

CONTENTS

Preface, ix

Acknowledgments, xi

SECTION 1: INTRODUCTION TO THE ARTHROPODS, 1

CHAPTER 1 INSECTS AND THEIR RELATIVES, 3

Naming of Taxa, 3

Arthropoda, 6

Arachnida, 6

Crustacea, 8

Diplopoda, 9

Chilopoda, 11

Entognatha, 11

Insecta, 14

Classification of Insects, 14

Characteristics of the Major Groups of Insects, 15

Evolution of Insects, 27

Insect Biogeography, 32

Summary, 33

References and Additional Reading, 33

CHAPTER 2 STRUCTURE AND FUNCTION OF INSECTS, 34

Integument, 34

Molting, 35

Body Regions, 35

The Head, 37

The Thorax, 41

The Abdomen, 43

Internal Anatomy, 45

Muscular System, 45

Fat Body, 47

Digestive System, 47

Circulatory System, 50

Ventilatory System, 51

Nervous System, 52

Vision, 54

Glandular Systems, 55

Polyphenism or Polymorphism, 57

Communication, 58

Sociality, 61

Ants, 62

Social Bees and Wasps, 62

Termites, 63

Metamorphosis, 63

Reproductive System, 65

Eggs of Insects, 66

Excretory System, 69

Thermal Biology, 69

Feeding Ecology, 71

Scavenging, 73

Feeding Belowground, 73

Feeding in Aquatic Habitats, 74

Feeding on Living Plants, 75

Feeding on Blood, 78

Predation and Parasitism, 79

Summary, 79

References and Additional Reading, 81

SECTION 2: FOOD RELATIONSHIPS, 83

CHAPTER 3 FOOD RESOURCES FOR WILDLIFE, 85

Assessment of Insectivory, 85

Methods for Determining the Abundance of Insects, 86

Methods for Determining Wildlife Diets, 91

Nutritional Value of Insects, 97
 Importance of Insects in the Diets of
 Wildlife, 98
 Summary, 103
 References and Additional Reading, 103

CHAPTER 4 WILDLIFE DIETS, 105

Analysis of Amphibian and Reptile Diets, 105
 Analysis of Mammal Diets, 107
 Analysis of Bird Diets, 126
 Analysis of Fish Diets, 152
 The Benefits of Insects for Wildlife Survival and
 Reproduction, 156
 How Insects Avoid Becoming Food for
 Wildlife, 158
 Crystis, 158
 Aposematism, 159
 Mimicry, 159
 Flight and Startle Behavior, 160
 Physical and Chemical Defenses, 162
 Group Actions, 163
 Nocturnal Activity, 165
 Summary, 165
 References and Additional Reading, 166

CHAPTER 5 INSECTS IMPORTANT AS FOOD FOR WILDLIFE, 171

Aquatic Insects, 171
 Mayflies (Order Ephemeroptera), 171
 Stoneflies (Order Plecoptera), 172
 Dragonflies and Damselflies (Order
 Odonata), 173
 Bugs (Order Hemiptera), 175
 Alderflies, Dobsonflies, and Fishflies (Order
 Megaloptera), 176
 Beetles (Order Coleoptera), 176
 Flies (Order Diptera), 177
 Caddisflies (Order Trichoptera), 177
 Terrestrial Insects, 179
 Termites (Order Isoptera), 179
 Cockroaches (Order Blattodea), 180
 Grasshoppers, Katydid, and Crickets (Order
 Orthoptera), 181
 Earwigs (Order Dermaptera), 184
 Barklice or Psocids (Order Psocoptera), 186
 Bugs (Order Hemiptera), 186
 Lacewings, Antlions and Mantidflies (Order
 Neuroptera), 188
 Beetles (Order Coleoptera), 189

Moths and Butterflies (Order Lepidoptera), 190
 Flies (Order Diptera), 192
 Wasps, Ants, Bees, and Sawflies (Order
 Hymenoptera), 192
 Summary, 194
 References and Additional Readings, 197

