

Contents

Preface	ix	CHAPTER 3	
Acknowledgments	xi	Biology of some common target pests	
About the authors	xiii	INTRODUCTION	33
		COMMON PEST SPECIES	33
CHAPTER 1		Slugs and Snails	33
The practice and application of biological control		Spider Mites	36
INTRODUCTION	1	Woodlice	38
Parasites and Parasitoids	2	Millipedes	39
Predators	2	Leafhoppers, Psyllids, Whitefly, Aphids, Scale insects, and Mealybugs	40
Pathogens	3	<i>Leafhoppers</i>	41
STRATEGIES FOR BIOLOGICAL CONTROL	3	<i>Psyllids</i>	42
Conservation or Preservation Biological Control	3	<i>Whiteflies</i>	42
Importation/Classical Biological Control	5	<i>Aphids</i>	44
Inoculative Control	5	<i>Scale Insects</i>	46
Inundative Control	5	<i>Mealybugs</i>	47
INTEGRATED CROP/PEST MANAGEMENT	6	<i>Thrips</i>	49
PRACTICAL ASPECTS OF BIOLOGICAL CONTROL	7	Lepidoptera	51
PEST MONITORING	10	<i>Caterpillars (of Moths and Butterflies)</i>	51
		Flies	54
CHAPTER 2		<i>Leaf Miners</i>	56
Biological control in various cropping systems		<i>Sciarids</i>	57
INTRODUCTION	11	<i>Shore Flies</i>	58
ARABLE	13	Beetles	58
Introduction	13	<i>Weevils</i>	62
Arable Production and Biologicals	14		
The Challenge of Biocontrol	14	CHAPTER 4	
The Use of Pesticides and Beneficial Insects	15	Arthropod biological control agents	
Monitoring Levels of Beneficial Insects	16	INTRODUCTION	65
<i>Carabid Beetles</i>	16	CLASS: ARACHNIDA (SPIDERS, HARVESTMEN, AND PREDATORY MITES)	69
<i>Staphylinid Beetles</i>	17	Family: Araneidae (Orb Web Spiders)	70
<i>Linyphiid Spiders</i>	18	Family: Linyphiidae (Money Spiders)	72
Integrated Crop Management (ICM)	18	Family: Lycosidae (Wolf Spiders)	73
Conservation Strategies Using Headlands and Beetle Banks	19	Family: Salticidae (Jumping Spiders)	74
FRUIT	19	Family: Thomisidae (Crab Spiders)	75
Introduction	19	Family: Phalangiidae (Harvestmen)	75
Fruit Production and Biologicals	20	SUBCLASS: ACARI (PREDATORY MITES)	77
The Challenge of Biocontrol	21	Family: Trombididae (Red Velvet Mites)	77
Major Pests	25	<i>Allotrombidium</i> spp.	77
Integrated Crop Management	25	Family: Phytoseiidae (Predatory Mites)	78
PROTECTED CROPS	27	<i>Amblyseius andersoni</i>	78
Introduction	27	<i>Amblyseius californicus</i> (syn. <i>Neoseiulus californicus</i>)	79
Crop Production and Biologicals	27	<i>Amblyseius cucumeris</i> (syn. <i>Neoseiulus cucumeris</i>)	80
Pest Monitoring	28	<i>Amblyseius degenerans</i> (syn. <i>Iphiseius degenerans</i>)	81
The Challenges of Biological Control	29		
Integrated Crop Management	31		

