

Preface to

Vector-Mediated Transmission of Plant Pathogens

It has been more than two decades since the appearance of the last of a series of 14 books published from 1962 to 1999 and inspired and edited by the prolific, dedicated student of plant pathogen–vector biology and lover of literature, music, and magic, Dr. Karl Maramorosch, and selected coeditors. These knowledge-packed, inspirational tomes bearing diverse titles over a range of relevant topics were, to name several, *Transmission of Disease Agents* (1962), *Viruses, Vectors, and Vegetation* (1969), *Aphids as Virus Vectors* (1977), *Leafhopper Vectors of Plant Disease Agents* (1979), *Vectors of Plant Pathogens* (1980), *Mycoplasma Diseases of Crops* (1988), *Viroids and Satellites: Molecular Parasites at the Frontier of Life* (1991), and *Plant Diseases of Uncertain Etiology* (1992). With each subsequent volume, rapid advancements were evidenced, as documented by the most recognized experts in vector biology. This rich legacy of diverse, complex, contemporary scientific discoveries in the compilations focused on the latest and most up-to-date knowledge from studies of vector biology of plant pathogens written by contemporary experts in their fields. Each of these volumes was welcomed with open arms by students studying insect anatomy, insect ecology, entomology, nematology, plant pathology, and/or virology throughout much of the world. These writings inspired in students a love of and dedication to vector biology, and many went on to follow in the footsteps of their pioneering predecessors, aiming to carry “the vector biology torch” onward by applying new ideas and creative approaches to overcome difficult technical and conceptual problems across diverse biological study systems, none of which were, or are today, model systems. These purposeful studies have led to advancements built on the previous ones, with successive discoveries that spawned new concepts and inspired new questions. As a result, we are beginning to appreciate the deep evolutionary complexities of plant pathogen–insect vector–host plant interactions based on unexpected discoveries of brand new kinds of plant-pathogenic organisms and previously unknown vector–pathogen complexes, among the most surprising of which perhaps have been phytoplasmas (obligate bacterial pathogens that resemble human mycoplasmas) and plant-infecting trypanosomatids (reminiscent of animal-infecting trypanosomes) as well as several families of plant viruses that also infect their animal vectors, an intriguing example of organisms that likely encode separate sets of genes to accommodate these evolutionarily divergent hosts. A final example of evolutionary and ecological versatility is the discovery that, unlike animal viruses, plant viruses do not utilize receptors to enter their hosts, but as they move along the transmission pathway in the insect vector prior to transmission to their host plants, many plant viruses and fastidious bacteria interact specifically with arthropod-, fungal-, or nematode-encoded (animal) receptors. How these unexpected interactions have evolved to function as they do, and to

be encoded by a relatively small number of genes, are in and of themselves small miracles to students of vector biology.

The study of vector biology encompasses a multitude of diverse aspects and levels of pursuit, each one required separately and then collaboratively with the others to explain holistically a range of vector host-finding, feeding or ingestion, and dispersal activities, among a plethora of other behaviors, including response to plant volatiles, phytochemicals, and physical factors. At another level, vector biologists characterize the behaviors of insects and their mouthparts at the host plant surface interface, while others investigate the complex external and internal anatomies of the vector using, in some instances, noninvasive electropenetration waveforms that characterize stylet penetration, salivation, ingestion of cellular contents, and inoculation of plant pathogens that result in pathogen transmission to the host. Others elucidate molecular-, cellular-, and functional genomics-level features and characteristics of pathogen effectors and determinants of specificity and their interactions with host proteins or other kinds of interactor molecules that culminate in successful passage through the vector and return to the plant host. Since 1999, clearly much has been learned about mechanistic aspects of these interactions at different levels of completeness and extents of complexity; however, because of the recalcitrant nature of these multitrophic biological systems, much more remains to be learned.

This book is organized into seven parts, each addressing a distinct area of focus in plant pathogen–vector biology. Part I sets the stage by providing insights into biochemical, genetic, and genomic considerations by exploring mechanistic parameters of chemical ecological roles in vector-mediated virus transmission, followed by a perspective ensuing from the piecing together of fine-level, coordinated functional genomics–physiological–biochemical analyses of interactions that govern the phytoplasma pathogen metabolic pathway genes that characterize the leafhopper–phytoplasma infection cycle.

Parts 2–6 cover systematically the interactions that govern each of the main modes of vector-mediated transmission in the context of a pathogen’s coevolved interactions with particular anatomical structures of each type of vector and the defined pathway and specificity of the retention–inoculation characteristics. Pathogens discussed in these sections include Eubacteria, including free-living and fastidious life styles, fungi and organisms once classified as fungal pathogens, plant pathogenic nematodes, and plant RNA and DNA viruses, some that infect only the plant host and others that replicate in both a plant and an animal (vector) host. The vectors themselves span arthropods, represented by insects with a variety of host-feeding tropisms and bearing diverse mouthpart types, to mites, fungi (including chytrids), organisms once classified as fungal pathogens, nematodes, and trypanosomatids. Each chapter discusses a best-studied plant pathogen–biological

vector example of the particular mode and associated anatomical locus, bringing together many years of research that has been undertaken to advance the understanding of pathogen–vector biology and these interactions at biochemical, cellular–tissue–organ, and functional genomics levels for which such information is currently available. Among these are noncirculative stylet-borne or mouthpart-borne (nonpersistent), noncirculative foregut-borne (semipersistent), noncirculative foregut-borne (persistent), circulative (persistent), nonpropagative circulative (persistent), and persistent propagative pathogen–vector complexes. This is an intriguing range of relationships recognized to occur among pathogen–vector complexes and perhaps does not yet represent all of the possibilities!

In Part 7, short treatises are presented that cover a number of emerging pathogen–vector complexes about which much more information is needed to elucidate the vector biology to a level that rational approaches may become possible to address the new, poorly recognized, or previously unrecognized plant–pathogen vectors and the constraints they pose to agriculture.

Finally, we are saddened by the recent loss of the pioneering virologist, Alan A. Brunt, who was a mentor and friend to many in the fields of tropical plant virology, vector biology, and epidemiology. We are honored to present one of his last works as Chapter 32, *Cowpea mild mottle virus*, a potential threat to productivity of leguminous and solanaceous crops in warm climates.

The authors and editor and the APS PRESS support staff

who have labored to make this volume possible truly hope that their creation is enjoyed by you, its reader, as you sojourn through it and hopefully return again and again to ponder the most recent advances in the field of plant pathogen–vector biology and arrive at new insights and unexplored conundrums that spur your curiosity to the extent that you too will become an ardent student of vector biology. We all trust that by gaining new knowledge of the coevolved meanderings of plant–pathogenic organisms within the hidden chambers of their biological vectors (and then the plant host too!) that the chapters in this book will continue to inspire the curiosity of those already “converted” while also encouraging new, aspiring students to pursue studies in the field of vector biology. To this end, we all take the torch that leads us to explore deeply all possibilities that will lead to identifying and characterizing the molecular and cellular mechanisms operating synchronously as one evolutionarily successful unit, despite its individually coevolving components. Collectively, those in our science will build upon current concepts and knowledge of processes that underlie and motivate these cryptic, evolutionary, interkingdom collaborations, so that years from now, what is today unfathomable will be increasingly developed into mature, clear depictions of key interactions at all levels possible, an accomplishment that will be achieved only by our collective reaching for it. We wish happy reading to the global students of vector biology!

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