CHAPTER 6 INSECTS AND ECOSYSTEMS, 198

Insects and Decomposition, 201
 Decomposition of Plant Remains, 201
 Decomposition of Excrement (Dung), 202
 Decomposition of Carrion, 204
 Nutrient Cycling, 206
 Herbivory by Insects, 210
 The Importance of Herbivory, 210
 Plant Compensation, 213
 Insect Outbreaks, 214
 Plant Diseases and Insects, 215
 Pollination and Seed Dispersal by Insects, 217
 Invasiveness of Insects, 218
 Pathways of Invasion, 219
 Ecological and Taxonomic Patterns
 of Invasion, 221
 Establishment and Spread, 222
 Latency Among Invaders, 223
 Why Invasive Species become so Abundant,
 225
 Impacts of Invaders, 226
 Summary, 227
 References and Additional Reading, 227

SECTION 3: ARTHROPODS AS DISEASE VECTORS AND PESTS, 231

CHAPTER 7 TRANSMISSION OF DISEASE AGENTS TO WILDLIFE BY ARTHROPODS, 233

Arthropod Feeding Behavior, 233
 Disease in Wildlife, 235
 Virulence, 236
 Disease Hosts, 239
 Disease Transmission, 240
 Causes of Disease, 241
 The Nature of Parasitism, 241
 Parasite-Induced Changes in Host Behavior, 242
 Summary, 243
 References and Additional Reading, 244

CHAPTER 8 INFECTIOUS DISEASE AGENTS TRANSMITTED TO WILDLIFE BY ARTHROPODS, 245

Viruses, 245

- Myxomatosis, 248
- Avian Pox, 248
- West Nile Virus, 249
- Yellow Fever, 250
- St. Louis Encephalitis, 250
- Hemorrhagic Disease, 251

Bacteria, 252

- Tularemia, 252
- Anaplasmosis, 254
- Lyme Disease, 254
- Plague, 255
- Avian Botulism, 258

Fungi, 259

- Aflatoxin Poisoning, 259

Summary, 261

References and Additional Reading, 261

CHAPTER 9 PARASITIC DISEASE AGENTS TRANSMITTED TO WILDLIFE BY ARTHROPODS, 263

Protozoa, 263

- American Trypanosomiasis, 263
- African Trypanosomiasis, 266
- Avian Malaria, 269
- Toxoplasmosis, 271

Helminths, 274

- Spirocerosis, 276
- Dirofilariasis, 276
- Elaeophorosis, 277
- Lancet Fluke, 279
- Dog Tapeworm, 279
- Giant Thorny-headed Worm, 279

Summary, 283

References and Additional Reading, 283

CHAPTER 10 ARTHROPODS AS PARASITES OF WILDLIFE, 285

Mites and Ticks (Arachnida: Acari or Acarina:

Several Orders), 289

Mites, 289

- Mange Mites, 289
- Respiratory Mites, 291
- Ear Mites, 291
- Bird Mites, 292
- Sarcoptic Mange Mite, 292

Ticks, 293

- Taiga Tick, 296
- Wood Tick, 297
- Blacklegged Tick, 297

Insects (Insecta), 298

Lice (Phthiraptera), 298

Bugs (Hemiptera: Reduviidae, Cimicidae, and Polyctenidae), 302

- Assassin Bugs, Subfamily Triatominae – Kissing or Blood-Sucking Conenose Bugs (Hemiptera: Reduviidae), 302

- Bed Bugs, Swallow Bugs, and Bat Bugs (Hemiptera: Cimicidae and Polyctenidae), 303

Flies (Diptera: Several Families), 304

- Mosquitoes (Diptera: Culicidae), 305
- Black Flies (Diptera: Simuliidae), 308
- Biting Midges (Diptera: Ceratopogonidae), 310
- Phlebotomine Sand Flies (Diptera: Psychodidae: Phlebotominae), 312
- Horse Flies and Deer Flies (Diptera: Tabanidae), 314

