habitat Selection	517
Physiological Constraints	517
Feeding Behavior	518
Predators and Parasites	518
Locomotion and Other Interspecific Interactions	518
Collecting Annelids and Specimen Preparation	519
Collecting Annelids	519
Preparation for Identification	519
Introduction to the Inland Water Polychaeta	519
General Introduction	519
General Systematics	520
Phylogenetic Relationships	521
Distribution and Diversity	521
General Biology of Polychaeta	522
External Anatomy	522
Internal Anatomy	522
Physiology	524
Reproduction	524
General Ecology and Behavior of Polychaeta	525
Distribution and Habitat Selection	525
Physiological Constraints	525
Feeding Behavior	525
Locomotion	526

Predators and Parasites	526
Invasive Tendencies	526
Collecting Polychaetes and Specimen Preparation	526
References	526

21. Clitellata: Oligochaeta

Tarmo Timm, Patrick J. Martin

Introduction	529
General Systematics	529
Phylogenetic Relationships	531
Distribution and Diversity	533
General Biology	535
External Anatomy	535
Internal Anatomy	537
Physiology	540
Reproduction and Life History	541
General Ecology and Behavior	542
Macrohabitat Distribution and Microhabitat Selection	542
Physiological Constraints	542
Feeding Behavior	543
Predators and Parasites	543
Other Ecological Aspects of Oligochaeta	544
Collecting, Culturing, and Specimen Preparation	544
Collecting	544
Rearing	545
Preparation for Identification	545
References	548

22. Clitellata: Branchiobdellida

Stuart R. Gelder, Bronwyn W. Williams

Introduction to the Branchiobdellida	551
General Systematics	551
Phylogenetic Relationships	552
Distribution (Endemic and Alien) and Diversity	552
General Biology	553
External Anatomy	553
Internal Anatomy	553
Physiology	555
Nutrition	556
Locomotion	556
Reproduction	556
General Ecology and Behavior	557
Habitat Selection	557
Population Abundance	558
Sympatric Crayfish Ectosymbionts and Interspecific Competition	559
Predators and Parasites	559

26. Subphylum Myriapoda, Class Diplopoda

Jean-Jacques Geoffroy

Introduction to the Subphylum	661
Evolution, Classification, and Phylogenetic Relationships	661
Biogeography and Diversity	662
General Biology	662
Millipede Anatomy	662
Millipede Physiology	663
Ecology and Behavior of Freshwater Millipedes	664
Physiological Problems Faced by Millipedes in Freshwater	664
Millipedes of Tropical Islands and Amazonian Floodplains	665
Millipedes of Swamps and Rivers	666
Aquatic Australian Millipedes	666
Millipedes in Subterranean Habitats of Europe	666
Collecting, Rearing, and Preparation for Identification	667
Sampling Methods	667
Extraction	667
Fixing and Mounting	667
Culturing	668
References	668

27. Introduction to "Crustacea"

James H. Thorp, D. Christopher Rogers, Alan P. Covich

Introduction	671
General Systematics and Phylogenetic Relationships	671
Distribution and Diversity	672
General Biology	673
External Anatomy	673
Internal Anatomy and Physiology	675
Reproduction and Development	678
General Ecology and Behavior	679
Habitat Selection	679
Physiological Constraints	680
Feeding Behavior	681
Predators and Parasites	682
Collecting, Culturing, and Specimen Preparation	682
Collecting	682
Culturing	682
Specimen Preparation	682
References	683

28. Class Branchiopoda

Carla E. Cáceres, D. Christopher Rogers

Introduction	687
General Phylogenetic Relationships	687
Fossil Record	688
Distribution and Diversity	689
General Biology	690
Morphology	690
Physiology	694
Reproduction and Development	696
Life History and Ecology	697
Behavior	697
Foraging	698
Predators and Parasites	699
Population Regulation	699
Collecting, Culturing, and Specimen Preparation	700
Field Collection	700
Sample Preparation	700
Culture Methods	701
Acknowledgments	701
References	701

