BOURTZIS, K., AND MILLER, T. A. (EDS.) 2009. Insect Symbiosis. Vol. 3. (Contemporary Topics in Entomology Series). CRC Press, Boca Raton, xvii + 408 pp. Hardback, ISBN 978-1-4200-6410-0, $119.95.

More about symbionts! What would justify purchasing this book if you already have volumes 1 and 2, which were published in 2003 and 2006, respectively? Well, each volume is different and much of what is new and exciting about the field is presented in this volume. There is essentially no overlap in content in these volumes. Research on symbionts of insects is a burgeoning and rapidly developing field. In recognition of the importance of this newly recognized subdiscipline, entomologists can now highlight their work on insect symbiosis by publishing in a new section in the *Annals of the Entomological Society of America*. Insect symbiosis research holds promise for not only understanding the basic biology and evolution of insects (and their symbionts) but as a possible method for managing pests and the diseases they transmit.

Volume 3 begins with a dedication to Paul Baumann, a pioneer in the study of bacterial endosymbionts of aphids, written by Nancy Moran. Her brief over view of Dr. Baumann's contributions to the field are insightful and informative and illustrate how rapidly the field has evolved sinse the development of molecular tools.

Chapter 1 (by V. Hypsa & E. Novakova) describes the trials and tribulations of attempting to resolve evolutionary relationships between bacterial endosymbionts of insects using molecular phylogenetics tools. The phylogenetic analyses are challenging due to problems caused by reduced genome sizes, missing links, and horizontal gene transfer and have required the development of new analysis methodologies.

Chapter 2 (O. Schmidt) discusses "Self-nonself recognition in symbiotic interactions". He leads off by stating that "Relationships where two organisms engage in close metabolic or cellular interactions can potentially lead to mutually beneficial coexistence. . . ." but ". . . symbiotic coexistence is never the primary aim of these interactions, but the result of an evolutionary race, where both organisms continuously adapt to stay in the relationship . . ." Schmidt asks ". . . whether multicellular organisms are in fact the result of symbiotic relationships of genetically identical but potentially independent cells", leading to a thought-provoking analysis of how symbiosis may evolve. This discussion of immunity and development is continued in Chapter 3, where Vavre et al. ask "Is symbiosis evolution influenced by the pleiotropic role of programmed cell death in immunity and development?"

Duron & Weill (Chapter 4) change the focus by discussing how insecticide resistance genes could mediate outcomes of symbiosis. As one example, they discuss the mosquito *Culex pipiens*, in which insecticide-resistance genes influence the interactions between the mosquito and its *Wolbachia* endosymbiont. More than 60 strains of *Wolbachia* have been identified among *C. pipiens* populations around the world, with many populations containing two or more types and these strains may cause different levels of cytoplasmic incompatibility and result in different fitness costs, thereby affecting the evolution of pesticide resistance in infected populations. The authors conclude that the effects of *Wolbachia* could affect studies of insecticide resistance in other insects, although such an interaction rarely has been investigated.

Fukatsu & Hosokawa discuss the "Capsule-transmitted obligate gut bacterium of plataspid stinkbugs" in Chapter 5 and make the case that this system is a useful and novel model for insect symbiosis studies because it is possible to exchange symbionts between pest and nonpest stinkbugs. In Chapter 6, Tsuchida, Koga & Fukatsu discuss how endosymbionts can broaden food-plant range of insects. For example, *Regiella* infection of the pea aphid is affected by environmental factors, including temperature and precipitation, as well as host-plant species. The authors discuss their methods for selectively eliminating *Regiella* from aphids in order to determine the role this symbiont plays in the biology of its host, particularly in broadening the aphid's ability to attack different host plants. In Chapter 7, Kikuchi & Fukatsu discuss insect-bacterial mutualism in alydid stinkbugs in which the *Burkholderia* symbiont is not transmitted in a vertical manner. Because the *Burkholderia* are culturable and can be genetically manipulated, they propose to investigate the bacterial genes responsible for the host-symbiont interactions.

Nakabuchi discusses how mutualism can be revealed by a study of symbiont genomics and bacteriocyte transcriptomics (Chapter 8). *Carsonella ruddii*, a primary symbiont found in all psyllids, has had its genome sequenced. The *Carsonella* genome from the psyllid *Pachypsylla venustas* is only about one-third the size of the *Buchnera* symbiont from aphids, known previously as the smallest bacterial genome. This *Carsonella* genome is highly streamlined, lacking genes for many basic metabolic functions, and has a high gene density, with many genes devoted to amino-acid metabolism and translation. The extreme loss in metabolic functions in the *Carsonella* genome suggests that some genes could have been transferred from the genome of the *Carsonella* ancestor to the nuclear genome of the ancestor of psyllids and are now expressed under control of the host nucleus. This raises the question: When does an endosymbiont become an organelle?