<i>Amblyseius montdorensis</i> (syn. <i>Typhlodromips montdorensis</i>)	82	<i>Chilocorus</i> spp.	116
<i>Amblyseius swirskii</i> (syn. <i>Typhlodromips swirskii</i>)	82	<i>Coccinella septempunctata</i> (Seven-Spot Ladybird)	117
<i>Phytoseiulus persimilis</i>	84	<i>Cryptolaemus montrouzieri</i>	119
<i>Typhlodromus pyri</i>	85	<i>Delphastus catalinae</i>	120
Family: Laelapidae (Soil-Dwelling Predatory Mites)	86	<i>Harmonia axyridis</i> (Harlequin Ladybird)	121
<i>Hypoaspis aculeifer</i> and <i>Hypoaspis miles</i>	86	<i>Harmonia globulata</i>	123
Family: Macrochelidae (Predatory Mites)	87	<i>Hippodamia convergens</i> (Convergent Lady Beetle)	124
<i>Macrocheles robustulus</i>	87	<i>Propylea quattuordecimpunctata</i> (14-Spot Ladybird)	125
CLASS: CHILOPODA	88	<i>Rodolia cardinalis</i> (Vedalia Beetle)	126
Family: Geophilidae and Lithobiidae (Centipedes)	88	<i>Scymnus subvillosus</i>	127
<i>Geophilus flavus</i> , <i>Stigmatogaster subterraneus</i> , and <i>Lithobius forficatus</i>	88	<i>Stethorus punctillum</i>	127
<i>Millipedes</i>	89	Family: Carabidae (Ground Beetles)	128
CLASS: INSECTA (INSECTS)	89	<i>Agonum dorsale</i>	130
Order: Odonata	89	<i>Bembidion lampros</i>	131
Suborder: Anisoptera (Dragonflies); Suborder: Zygoptera (Damsel Flies)	89	<i>Carabus violaceus</i>	131
ORDER: DERMAPTERA	93	<i>Demetrias atricapillus</i>	132
Family: Forficulidae (Earwigs)	93	<i>Harpalus rufipes</i>	133
<i>Forficula auricularia</i>	93	<i>Loricera pilicornis</i>	134
ORDER: HEMIPTERA	95	<i>Nebria brevicollis</i>	134
Suborder: Heteroptera (Predatory Bugs)	95	<i>Notiophilus biguttatus</i>	135
Family: Gerridae (Pond Skaters)	96	<i>Poecilus cupreus</i>	136
Common Pond Skater or Common Water Strider (<i>Gerris lacustris</i>)	96	<i>Pterostichus melanarius</i>	136
Family: Anthocoridae (Predatory Bugs/Flower Bugs)	97	<i>Trechus quadristriatus</i>	137
<i>Anthocoris nemoralis</i>	97	Family: Cicindelidae (Tiger Beetles)	138
<i>Anthocoris nemorum</i>	98	<i>Cicindela campestris</i> (Field Tiger Beetle)	138
<i>Orius laevigatus</i>	99	Family: Staphylinidae (Rove Beetles)	139
<i>Orius majusculus</i>	100	<i>Aleochara</i> spp.	139
Family: Miridae (Predatory Bugs)	101	<i>Atheta coriaria</i>	140
<i>Atractotomus mali</i>	101	<i>Philonthus cognatus</i>	141
<i>Blepharidopterus angulatus</i>	101	<i>Tachyporus</i> spp.	142
<i>Deraeocoris ruber</i>	102	<i>Xantholinus</i> spp.	143
<i>Heterotoma planicornis</i>	103	ORDER: DIPTERA	143
<i>Macrolophus pygmaeus</i> (syn. <i>M. caliginosus</i>)	104	Family: Empididae (Dance Flies)	144
<i>Pilophorus perplexus</i>	105	<i>Empis stercorea</i> and <i>Empis tessellata</i>	144
Family: Pentatomidae (Shield Bug)	106	Family: Muscidae (Hunter Flies)	145
<i>Podisus maculiventris</i>	106	<i>Coenosia attenuata</i>	145
Family: Psyllidae (Psyllids)	107	Family: Tachinidae (Parasitoid Flies)	146
<i>Aphalara itadori</i>	107	Family: Cecidomyiidae (Predatory Midges)	147
Family: Thripidae (Predatory Thrips)	109	<i>Aphidoletes aphidimyza</i>	147
<i>Franklinothrips vespiformis</i>	109	<i>Feltiella acarisuga</i>	149
ORDER: NEUROPTERA	110	Family: Syrphidae (Hoverflies)	151
Family: Chrysopidae (Predatory Lacewings)	111	<i>Episyrphus balteatus</i>	152
<i>Chrysopa perla</i>	111	<i>Scaeva pyrastris</i>	154
<i>Chrysoperla carnea</i> (Common Green Lacewings)	111	<i>Syrphus ribesii</i>	155
ORDER: COLEOPTERA (THE BEETLES)	113	ORDER: HYMENOPTERA (PARASITOID WASPS)	156
Family: Coccinellidae (Ladybird Beetles)	113	Family: Mymaridae	159
<i>Adalia bipunctata</i> (Two-Spot Ladybird)	115	<i>Anagrus atomus</i>	159
		Family: Aphelinidae	159
		<i>Aphelinus abdominalis</i>	159
		<i>Encarsia formosa</i>	161

