

CONTENTS

List of colour plates, ix

List of boxes, xiii

Preface to the fifth edition, xv

Preface to the fourth edition, xvii

Preface to the third edition, xix

Preface to the second edition, xxi

Preface and acknowledgments for first edition, xxiii

About the companion website, xxv

1 THE IMPORTANCE, DIVERSITY AND CONSERVATION OF INSECTS, 1

- 1.1 What is entomology?, 2
 - 1.2 The importance of insects, 2
 - 1.3 Insect biodiversity, 6
 - 1.4 Naming and classification of insects, 10
 - 1.5 Insects in popular culture and commerce, 11
 - 1.6 Culturing insects, 13
 - 1.7 Insect conservation, 14
 - 1.8 Insects as food, 20
- Further reading, 25

2 EXTERNAL ANATOMY, 26

- 2.1 The cuticle, 27
 - 2.2 Segmentation and tagmosis, 33
 - 2.3 The head, 35
 - 2.4 The thorax, 45
 - 2.5 The abdomen, 52
- Further reading, 55

3 INTERNAL ANATOMY AND PHYSIOLOGY, 56

- 3.1 Muscles and locomotion, 57
 - 3.2 The nervous system and co-ordination, 63
 - 3.3 The endocrine system and the function of hormones, 66
 - 3.4 The circulatory system, 69
 - 3.5 The tracheal system and gas exchange, 73
 - 3.6 The gut, digestion and nutrition, 77
 - 3.7 The excretory system and waste disposal, 86
 - 3.8 Reproductive organs, 90
- Further reading, 93

4 SENSORY SYSTEMS AND BEHAVIOUR, 95

- 4.1 Mechanical stimuli, 96
 - 4.2 Thermal stimuli, 105
 - 4.3 Chemical stimuli, 107
 - 4.4 Insect vision, 117
 - 4.5 Insect behaviour, 122
- Further reading, 124

5 REPRODUCTION, 125

- 5.1 Bringing the sexes together, 126
- 5.2 Courtship, 128
- 5.3 Sexual selection, 128
- 5.4 Copulation, 131
- 5.5 Diversity in genitalic morphology, 136
- 5.6 Sperm storage, fertilization and sex determination, 139
- 5.7 Sperm competition, 140
- 5.8 Oviparity (egg-laying), 144

- 5.9 Ovoviviparity and viviparity, 150
- 5.10 Other modes of reproduction, 150
- 5.11 Physiological control of reproduction, 153
- Further reading, 154

6 INSECT DEVELOPMENT AND LIFE HISTORIES, 156

- 6.1 Growth, 157
- 6.2 Life-history patterns and phases, 158
- 6.3 Process and control of moulting, 169
- 6.4 Voltinism, 172
- 6.5 Diapause, 173
- 6.6 Dealing with environmental extremes, 174
- 6.7 Migration, 178
- 6.8 Polymorphism and polyphenism, 180
- 6.9 Age-grading, 181
- 6.10 Environmental effects on development, 183
- Further reading, 188

7 INSECT SYSTEMATICS: PHYLOGENY AND CLASSIFICATION, 190

- 7.1 Systematics, 191
- 7.2 The extant Hexapoda, 201
- 7.3 Informal group Entognatha: Collembola (springtails), Diplura (diplurans) and Protura (proturans), 202
- 7.4 Class Insecta (true insects), 203
- Further reading, 224

8 INSECT EVOLUTION AND BIOGEOGRAPHY, 227

- 8.1 Relationships of the Hexapoda to other Arthropoda, 228
- 8.2 The antiquity of insects, 229
- 8.3 Were the first insects aquatic or terrestrial?, 236
- 8.4 Evolution of wings, 238
- 8.5 Evolution of metamorphosis, 241
- 8.6 Insect diversification, 242
- 8.7 Insect biogeography, 244
- 8.8 Insect evolution in the Pacific, 245
- Further reading, 247

9 GROUND-DWELLING INSECTS, 249

- 9.1 Insects of litter and soil, 250
- 9.2 Insects and dead trees or decaying wood, 260
- 9.3 Insects and dung, 261
- 9.4 Insect–carion interactions, 264
- 9.5 Insect–fungal interactions, 265
- 9.6 Cavernicolous insects, 268
- 9.7 Environmental monitoring using ground-dwelling hexapods, 268
- Further reading, 270

10 AQUATIC INSECTS, 271

- 10.1 Taxonomic distribution and terminology, 272
- 10.2 The evolution of aquatic lifestyles, 275
- 10.3 Aquatic insects and their oxygen supplies, 277
- 10.4 The aquatic environment, 282
- 10.5 Environmental monitoring using aquatic insects, 284
- 10.6 Functional feeding groups, 285
- 10.7 Insects of temporary waterbodies, 286
- 10.8 Insects of the marine, intertidal and littoral zones, 287
- Further reading, 288