- Tsetse Flies (Diptera: Glossinidae), 316

- Muscid Flies (Diptera: Muscidae), 318

- Stable Fly, 319

- House Fly, 320

- Blow Flies (Diptera: Calliphoridae), 321

- New World Screwworm Fly, 322

- Flesh Flies (Diptera: Sarcophagidae), 324

- Bot and Warble Flies (Diptera: Oestridae), 325

- Louse Flies (Diptera: Hippoboscidae), 329

Fleas (Siphonaptera), 330

Other Taxa of Occasional Importance, 332

- Eye Gnats (Diptera: Chloropidae), 333

- Snipe Flies (Diptera: Rhagionidae), 333

- Bees and Wasps (Hymenoptera: Various Families), 333

- Ants (Hymenoptera: Formicidae), 333

- Dermestids (Coleoptera: Dermestidae), 334

Summary, 334

References and Additional Reading, 335

SECTION 4: PEST MANAGEMENT AND ITS EFFECTS ON WILDLIFE, 339

CHAPTER 11 PESTICIDES AND THEIR EFFECTS ON WILDLIFE, 341

Pesticides, 343

Insecticide Mode of Action, 345

Persistence of Insecticides, 349
Acute Effects of Insecticides, 350
Sublethal Effects of Insecticides, 354
Other Pesticides, 355
Indirect Effects of Pesticides on Wildlife, 356
Insecticides in The Food Chain, 357
Risks of Insecticides, 359
Resistance to Insecticides, 361
Summary, 362
References and Additional Reading, 363

CHAPTER 12 ALTERNATIVES TO INSECTICIDES, 366

Environmental Management or Cultural Control, 366
Physical and Mechanical Control, 370
Host Resistance, 371
Semiachemicals, 373
Biological Control, 375
Area-Wide Insect Management, 379
Integrated Pest Management (IPM), 381
Preventing versus Correcting Problems, 382
Summary, 383
References and Additional Reading, 383

SECTION 5: CONSERVATION ISSUES, 385

CHAPTER 13 INSECT-WILDLIFE RELATIONSHIPS, 387

How Wildlife Affect Insect Survival, 387
Naturally Occurring Predation by Wildlife on Insects, 387
Western Pine Beetle and Woodpeckers, 392
Spruce Budworm, Birds, and Mammals, 392
Gypsy Moth, Birds, Mammals, and Beneficial Insects, 393
Rangeland Grasshoppers and Birds, 393
Crop-Feeding Aphids and Birds, 393
Crop-Feeding Caterpillars, Spiders, and Birds, 394
Tropical Forest Floor-Dwelling Insects, Lizards, and Birds, 394

Tropical Forest Insects, Bats, and Birds, 394
Aquatic Insects, Ducks, and Fish, 395
Predation of Animal Ectoparasites by Birds, 395
Introduction of Vertebrates for Biological Suppression of Insects, 396
How Insects Affect Wildlife Survival, 397
Predation by Insects on Wildlife, 397
Effects on Terrestrial Wildlife, 397
Effects on Aquatic Wildlife, 400
Symbiotic Relationships Between Insects and Wildlife, 400
The Benefits of Insects for Habitat Conservation, 402
The Benefits of Insects for Wildlife-Based Recreation, 406
Summary, 407
References and Additional Reading, 408

CHAPTER 14 INSECT AND WILDLIFE CONSERVATION, 410

Other Economic Benefits of Insects, 410
Pollination, 410
Honey, 412
Silk Production (Sericulture), 413
Shellac and Lacquer, 414
Dyes, 414
Food for Humans and Domestic Animals, 414
Medical Treatment, 416
Conservation of Insects, the 'Smallest Wildlife', 416
Conservation Status, 418
Advancing the Conservation of Insects, 419
Conservation of Bumble Bees, 422
Conservation of Butterflies, 423
Conservation of Beetles, 424
Managing Insect Resources for the Benefit of Wildlife, 425
Principles, 426
Practices, 426
Summary, 434
References and Additional Reading, 435
Glossary, 437
Index, 457