BOOK REVIEW

BOURTZIS, K. A., AND MILLER, T. A., EDITORS. 2006. Insect Symbiosis. Volume 2. CRC Press, Taylor & Francis Group; Boca Raton, FL. 276 pp. ISBN 0-8493-1286-8. Hardback. $119.95.

There are several definitions of symbiosis, but in this book it involves an association where one organism (the symbiont) lives within or on the body of another organism (the host), regardless of the actual effect on the host. Some symbioses are mutualistic, some parasitic, and some involve commensalism, in which one partner derives some benefit without either harming or benefiting the other.

This is the second volume in this exciting and rapidly advancing topic by these editors. The first volume was published in 2003 and during the intervening three years additional data have been produced that make this book a useful addition to your library. The first book provided chapters that provided an overview of insect symbiosis, discussions of the primary aphid symbiont *Buchnera* and other aphid symbionts, symbiosis in tsetse, symbionts in the weevil *Sitophilus*, the possible use of paratransgenic symbionts of *Rhodnius prolixis* to prevent disease transmission, bark beetle and fungal symbiosis, symbionts of tephritid fruit flies, symbionts affecting termite behavior, an overview of microsporidia as symbionts (parasites?) of insects, an overview of a newly discovered bacterium that causes sex-ratio distortion in insects and mites (from the Bacteroides group), symbionts that selectively kill male insects, and several chapters on the ubiquitous endosymbiont *Wolbachia*.

This new volume has a brief foreword by Lynn Margulis and fifteen chapters. The first chapter, by Paul Baumann, provides an excellent overview of the diversity of symbiont-insect relationships in the psyllids, whiteflies, aphids and mealybugs. Chapter two by Nathan Lo, Tiziana Beninati, Luciano Sacchi and Claudio Bandi describe an alpha-proteobacterium that invades the mitochondria of the tick *Ixodes ricinus*, which has been found, so far, to occur only in three ciliate species and this tick. The role of the bacterium in the biology of the tick is not yet understood, but may provide some fitness benefit to the tick. The bacterium is found in the ovaries and only rarely in males. Chapter three, by Martha S. Hunter and Einat Zchori-Fein, updates the work conducted on the *Bacteroides* symbionts in arthropods that was discussed in Volume One. Michael Poulsen and Cameron R. Currie describe the complexity of attine ant-fungus symbiosis. Chapter five, by Duur K. Aanen and Jacobus J. Boomsma, covers the evolution of the mutualistic symbiosis between termites and fungi, while Chapter six, by El-Desouky Ammar and Saskia A. Hogenhout, discusses mollicutes associated with arthropods and plants.

A chapter (eight) by Alistair C. Darby and Susan C. Welburn discuss symbiont culture; this is a particularly interesting chapter because the 'dogma' is that intracellular microbial symbionts of insects are extremely difficult to culture. Darby and Welburn provide an overview of how to culture symbionts and note that insect cell lines from the mosquito *Aedes albopictus*, the fruitfly *Drosophila melanogaster* and *Spodoptera frugiperda* have been used to culture *Wolbachia,* the tsetse fly symbionts *Sodalis glossinidius* and *Candidatus Arsenophonus triatominarum*, as well as the aphid symbionts *Candidatus Adiaceo aphidicola* and *Candidatus Consessoris aphidicola*. Cell-free culture of *Sodalis glossinidius* was recently achieved. Darby and Welburn note that the culture of "obligate endosymbionts in a cell-free culture may be extremely difficult due to the bacterial cell having a dedicated structural or physical need for a particular intracellular environment, and the alternatives to cell-based culture, such as encapsulation of cells in agarose gel microdroplets" may be successful. This area of research is important because growing microorganisms under controlled conditions allows detailed studies on their physiology and metabolic pathways that are difficult to obtain in any other manner. Lynn J. Rothschild (Nature 443(7109): 249), recently complained that papers and presentations should say "that culturing was not successful or not attempted, not that organisms are intrinsically unculturable." Darby and Welburn hint that insufficient efforts have been expended to culture 'unculturable' symbionts.

In Chapter nine, Amparo Latorre and Andres Moya describe the comparative genomics of the primary aphid endosymbiont *Buchnera aphidicola* and discuss the question "Is *Buchnera* being driven to extinction?" because its genome is very reduced and is accumulating deleterious mutations due to Muller's ratchet. In Chapter 10, Jeremy C. Brownlie and Scott L. O'Neill discuss *Wolbachia* genomics as a tool in understanding symbiosis of this common microbial symbiont of arthropods. Since the publication of Volume One, the genomes of two *Wolbachia* strains have been completely sequenced (one infecting the nematode *Brugia malayi* and the other a strain that causes cytoplasmic incompatibility in *Drosophila melanogaster*), and some surprises were found. The *Wolbachia* genome from *Drosophila* has a large number of transposable elements and prophage sequences (including the WO bacteriophage) within it, which is highly unusual for microbial genomes. Because *Wolbachia* has the

ability to exchange genetic information between *Wolbachia* strains, it is less likely to undergo the deleterious effects of Muller's ratchet because it can recombine its genome and acquire foreign DNA, making it more able to infect and adapt to a large range of insect hosts.