11 INSECTS AND PLANTS, 289

- 11.1 Coevolutionary interactions between insects and plants, 291
- 11.2 Phytophagy (or herbivory), 293
- 11.3 Insects and plant reproductive biology, 313
- 11.4 Insects that live mutualistically in specialized plant structures, 318
- Further reading, 320

12 INSECT SOCIETIES, 322

- 12.1 Subsociality in insects, 323
- 12.2 Eusociality in insects, 327
- 12.3 Inquilines and parasites of social insects, 345
- 12.4 Evolution and maintenance of eusociality, 348
- 12.5 Success of social insects, 351
- Further reading, 353

13 INSECT PREDATION AND PARASITISM, 354

- 13.1 Prey/host location, 355
- 13.2 Prey/host acceptance and manipulation, 361
- 13.3 Prey/host selection and specificity, 364
- 13.4 Population biology – predator/parasitoid and prey/host abundance, 372
- 13.5 The evolutionary success of insect predation and parasitism, 375

Further reading, 376

14 INSECT DEFENCE, 377

- 14.1 Defence by hiding, 379
- 14.2 Secondary lines of defence, 380
- 14.3 Mechanical defences, 382
- 14.4 Chemical defences, 384
- 14.5 Defence by mimicry, 388
- 14.6 Collective defences in gregarious and social insects, 392

Further reading, 396

15 MEDICAL AND VETERINARY ENTOMOLOGY, 397

- 15.1 Insects as causes and vectors of disease, 398
- 15.2 Generalized disease cycles, 399
- 15.3 Pathogens, 399
- 15.4 Forensic entomology, 413
- 15.5 Insect nuisance and phobia, 414
- 15.6 Venoms and allergens, 416

Further reading, 417

16 PEST MANAGEMENT, 418

- 16.1 Insects as pests, 419
- 16.2 The effects of insecticides, 425
- 16.3 Integrated pest management, 428
- 16.4 Chemical control, 429
- 16.5 Biological control, 435
- 16.6 Host-plant resistance to insects, 447
- 16.7 Physical control, 451
- 16.8 Cultural control, 451
- 16.9 Pheromones and other insect attractants, 452
- 16.10 Genetic manipulation of insect pests, 454

Further reading, 455

17 INSECTS IN A CHANGING WORLD, 457

- 17.1 Models of change, 458
 - 17.2 Economically significant insects under climate change, 463
 - 17.3 Implications of climate change for insect biodiversity and conservation, 467
 - 17.4 Global trade and insects, 468
- Further reading, 473

18 METHODS IN ENTOMOLOGY: COLLECTING, PRESERVATION, CURATION AND IDENTIFICATION, 474

- 18.1 Collection, 475
 - 18.2 Preservation and curation, 478
 - 18.3 Identification, 488
- Further reading, 491

TAXOBOXES, 493

- 1 Entognatha: non-insect hexapods (Collembola, Diplura and Protura), 493
- 2 Archaeognatha (Microcoryphia; archaeognathans or bristletails), 495
- 3 Zygentoma (silverfish), 496
- 4 Ephemeroptera (mayflies), 497
- 5 Odonata (damselflies and dragonflies), 498
- 6 Plecoptera (stoneflies), 500
- 7 Dermaptera (earwigs), 500
- 8 Zoraptera (zorapterans or angel insects), 501
- 9 Orthoptera (grasshoppers, locusts, katydids and crickets), 502
- 10 Embioptera (Embiidina, Emboidea; embiopterans or webspinners), 503
- 11 Phasmatodea (phasmids, stick-insects or walking sticks), 503
- 12 Grylloblattodea (Grylloblattaria or Notoptera; grylloblattids, ice crawlers or rock crawlers), 504
- 13 Mantophasmatodea (heelwalkers), 505
- 14 Mantodea (mantids, mantises or praying mantids), 506
- 15 Blattodea: roach families (cockroaches or roaches), 507

16	Blattodea: epifamily Termitoidae (former order Isoptera; termites, “white ants”), 508	23	Strepsiptera (strepsipterans), 517
17	Psocodea: “Psocoptera” (bark lice and book lice), 509	24	Diptera (true flies), 519
18	Psocodea: “Phthiraptera” (chewing lice and sucking lice), 510	25	Mecoptera (hangingflies, scorpionflies and snowfleas), 520
19	Thysanoptera (thrips), 511	26	Siphonaptera (fleas), 521
20	Hemiptera (bugs, moss bugs, cicadas, leafhoppers, planthoppers, spittle bugs, treehoppers, aphids, jumping plant lice, scale insects and whiteflies), 512	27	Trichoptera (caddisflies), 522
21	Neuropterida: Neuroptera (lacewings, owlflies and antlions), Megaloptera (alderflies, dobsonflies and fishflies) and Raphidioptera (snakeflies), 514	28	Lepidoptera (butterflies and moths), 523
22	Coleoptera (beetles), 516	29	Hymenoptera (ants, bees, wasps, sawflies and wood wasps), 524
			Glossary, 526
			References, 555
			Index, 563
			Appendix: A reference guide to orders, 589