CONTENTS

Contributors	хi
Preface	xiii
1. Diversity of Entomopathogenic Fungi: Which Groups Conquered the Insect Body? J.P.M. Araújo, D.P. Hughes	1
 Introduction The Major Groups of Entomopathogenic Fungi and Oomycetes Methods Results Discussion Conclusion Acknowledgments Supplementary Data References 	2 4 12 14 27 31 32 32 32
 Utilizing Genomics to Study Entomopathogenicity in the Fungal Phylum Entomophthoromycota: A Review of Current Genetic Resources H.H. De Fine Licht, A.E. Hajek, J. Eilenberg, A.B. Jensen 	41
 Introduction Genetic Tools Used for Phylogenetic Inference, Evolution, and Epizootiology Host-Pathogen Interactions Genome Characteristics Insights to Be Gained From Entomophthoromycota Genomic Resources Acknowledgments References 	42 45 49 53 55 59
3. Advances in Genomics of Entomopathogenic Fungi J.B. Wang, R.J. St. Leger, C. Wang	67
 Introduction Evolutionary Relationships of Entomopathogenic Fungi Evolution of Sex in Entomopathogenic Fungi Evolution of Fungal Host Specificity Protein Family Expansions and Contractions 	68 70 72 77 80

viii Contents

	6. Horizontal Gene Transfer	94
	7. Conclusions and Future Perspectives	96
	Acknowledgments	97
	References	97
4.	Insect Pathogenic Fungi as Endophytes	107
••	S. Moonjely, L. Barelli, M.J. Bidochka	107
	1. Introduction	108
	2. Evolution of Endophytic Insect Pathogenic Fungi	109
	3. Multifunctional Lifestyles	110
	4. Relationship Between Insect Pathogen Genes and Endophytism	116
	5. Application of Endophytic Insect Pathogenic Fungi	122
	6. Secondary Metabolites	126
	References	127
5.	Genetically Engineering Entomopathogenic Fungi H. Zhao, B. Lovett, W. Fang	137
	1. Introduction	138
	2. Improving Virulence	139
	3. Improving the Efficacy of Mycoinsecticides to Control Vector-Borne	
	Diseases	149
	4. Improve Tolerance to Abiotic Stresses	151
	5. Promoters Used for Genetic Engineering of Entomopathogenic Fungi6. Methods to Mitigate the Safety Concerns of Genetically Modified	154
	Entomopathogenic Fungi	155
	7. Conclusion	157
	Acknowledgments	158
	References	158
6.	Molecular Genetics of <i>Beauveria bassiana</i> Infection of Insects A. Ortiz-Urquiza, N.O. Keyhani	165
	1. Introduction	166
	2. The Infection Process	207
	3. Techniques for Molecular Manipulation of Beauveria bassiana	211
	4. What Constitutes a Virulence Factor?	213
	5. Genetic Dissection in Beauveria bassiana	215
	6. Conclusions and Future Prospects	236
	Acknowledgments	237
	References	237

Contents

7.	Insect Immunity to Entomopathogenic Fungi HL. Lu, R.J. St. Leger	251
	1. Behavioral Avoidance of Pathogens	254
	2. The Impact of Physiological State on Immune Functions in Insects	256
	3. Cuticle as a Barrier to Microbial Infections	259
	4. Overview of Insect Immune Defense Mechanisms	261
	5. Immune Recognition of Fungi	262
	6. Cellular Immune Responses to Fungi	264
	7. Interaction of Fungi with the Phenoloxidase and Coagulation Responses	266
	8. Humoral Immune Responses to Fungi	268
	9. The Evolutionary Genetics of Insect Immunity	269
	10. Fungal Countermeasures to Host Immunity	273
	11. Tolerance versus Resistance	274
	12. Concluding Remarks and Future Perspectives	275
	Acknowledgments	277
	References	277
	Relevance of Using Generalist Fungi to Study Infections in Insect Societies R.G. Loreto, D.P. Hughes	287
	1. Introduction	288
	2. Origin and Trends of Using Generalist Fungal Parasites to Study	
	Ant–Fungal Parasite Interactions	291
	3. The Ecological Relevance of Laboratory Experimentation With	
	Beauveria and Metarhizium in Ants	292
	4. Natural Occurrence of Beauveria and Metarhizium in Ants: Opportunistic	
	Parasites?	297
	5. Future Perspectives	300
	Acknowledgments	201
		301
	Supplementary Data	302
		301 302 302
9.	Supplementary Data	302
9.	Supplementary Data References Entomopathogenic Fungi: New Insights into Host–Pathogen Interactions	302
9.	Supplementary Data References Entomopathogenic Fungi: New Insights into Host–Pathogen	302 302
9.	Supplementary Data References Entomopathogenic Fungi: New Insights into Host–Pathogen Interactions	302 302
9.	Supplementary Data References Entomopathogenic Fungi: New Insights into Host–Pathogen Interactions T.M. Butt, C.J. Coates, I.M. Dubovskiy, N.A. Ratcliffe	302 302 307

	4. Penetration of the Integument	324
	5. Post-penetration HPI	328
	6. Fungal Strategies to Evade and/or Tolerate the Host's Immune Response	339
	7. Using Knowledge of HPI in Pest Control Programs	341
	Acknowledgments	345
	References	345
10.	Molecular Genetics of Secondary Chemistry in Metarhizium	
	Fungi	365
	B.G.G. Donzelli, S.B. Krasnoff	
	1. Introduction	366
	2. The Small Molecule Metabolites of Metarhizium	368
	3. Molecular Bases of Secondary Metabolism in the Genus Metarhizium	380
	4. Conclusions	416
	Supplementary Data	418
	References	418
11.	From So Simple a Beginning: The Evolution of Behavioral	
	Manipulation by Fungi	437
	D.P. Hughes, J.P.M. Araújo, R.G. Loreto, L. Quevillon, C. de Bekker,	
	H.C. Evans	
	1. Introduction	438
	2. What Is Behavioral Manipulation?	439
	3. Diversity of Fungi Controlling Animal Behavior	441
	4. Tinbergen's Four Questions as They Apply to Behavioral Manipulation of	
	Arthropods by Fungi	450
	5. Mechanisms of Behavioral Manipulation	455
	6. Can Behavioral Manipulation be Evolved In Silico?	462
	7. Conclusion	464
	Acknowledgments	464
	References	465
Inde	2X	471