In Chapter 9, Perotti et al. discuss the endosymbionts of booklice and barklice (Psocoptera) and true lice (Phthiraptera). Psocids (Psocoptera) feed on spores, fungal hyphae, lichens, algae and yeast or bacterial films. Despite this apparently rich diet that may not require dietary augmentation, mycetomes are present and contain endosymbionts (*Rickettsia*) in two parthenogenetic booklice. The *Rickettsia* appear to be essential for development of oocytes and may be important in restoring diploidy in the oocytes. In addition, *Wolbachia* have also been found in the Psocoptera. In the true lice (Phthiraptera) that feed on keratin found in hair or feathers, oily secretions and/or blood, symbionts may be useful in providing essential nutrients to their hosts. As expected, true lice contain mycetomes and at least four different primary endosymbionts have been found so far. The possibility that human lice, which have become resistant to many insecticides, can be controlled by controlling their endosymbionts with antibiotics is discussed.

Braig et al. provide a very useful review of the biology and evolution of symbiotic *Rickettsia* (Chapter 10). *Rickettsia* now are known as pathogens of vertebrates, as facultative endosymbionts, and as obligate endosymbionts in mycetomes in insects, as well as occurring in plants, sometimes as plant pathogens. *Rickettsia* are obligate intracellular Gram-negative and non-spore-forming and are most likely ancestors of mitochondria.

Behar et al. discuss the structure and function of the bacterial community associated with the Mediterranean fruit fly (Chapter 11). Surprisingly, most of the work on symbionts in this economically important pest is of very recent origin. Most of the microbes associated with this pest are species of *Klebsiella* (Enterobacteriaceae), but other species are present, as well. This community appears to perform different functions during the life cycle, including nitrogen fixation and cycling, carbon metabolism, chemical communication and defense again pathogens. Some bacteria may be important in accelerating fruit decay to enhance larval development.

One of the most unusual stories about *Wolbachia* is reviewed Bouchon et al. (Chapter 12), where they update what is known about the roles of feminizing *Wolbachia* in isopods (Crustacea). It appears that *Wolbachia* is widespread among crustaceans (Isopoda, Ostracoda, Maxillopoda, Amphipoda, Tanaidacea, Cumacea, and Decapoda). One of the best-studied isopods is *Armadillidium vulgare*, where infection with *Wolbachia* leads to cytoplasmic sex determination in which all individuals contain two ZZ chromosomes (which would make them males genetically), although they are functional females! Apparently, the feminization of genetic males by *Wolbachia* is due to an inhibition of androgenic gland differentiation. The story has become very complex and very interesting. The authors suggest that understanding sex determination systems in isopods could lead to a better understanding of the origin and evolution of sex. Narita & Kageyama (Chapter 13) continue the discussion of *Wolbachia*-induced sex reversal with a review of feminization of males in the Lepidoptera, with a focus on the butterfly *Eurema hecab* and *Ostrinia* moths.

The next 2 chapters discuss symbionts of mosquitoes, with the ultimate goal of using the knowledge obtained to improve pest control. Rasgon (Chapter 14) reviews what is known about *Wolbachia* and *Anopheles* mosquitoes, with a discussion of how *Wolbachia* might be used for the control of malaria. Favia et al. (Chapter 15) provide a review of all bacterial symbionts in *Anopheles* and other mosquito vectors, including the effects of midgut bacteria on the biology of the mosquito. They discuss the possibility of using gut bacteria to express mosquito larvicidal proteins or anti-*Plasmodium* molecules.

The effort to control disease transmission is extended to plant diseases by insect vectors when Alma et al. (Chapter 16) discuss symbiotic microorganisms in leafhopper and planthopper vectors of phytoplasmas in grapevines. They speculate as to whether the symbionts may be used to prevent or control diseases transmitted by these pests.

Husseneder & Collier (Chapter 17) continue the discussion of using symbionts to control pests by discussing paratransgenesis in termites. Paratransgenesis is the genetic modification of microbial symbionts, which are then reintroduced into their insect hosts. If these genetically modified microbes become established, are self sustaining, self replicating and perpetuated in populations, the genetically modified symbiont can be transferred throughout the entire termite colony. The authors describe their research that shows that genetically engineered bacteria containing a reporter gene can be ingested and transferred by subterranean termites. They also describe a yeast strain that expresses lytic peptides, which can kill the protozoa in the termite gut and cause the colony to starve. Many issues remain to be resolved before paratransgenesis can be used to control termites, including environmental safety and regulatory issues, as well as deployment methods.

The final chapter (18) by Pontes et al. reviews the biology, culture, and genetic modification of facultative symbionts of insects. Again, the goal is to learn enough so that facultative symbionts within pests of medical, veterinary and agricultural importance can be modified and be reinserted into the insect host to prevent the ill effects of the pest insects or their vectored disease agents. Again, the authors conclude with the statement, "Further studies are therefore needed to provide a more complete understanding of the ecology, evolutionary history, and mechanisms of animal-bacterial associations."

This volume is a step forward in advancing the goal of using our knowledge about endosymbionts for practical pest management programs. Impressive advances have been made in our knowledge of insect symbionts, although much more remains to be learned before we can deploy these microbes to control pest insects and vector-borne plant and animal diseases.

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