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What Mosquitos Smell These Days

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Olfaction in Mosquito–Host Interactions. Gregory F. Bock and Gail Cardew, eds. John Wiley & Sons, Chichester, UK. 1996. 342 pp., illus. $90.00 (ISBN 0-471-96362-3 hardcover).

The CIBA Foundation sponsored a symposium on olfaction in mosquito–host interactions in London (31 Oc-

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tober–2 November 1995) at the suggestion of John Hildebrand, of the University of Arizona. Given my own interest in this topic, I was curious about the resulting volume, to which some of the major workers in the field contributed.

The book introduces some of the active scientists in the field of chemical-oriented entomology. As one who was repeatedly "cited but not invited," I will try to point out the strengths of the book rather than of the research per se. This volume is well organized, well prepared, and nicely presented, with no apparent errors. The book allows both the novice and scientists well versed in this field to catch up with some of the recent mosquito attractant efforts.

The text begins with discussions of biology, mosquito control, ecology, behavior, and genetics, and then moves to olfactory control of behavior. I found the olfactory theory somewhat heavily focused on *Drosophila* and moth presentations; this focus may be a function of the organizer's interests or of the "coming philosophy" that was described at a 1991 meeting of the Entomological Society of America by the late eminent mosquito scientist, George Craig. Craig lamented that it had become difficult for mosquito workers to obtain support from US granting agencies such as the National Institutes of Health because of increased funding of scientists studying *Manduca* and pressure from malaria vaccine advocates on traditional medical entomology funding sources.

Later parts of the book discuss the sensory physiology of the carbon dioxide receptor and the effect of carbon dioxide on antennal receptors. The reader is introduced to modern olfactometer systems as devices to measure mosquito behavior. A useful discussion is reported after each presentation, in which meeting participants point out particularly appropriate or inappropriate aspects of olfactometer use. It is well known that each type of olfactometer has good and bad points, yielding data that are biased by factors that are guessed at and minimized, but are not obvious. The trickiness of olfactometer use will become apparent to readers sensitive to nuances of the "art" of doing science.

Chemical background covering the early years before the modern era (1968–1998) is covered in several chapters, with numerous citations of the seminal paper by Smith et al. (1968), which described lactic acid as a critical part of the mix of attractive volatiles produced by human skin, together with carbon dioxide. Several series of olfactometer experiments with *Aedes aegypti* are described that derived from Smith's effort, and other reports are cited that use the Smith paper as a paradigm. Perhaps this means that copying of good mosquito experimental efforts is common.

I was particularly interested in descriptions of new analytical chemistry results on human odor compounds, but only two papers address this area. Descriptions of the next step in determining what mosquitoes smell—preparative separation chemistry—were also sparse, although this technique is a necessary part of experiments to integrate separation of chemical compounds with a useful, reproducible bioassay. Descriptions of olfactometer bioassays are presented that follow the wind-tunnel/dual-port olfactometer versus Y-tube olfactometer methods and the two camps of many–whole animal assays versus videotaped single-animal assays. The olfactometer camp was formerly arrayed against the antennal electrophysiology camp. It is therefore refreshing to read of the efforts of Alan Cork (p. 71) and of Martin Geier, Hinrich Sass, and Jürgen Boeckh (p. 132) that now integrate wind-tunnel, olfactometer, and electroantennagraphic detection techniques to approach host odor problems.

This book also has illustrative studies that point out the difficulty in sorting chemicals into bits by gas chromatography or HPLC, and then reassembling the bits into something attractive to mosquitoes. This problem is not like moth pheromone chemistry, for which identifiable classes of compounds can be attacked. The discussions point out confusion in many areas, in that it is complicated to sort out stimulus/response when testing ephemeral water-soluble compounds. For some analytical problems, therefore, gas chromatography may not provide a ready answer, and other modern analytical techniques may be better for identification. Also, without useful quantification, the chemist has problems providing release rates from formulations to be deployed in the field for these difficult compounds.

Unfortunately, there was no presentation of new work on animal odors. Curiously, human host odor bioassays of only two species of mosquitoes were described, *A. aegypti*, which is the white rat of medical entomology, and *Anopheles gambiae*, the African malaria vector. Perhaps whole-animal bioassayists are reluctant to move to new insect models, a point made by an attendee at one of the discussions covered by this volume.

A thoughtful summary by Willem Takken discusses essential kairomones (olfactory cues; p. 302) that must eventually be correlated with mosquito species, age, and physiological stage to understand host attraction and, ultimately, zoophilic versus anthropophilic female responses. In the summary, Pickett expresses the hope that information expected over the next 4 or 5 years can be applied to successful mosquito control strategies. However, in the nearly 3 years since the meeting that gave rise to this book, I have heard of failures in the field with some of the chemical attractants discussed in the book, but I am aware of no dramatic breakthroughs.

In any case, the hope is that knowledge of mosquito–host interactions may be employed in future mosquito control strategies. Interestingly, behavioral scientists who propose to work with mosquitoes generally find it difficult to find support in the United States, but support by the European Union/Community and Bayer AG was cited by several attendees.

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