29. Class Maxillopoda

Eduardo Suárez-Morales

Introduction	710
Subclass Copepoda	710
Subclass Branchiura	711
Subclass Thecostraca	711
General Biology of Copepoda	712
External Anatomy	712
Internal Anatomy	717
Reproduction and Life History	718
General Ecology of Copepoda	720
Adaptations, Behavior, and Feeding	720
Population Regulation	723
Diversity, Distributional Patterns, and Conservation	726
Importance for Humans	732
General Biology and Ecology of Branchiura	734
External Anatomy	734
Internal Anatomy	737
Reproduction and Life History	739
Diversity and Distribution	740
Host, Infection, and Control	741
General Biology and Ecology of Cirripedia	742
External Anatomy	742
Internal Anatomy	743
Reproduction and Life History	744
Ecology, Distribution, Impacts, and Control	746

Collecting, Culturing, and Specimen Preparation	748	Notable Radiations	792
Copepoda	748	Collecting, Culturing, and Specimen Preparation	793
Argulidae	749	References	794
Cirripedia	750		
Acknowledgement	751	32. Class Malacostraca, Order Decapoda	
References	751	<i>Neil Cumberlidge, Horton H. Hobbs, David M. Lodge</i>	
30. Class Ostracoda		Introduction	798
<i>Alison J. Smith, David J. Horne, Koen Martens, Isa Schön</i>		Systematics and Phylogenetic Relationships	798
Introduction	757	Distribution and Global Diversity	803
General Systematics	758	General Biology	807
An Overview of Phylogenetic Relationships	759	External Morphology	807
Fossil Record	760	Internal Anatomy	809
Distribution and Diversity	760	Aspects of Decapod Physiology	813
Taxonomic and Biogeographic Databases	761	Reproduction and Life History	821
General Biology	763	General Ecology and Behavior	823
Shell Morphology	763	Habitat Selection	823
Body and Appendage Morphology	764	Dispersal	829
Internal Anatomy and Physiology	767	Diet and Resources	830
General Ecology and Behavior	769	Intraspecific and Interspecific Competition	831
Habitat Selection	769	Predation on Decapods	831
Environmental Constraints on Distribution	770	Ecological Importance	832
Feeding Behavior	773	Collecting, Culturing, and Specimen Preparation	837
Predators and Parasites	774	Collecting and Culturing	837
Collecting, Culturing, and Specimen Preparation	774	Preservation of Shrimps, Crayfish, and Crabs	839
Field Collection	774	References	839
Sample Preparation	776		
Rearing Techniques	777	33. Hexapoda—Introduction to Insects and Collembola	
References	777	<i>James H. Thorp, Brian J. O'Neill</i>	
31. Class Malacostraca, Superorders Peracarida and Syncarida		Introduction to Hexapoda	849
<i>Gary A. Wellborn, Jonathan D.S. Witt, Rickey D. Cothran</i>		General Introduction to Hexapoda	849
Introduction	781	Phylogenetic Relationships	850
Superorder Peracarida	781	Introduction to the Class Insecta	851
Superorder Syncarida	783	Evolutionary Diversification of Aquatic Insects	851
General Biology	783	Additional Literature Sources	851
External Morphology	783	General Biology of Aquatic Insects	851
Internal Anatomy	784	Tagmatization	852
Environmental Physiology	785	Respiration and Circulation	852
Reproduction and Life History	787	Excretion and Osmotic Balance	854
General Ecology and Behavior	788	Reproduction and Development	855
Habitat Selection	788	General Ecology and Behavior of Aquatic Insects	855
Dispersal	790	Habitat Selection	856
Feeding Behavior and Diet	790	Physiological Constraints	861
Population and Community Ecology	791	Feeding Behavior	863
Ecological Impacts of Invasive Species	792	Predators and Parasites	864