<i>Encarsia tricolor</i>	163
<i>Eretmocerus eremicus</i>	164
Family: Braconidae	166
<i>Aphidius colemani</i>	166
<i>Aphidius ervi</i>	167
<i>Cotesia glomerata</i> (syn. <i>Apanteles glomeratus</i>)	168
<i>Dacnusa sibirica</i>	169
<i>Diaeretiella rapae</i>	170
<i>Praon myzophagum</i> and <i>Praon volucre</i>	171
Family: Ichneumonidae	172
<i>Diadegma insulare</i>	172
Family: Eulophidae	173
<i>Diglyphus isaea</i>	173
<i>Tetrastichus asparagi</i> (syn. <i>T. coeruleus</i>)	175
Family: Encyrtidae	176
<i>Encyrtus infelix</i>	176
<i>Leptomastix dactylopii</i> and <i>Leptomastix epona</i>	177
<i>Metaphycus helvolus</i>	178
Family: Trichogrammatidae	179
<i>Trichogramma</i> spp.	179
Family: Crabronidae (Predatory Wasps)	180
<i>Cerceris arenaria</i> (Digger Wasps)	180
Family: Vespidae (Predatory Wasp)	181
<i>Vespa vulgaris</i> (Common Wasp)	181

CHAPTER 5 Beneficial pathogens

INTRODUCTION	185
FAMILY: BACULOVIRIDAE	186
Viruses	186
<i>Nucleopolyhedroviruses</i> (NPVs) and <i>Granuloviruses</i> (GVs)	186
Bacteria	187
FAMILY: BACILLACEAE	188
<i>Bacillus subtilis</i>	188
<i>Bacillus thuringiensis</i>	190
Fungi	191
FAMILY: HYPOCREACEAE	192
<i>Beauveria bassiana</i>	192
<i>Glocladium catenulatum</i> , <i>G. virens</i>	193
<i>Trichoderma asperellum</i>	195
FAMILY: CLAVICIPITACEAE	196
<i>Lecanicillium muscarium</i> , <i>Lecanicillium</i> <i>longisporum</i> (syn. <i>Verticillium lecanii</i>)	196
<i>Metarhizium anisopliae</i>	197
FAMILY: PHAEOSPHAERIACEAE	198

<i>Ampelomyces quisqualis</i>	198
FAMILY: ENTOMOPHTHORACEAE	200
<i>Furia sciarae</i>	200
<i>Pandora neoaphidis</i> (syn. <i>Erynia neoaphidis</i>)	201
Nematodes	202
Eelworms or Roundworms	202
FAMILY: HETERORHABDITIDAE	203
<i>Heterorhabditis bacteriophora</i> , <i>H. megidis</i>	203
FAMILY: STEINERNEMATIDAE	203
<i>Steinernema carpocapsae</i> , <i>S. feltiae</i> , <i>S. glaseri</i> , <i>S. kraussei</i> , <i>S. riobrave</i> , and <i>S. scapterisci</i>	203
<i>Phasmarhabditis hermaphrodita</i>	204

CHAPTER 6 Biological control in perspective

INTRODUCTION	207
CLASSICAL BIOLOGICAL CONTROL— FOREIGN PLANTS	207
CLASSICAL BIOLOGICAL CONTROL— FOREIGN PESTS	209
FOREIGN PREDATORS THAT MIGHT DO HARM	211
ANIMAL GROUPS	211
<i>Nematodes</i>	211
Mites	213
MECHANISMS INVOLVED	215
Pollination and Seed Dispersal	218
Sugars That Fuel Animal Activity	219
The Combination of Sucking Insects and Ants	220
Development of Resistance to Pesticides and Pollination Drives the Need for Biological Control	220
REGULATION OF BIOLOGICAL CONTROL	221
MICROORGANISMS	225
Bacteria	227
<i>Bacterial Diseases of Plants</i>	227
<i>Bacterial Diseases of Insects</i>	228
Fungi	228
Viruses	230
NATURAL PLANT RESISTANCE MECHANISMS	232
Resistance Mechanisms	234
THE FUTURE OF BIOLOGICAL CONTROL	235

Glossary	237
References	241
Further reading	243
Useful websites	245
Index	247