The role of *Wolbachia* in the biology and pathogenesis of filariasis is discussed in Chapter 11 by Joseph D. Turner, Jeremy M. Foster, Mehul Ganatra, Barton E. Slatko and Mark J. Taylor. Sixteen of 21 filarial nematodes in the Onchocercinae and Dirofilariinae (leading causes of tropical diseases) are positive for *Wolbachia*, and the *Wolbachia* are essential for normal development and fertility in these worms. The release of the *Wolbachia* or *Wolbachia*-encoded molecules from the nematode is associated with activation of immune responses associated with adverse reactions to treatment and pathogenesis of river blindness. Antibody responses to *Wolbachia* are also associated with chronic inflammatory disease in lymphatic filariasis, suggesting that activation of acquired immunity by *Wolbachia* may trigger the progression toward chronic filarial disease. The *Wolbachia*-nematode mutualism is being considered as a target for chemotherapy.

Paternal sex ratio (PSR) chromosomes in parasitoids wasps (B chromosomes), which were discovered in 1979 in the parasitoid wasp *Nasonia vitripennis,* are discussed by Joke J. F. A. van Vugt, Hans de Jong and Richard Stouthamer in Chapter 12. It is not clear to me why chromosomes are considered symbionts, but the story is very interesting. Two additional cases of PSR have been found in the parasitoids *Encarsia pergandiella* and *Trichogramma kaykai*. PSR chromosomes cause initially diploid eggs to develop into haploid males carrying the PSR chromosome by loss of the parasitoid's paternal chromosomes, but how PSR chromosomes cause the paternal chromosomes to be lost is not known. I also wondered how many more parasitoids would be found that contain PSR chromosomes, if populations with altered sex ratios are examined carefully.

Richard H. ffrench-Constant, Andrea Dowling and Nicholas Waterfield discuss insecticidal products produced by the microbial symbionts, *Photorhabdus* and *Xenorhabdus*, of insect-killing nematodes in Chapter 13. These symbionts live within the gut of the nematode and are regurgitated by the nematode following entry into the insect. Once inside the insect, the bacteria produce a range of insecticidal proteins and proteases that kill the insect.

In Chapter 14, Kostas Bourtzis and Alan S. Robinson discuss the practical uses of using *Wolbachia* and/or radiation for insect pest control. The authors describe the ongoing and completed operational programs using the sterile insect technique (SIT) to control the Mediterranean fruit fly, the Mexican fruit fly, the New World screwworm, the pink bollworm, the codling moth, the painted apple moth, the tsetse fly, the melon fly, the Oriental fruit fly, the Guava fruit fly, the Queensland fruit fly and the onion fly prior to discussing *Wolbachia* and cytoplasmic incompatibility, which is widespread among major insect pests. They note that *Wolbachia* is a potential tool for insect control because it could be used as a para-transformation system, although transformation of *Wolbachia* has not yet been achieved despite substantial efforts. Another option is that the cytoplasmic incompatibility caused by some *Wolbachia* might be used to drive genes into natural populations. Finally, cytoplasmic incompatibility caused by *Wolbachia* might be used to induce sterility in field populations. The authors review historical examples of using cytoplasmic incompatibility to control pests and discuss recent work to use this approach to control the medfly and mosquitoes. The authors clearly outline the data required before cytoplasmic incompatibility can be used to manage pest insects, including effects of male age, temperature, mating history, sperm competition and other factors, such as antibiotics and poor nutrition, on the expression of cytoplasmic incompatibility. The authors also discuss the possible biosecurity issues of escaped insects from a rearing facility and conclude that the use of *Wolbachia* is "in an experimental stage, but it holds great promise for becoming a component of integrated control of arthropod disease vectors or agricultural pests."

Finally, in Chapter 15, Thomas Miller, Carol Lauzon, David Lampe, Ravi Durvasula and Scott Matthews discuss the use of paratransgenesis for the control of insect-transmitted plant diseases, using Pierce's disease as a model. Paratransgenesis is the genetic modification of a symbiotic microbe of a host, rather than the genetic modification of the host itself. Grapevines in the wine-growing area of California began experiencing an epidemic of Pierce's disease, which is caused by the bacterium *Xylella fastidiosa*, which is transmitted by the glassy-winged sharpshooter, *Homalodisca coagulata*. A bacterium, *Alcaligenes xylosoxidans* var. *denitrificans*, was isolated from the foregut of *H. coagulata* and also was found to colonize the xylem of host plants. *Alcaligenes* is easily cultured and was chosen as a 'delivery vehicle' for anti-*Xylella* reagents. *Alcaligenes* was genetically modified using recombinant DNA methods using a transposable-element (*mariner*) vector, which contained kanamycin and tetracycline resistance genes, as well as a mobility group sequence from the *E. coli* plasmid RP4, which allows this plasmid to be mated from other suitable *E. coli* strains to virtually any other bacterial species. The authors evaluated fitness of multiple transgenic stains of *Alcaligenes* and discussed risk assessment issues. Releases of a transgenic strain of

Alcaligenes containing a marker gene were conducted in 2003 and 2004 in California with regulatory oversight of these field trials provided by the Environmental Protection Agency.

Thus, in comparison to Volume One, new topics have been introduced and previously discussed topics have been updated. This volume is a welcome addition to your library if you are working on symbionts of insects (or nematodes!). The field of insect symbiosis is expanding rapidly and its maturation is exemplified by the use of genomics, as well as the more traditional experimental tools. To really keep up with the literature, however, one needs to read the primary literature because nearly every week there are key papers on insect symbionts published in high-impact journals such as *Science, Nature* and the *Proceedings of the National Academy of Sciences*. The chapters in this volume make it clear that the biology, behavior, ecology and genetics of insects cannot be fully understood without understanding the role(s) of their symbionts. Although this volume is not an exhaustive review of all that is known about symbionts, it provides an entry into the literature of key topics within this exciting subdiscipline.

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