Introduction to Collembola	864	Respiration	908
Introduction	864	Thermoregulation	910
Phylogeny and Species Diversity	865	Flight	910
General Biology of Collembola	865	Reproduction	911
General Ecology of Collembola	867	Life Cycle	913
Collecting, Culturing, and Specimen		General Ecology and Behavior	917
Preparation of Insects and Springtails	868	Foraging	917
Collecting and Culturing	868	Dispersal and Migration	918
Specimen Preservation and Preparation	869	Habitats	918
Acknowledgments	869	Biotic Interactions	922
References	869	Distribution and Diversity	925
		Conservation Status and Biotic Indicators	927
34. Order Ephemeroptera		Collecting, Culturing, and Specimen	
<i>Michel Sartori, John E. Brittain</i>		Preparation	928
Introduction To Mayflies (Ephemeroptera)	873	Collecting and Sampling	928
Brief History and Paleontology	873	Culturing	929
General Systematics	874	Preservation	929
Phylogenetic Relationships	874	Acknowledgments	930
Distribution, Diversity, and Endemism	876	References	930
General Biology	877	36. Order Plecoptera	
External Anatomy of Imagos and Nymphs	877	<i>R. Edward DeWalt, Boris C. Kondratieff,</i>	
Internal Anatomy of Nymphs	880	<i>John B. Sandberg</i>	
Life Cycle	880	Introduction	933
Behavior of the Winged Stages	881	Overview of the Insect Order Plecoptera	933
Reproduction	884	Phylogeny and Biogeography	933
General Ecology and Behavior	884	General Biology	935
Habitat Selection	884	External Anatomy	935
Physiological Constraints	885	Life History	937
Feeding Behavior	885	General Ecology and Behavior	939
Other Relevant Behavior	885	Macro- and Micro-habitat Usage	939
Predators	886	Physiological Constraints on Distribution	
Parasitic and Commensal Relationships	886	and Survival	939
Environmental Changes and Human Effects	886	Feeding Behavior	939
Mayfly Interactions with Humans	887	Parasites and Symbionts of Stoneflies	940
Collecting, Rearing, and Specimen		Conservation of Stoneflies	940
Preparation	888	Behavior	940
References	888	Collecting and Rearing Stoneflies	942
		Collecting Nymphs and Adults	942
35. Order Odonata		Preservation Techniques and Labeling	945
<i>Frank Suhling, Göran Sahlén, Stanislav Gorb,</i>		Rearing of Stoneflies	946
<i>Vincent J. Kalkman, Klaas-Douwe B. Dijkstra,</i>		Acknowledgements	947
<i>Jan van Tol</i>		References	947
Introduction	894	37. Order Hemiptera	
Systematic and Phylogenetic Relationships	894	<i>David A. Lytle</i>	
General Biology	899	Introduction	951
External Features of the Larva	899	Distribution, Diversity, and Phylogenetic	
External Features of the Imago	900	Relationships	951
Size	902	General Biology	953
Egg Structure	902	External Anatomy	953
Ultrastructures	903	Locomotion	953
Perception: The Sensory Organs and			
Neural System	905		

Physiology	956	Physiological Adaptations to Aquatic	
Life Cycle and Reproduction	956	Environments	1011
Ecology and Behavior	957	Life Cycles and Reproduction	1013
Feeding	957	Ecology and Behavior	1013
Mating	958	Habitat Associations	1013
Body Size and Evolution of Paternal Care	958	Dispersal	1014
Flood Survival	959	Community Patterns	1015
Importance to Humans	959	Feeding Behavior	1015
Conservation of Hemiptera	960	Predation on Beetles	1016
Collecting, Culturing, and Preparing		Conservation and Environmental	
Specimens	960	Susceptibility	1016
References	961	Collecting, Preservation, and Culturing	1017
		Collecting	1017
		Preservation	1018
		Culturing	1018
38. Order Trichoptera		Appendix 1: Family Descriptions by	
		Suborders	1018
<i>Ralph W. Holzenthal, Robin E. Thomson, Blanca</i>		Families in the Suborder Myxophaga	1018
<i>Ríos-Touma</i>		Families in the Suborder Aedeoidea	1020
		Families in the Suborder Polyphaga	1028
Introduction	965	References	1039
Phylogenetic Relationships	965		
Distribution	969	40. Order Diptera	
General Biology	971		
External Morphology	971	<i>Gregory W. Courtney, Peter S. Cranston</i>	
Physiological Adaptations	984	Introduction	1043
Reproduction and Life History	986	General Introduction	1043
General Ecology and Behavior	988	Phylogenetic Relationships	1043
Predation and Parasitism	988	Distribution and Diversity	1044
Case- and Retreat-Making Behavior	988	General Biology	1044
Drift	989	Larval Morphology	1044
Food and Feeding	990	Pupal Morphology	1050
Secondary Production	990	Life Cycles	1050
Habitats and Aquatic Adaptations	991	Reproduction	1052
Disturbance Effects	992	Phenology	1053
Human Impacts, Conservation, and		General Ecology and Behavior	1053
Climate Change	993	Habitat Selection	1053
Collecting, Rearing, and Specimen		Feeding Behavior	1056
Preparation	994	Predators, Parasites, and Parasitoids of	
Field Collecting	994	Diptera	1056
Rearing and Association	995	Collecting, Culturing, And Specimen	
Specimen Preparation	996	Preparation	1057
References	996	Collecting	1057
		Rearing Diptera	1057
		Preserving Specimens for Later	
		Identification	1058
		References	1058
39. Order Coleoptera			
<i>Donald A. Yee, Siegfried Kehl</i>		41. Minor Insect Orders	
		<i>Matthew R. Cover, Michael T. Bogan</i>	
Introduction to Aquatic Coleoptera	1004	Introduction	1059
What is an Aquatic Beetle?	1004	Megaloptera	1060
Diversity and Global Distribution	1004	Introduction	1060
Systematic and Phylogenetic Relationships	1008		
General Biology	1009		
External Anatomy	1009		
Size	1009		
Morphological Adaptations to the Aquatic			
Environment	1009		
Internal Anatomy	1010		

