Book Review

McPherson JE [Ed.]. 2018. Invasive Stink Bugs and Related Species (Pentatomoidea). Biology, Higher Systematics, Semiochemistry, and Management. CRC Press, Boca Raton, FL. 819 pp. ISBN 9781498715089 $149.95 (hardcover).

Over time, various arthropod pest taxa assume extraordinary importance, and then their significance fades as the pest problem is 'solved,' diminishes naturally, or yet another taxon assumes greater priority. In the last 50 years, we have seen problems arise and dissipate like waves on a shoreline. Examples include gypsy moth, spruce budworm, phytophagous mites, grasshoppers, southern and mountain pine beetles, Colorado potato beetle, tephritid fruit flies, diamondback moth, whiteflies, thrips, black-legged tick, and bed bug, to name a few. Many of these issues are related to the onset of insecticide resistance or introduction of new pests, though some are attributable to changes in resource availability or weather. So what is our 'bug du jour'?

In recent years, stink bugs (Pentatomidae) have assumed much greater importance. As with many other "bugs du jour" situations, invasiveness is a large part of the equation as to why stink bugs have gained greater significance, but changes in pesticide use (less residual and more selective materials) also factor into this situation. In keeping with the pattern discussed previously, these insects are causing increasing levels of damage to crops. To bring focus to an upwelling of interest in stink bugs, JE McPherson assembled a team of 60 authors from 13 countries to review the principal pests, to accent the important and unique characteristics of stink bugs, and to highlight potential invaders.

This book opens with an overview of the superfamily Pentatomoidea, and this short section presents a brief synopsis of what is to come, including a paragraph devoted to the origin of each of the 6 invasive (to North America) species and a key to the families. The next 180 pages are devoted to the higher systematics of the Pentatomoidea. Those who are taxonomically or phylogenetically inclined will find this to be a very comprehensive and scholarly treatment, discussing families, subfamilies, and for the Pentatomidae, the tribes, and generic groups. This is a world-wide treatment. This section also contains an 8-page color insert, and for anyone who thinks stink bugs are cryptic, boring, brown and green insects, these images will likely change your mind; many rival beetles for beauty.

Nearly 300 pages are devoted to discussion of 6 invasive species [*Bagrada hilaris* Burmeister, *Halyopmorpha halys* (Stål), *Megacopta cribraria* (F.), *Murgantria histrionica* (Hahn), *Nezara viridula* (L.), *Piezodorus guildinii* (Westwood)], and a few species that have been identified as potential invaders. These contributions best relate to the title of this book, and contain information on important topics such as taxonomy and identification, distribution, biology, impact, and management (including natural enemies) of the invaders.

One chapter on "potentially invasive" pentatomids contains information on *Oebalus* spp. and *Arvelius albopunctatus*. These species are, in fact, invaders of Florida (*Oebalus* spp.), or Florida, Texas, and Arizona (*A. albopunctatus*). They are called potentially invasive because they do not meet the author's definition of invasive, which includes spread, uncontrolled growth, and adverse effects. I'm not sure that everyone would subscribe to this definition. Many non-native insects invade, establish, and seemingly take a while to adapt before they spread and/or cause injury. I'm more comfortable calling all non-native insects that establish permanent populations in new areas 'invasives', and simply adding the adjective 'damaging' if and when this becomes appropriate. This brings us to a related topic, a section called "A noninvasive group (Antestia complex)" in the table of contents, but a less judgmental "The Antestia bug complex in Africa and Asia" in the chapter devoted to the subject. These insects also are called 'variegated coffee bugs' and occur principally in Africa, but also to some degree in India. Who is to say they do not have potential to invade South America or another coffee-growing areas? As the authors acknowledge, all the other serious coffee pests have found their way to other locations. I think that this is the chapter I would have labeled 'potential invasives'.

Stink bugs have many forms of diapause, and diapause is induced or terminated by any number of factors. This aspect of insect biology is important from both biological and management perspectives, and the chapter devoted to this is complex enough that the authors thoughtfully provided a glossary to help the reader understand the intricacies of how bugs survive adverse conditions. Related to this is another chapter by the same authors that deals with seasonal cycles. Again, there are many means by which stink bugs survive adverse environments, and the dynamic interplay of diapause and seasonality are key elements in stink bug adaptation.

The ability of stinkbugs to vector plant pathogens warrants a chapter, and it is a useful contribution. Entomologists mostly think of plant pathogen transmission from the perspective of the suborders Sternorrhyncha and Auchenorrhyncha (the former order Homoptera) and mostly the whiteflies, aphids, leaf- and planthoppers, mealybugs, and psyllids. Slowly it is becoming apparent that stink bugs and other heteropterans can have a role in induction of plant disease. Their repertoire of disease-causing agents is somewhat limited, but potent nonetheless. They vector principally fungi, and in a more limited way, they transmit virus, non-fastidious bacteria, and trypanostomatid pathogens. This chapter is useful reading for anyone interested in plant disease.

A relatively new area of stinkbug research is discussed in a chapter on symbiotic microorganisms. Bacteria often are associated with the midgut of stinkbugs, and they play important roles in bug development, survival, and reproduction.

A more well-developed area of research is the various roles of semiochemicals in stink bug biology. Stink bugs use various semiochemicals including both male-produced and female-produced sex pheromones, alarm pheromones, aggregation pheromones, and defensive chemicals (allomones) produced in abdominal and thoracic glands. In turn, predators and parasitoids exploit the production of volatiles by bugs to locate their prospective hosts. This chapter presents a very nice summary of bug semiochemicals, including practical applications for monitoring, trapping and poisoning pests.

The final chapter is called "general insect management" and is an overview of insect management that, in about 40 pages, covers everything from chemicals used by the Sumerians in 2500 BC to RNAi technology. It is a very informative, if concise, treatment. However, much of it has little or no relevance to stink bugs. For example, tillage is mentioned as a means of disturbing the habitat of pests, and

the examples of European corn borer and corn earworm management through tillage are cited, but stink bugs are not mentioned. Tillage (clean culture) as a means of weed management is highly relevant to stink bugs, as weeds often are preferred hosts of stink bugs, but stink bugs are not mentioned in this section. Similarly, tillage could potentially affect *Bagrada* populations, as they oviposit in the soil, but again this is not mentioned here.

Overall, this is a nice addition to the literature, as I know of no other comprehensive source of information about the 6 important invasive stink bugs now found in North America. Many of the chapters, such as those on semiochemistry and vectors of plant pathogens, are very timely. This is a volume that stink bug workers will want, and research libraries should possess.

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