Phylogenetic Relationships 1060
 Distribution and Diversity 1061
 Life History, Ecology, and Behavior 1062
 Larval Morphology and Physiology 1063
 Collecting, Rearing, and Specimen Preparation 1063
Neuroptera 1064
 Introduction 1064
 Phylogenetic Relationships 1064
 Distribution and Diversity 1064
 Life History, Ecology, and Behavior 1065
 Larval Morphology and Physiology 1066

Introduction 1068
 General Introduction 1068
 Phylogenetic Relationships 1068
 Distribution and Diversity 1068
 General Biology 1068
 Larval Morphology 1068
 Food and Feeding 1068
 Life Cycle and Development 1068
 Environmental Changes 1068
 General Ecology and Behavior 1068
 Habitat Selection 1068
 Feeding Behavior 1068
 Predator, Parasite, and Parasitoid of Diptera 1068
 Collecting, Rearing, and Specimen Preparation 1068
 Field Collecting 1068
 Rearing and Association 1068
 Specimen Preparation 1068
 References 1068

Introduction 1069
 General Introduction 1069
 Phylogenetic Relationships 1069
 Distribution and Diversity 1069
 General Biology 1069
 Larval Morphology 1069
 Food and Feeding 1069
 Life Cycle and Development 1069
 Environmental Changes 1069
 General Ecology and Behavior 1069
 Habitat Selection 1069
 Feeding Behavior 1069
 Predator, Parasite, and Parasitoid of Diptera 1069
 Collecting, Rearing, and Specimen Preparation 1069
 Field Collecting 1069
 Rearing and Association 1069
 Specimen Preparation 1069
 References 1069

Introduction 1070
 General Introduction 1070
 Phylogenetic Relationships 1070
 Distribution and Diversity 1070
 General Biology 1070
 Larval Morphology 1070
 Food and Feeding 1070
 Life Cycle and Development 1070
 Environmental Changes 1070
 General Ecology and Behavior 1070
 Habitat Selection 1070
 Feeding Behavior 1070
 Predator, Parasite, and Parasitoid of Diptera 1070
 Collecting, Rearing, and Specimen Preparation 1070
 Field Collecting 1070
 Rearing and Association 1070
 Specimen Preparation 1070
 References 1070

Collecting, Rearing, and Specimen Preparation 1067
Blattodea 1067
Hymenoptera 1068
Lepidoptera 1068
Mecoptera 1069
Orthoptera 1069
References 1070

Subject Index 1073
 Taxonomy Index 1093

Introduction 1094
 General Introduction 1094
 Phylogenetic Relationships 1094
 Distribution 1094
 General Biology 1094
 External Morphology 1094
 Physiological Adaptations 1094
 Reproduction and Life History 1094
 General Ecology and Behavior 1094
 Habitat and Distribution 1094
 Case- and Behavioral Adaptations 1094
 Diet 1094
 Food and Feeding 1094
 Secondary Production 1094
 Habitat and Abundance 1094
 Dispersal 1094
 Human Impacts 1094
 Climate Change 1094
 Collecting, Rearing, and Specimen Preparation 1094
 Field Collecting 1094
 Rearing and Association 1094
 Specimen Preparation 1094
 References 1094

Introduction to Aquatic Coleoptera 1095
 What is an Aquatic Beetle? 1095
 Diversity and Global Distribution 1095
 Systematic and Phylogenetic Relationships 1095
 General Biology 1095
 External Anatomy 1095
 Size 1095
 Morphological Adaptations to the Aquatic Environment 1095
 Internal Anatomy 1095