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Bioassays with Arthropods

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ROBERTSON, J. L., R. M. RUSSELL, H. K. PREISLER, AND E. SAVIN. 2007. Bioassays with Arthropods. CRC Press, Boca Raton, FL, U.S.A. 2nd edition, xxii + 199 pp. Hardcover, ISBN-10: 0-8493-2331-2, $89.95 [Also, ISBN-13: 978-0-8943-2331-7].

A bioassay is very generally defined as any experiment in which a living organism is used as a test subject. When a stimulus is applied, the organism responds; thus, bioassays provide a means to quantify an organismal response or responses to manipulated experimental variables. With any bioassay, experiments must be carefully designed so that biological information can be obtained from statistically valid data. Design of statistically valid bioassay experiments includes many considerations such as randomization of test subjects, control treatments, number of replications and methods of treatment, to name but a few. The book *Bioassays with Arthropods* by Robertson et al. is an excellent reference and guide for use in designing, conducting, and analyzing a wide variety of bioassays.

This second edition is a revision of a book by Robertson & Preisler (1992), entitled *Pesticide Bioassays with Arthropods*. As explained by the authors, the term "*pesticide*" has been dropped from the title of this edition since the quantal dose-response concept can be applied when testing many other chemicals besides toxicants, as well as many physical or environmental factors. This is very true. The first edition was 10 chapters in length and the revised second edition has increased to 15. Additions to the second edition include chapters on natural variation, quarantine statistics, microbial insecticide testing, and pesticide resistance. Many topics and discussions also have been expanded throughout the second edition. Another important and noteworthy revision is that much of the text is geared towards POLO-PLUS™, which is an analytical software package developed and marketed by the co-authors. Other proprietary software described in the book includes PoloMix™ and PoloEncore™.

There are 2 aspects of the book to which potential readers should be alerted. First, the authors use a unique style of fictional storytelling to introduce each chapter and throughout some chapters. The use of fiction in this context often makes it difficult for the reader to realize major chapter themes and understand key definitions that underlie chapter material. This stylistic approach can be a hindrance if one is in need of rapidly accessing relevant information. The second aspect readers should note is that the book is designed in part as a user's guide to POLO-PLUS™ and other software developed by the authors for analysis of bioassay data. POLO-PLUS™ was created as an alternative to the now-defunct Probit Analysis program developed by Finney (1964, 1971). Scant details and often criticisms are presented for other fully capable statistical programs such as SAS (Chapter 4, p. 51). In addition, the author of this review knows of 1 legitimate example where software code problems in POLO-PLUS make 1 analysis described in the book impossible to accomplish.

From this reviewer's perspectives in insect toxicology and pesticide resistance, 2 of the most useful analyses described in the second volume are calculation of lethal dose ratios with 95% confidence limits (Chapter 9.III.B and Chapter 3.III.A.2) and statistical comparison of slopes for logit or probit mortality lines (Chapter 3.III.B.1-3). In particular, the lethal dose ratio calculation originally described in the first volume has excellent utility for calculating resistance, synergism, or general toxicity ratios that include measures of statistical confidence at $P < 0.05$ (e.g., Scharf et al. 1995, 1996, 1997, 1999). Slope comparisons are especially useful for investigating the genetic variation of different insect populations with differing pesticide susceptibilities. A chapter-by-chapter breakdown of the second edition is provided in the following paragraphs.

Chapters 1-3 introduce fundamental concepts and major themes that are revisited throughout subsequent chapters. Chapter 1 is an introduction to underlying concepts and terminology. Chapter 2 is an overview of quantal response bioassays, which are bioassays that estimate the relationships between varied quantity or intensity of stimuli and responses to them. Chapter 2 provides an overview of the highly important assay factors of experimental design, treatments, controls, randomization and replication. Chapter 3 presents concepts related to binary quantal responses such as goodness of fit relative to expected models, LD ratios, and slope, as well as an introduction to probit and logit analysis.

Chapter 4 is an overview of binary quantal response data and analyses with emphasis on POLO software, but with discussion and examples of other software packages as well. Chapter 5 delves more deeply into binary quantal response bioassays and design considerations, with special emphasis on specialized bioassays that can develop discriminating doses that distinguish, for example, resistant and susceptible genotypes. Chapter 5 concludes with some practical considerations for such bioassays, including a "reality checklist" that helps the reader to understand experimental limitations and set realistic goals in arthropod bioassay research.

Chapters 6 and 7 are new in the 2nd edition. Chapter 6 addresses natural variation and emphasizes the concept that bioassays provide an estimate of a population response, and not a direct measurement. Chapter 7 deals with quarantine statistics that are useful for defining pesticide doses that, for example, enable complete elimina-

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tion of exotic pests that might be introduced to a new area on a commodity. This chapter seems to mostly be a criticism of USDA "probit 9 security" policies but certainly also contains information useful to scientists working in the areas of invasion/quarantine biology.

Chapters 8 and 9 are also new additions. Chapter 8 provides an overview of bioassay design and analysis considerations that are applicable when working with microbial pesticides like viruses and bacteria/bacterial endotoxins. Chapter 9 covers the very important topic of pesticide resistance and its measurement with bioassays. Very useful components of Chapter 9 include distinguishing natural variation from resistance, lethal dose ratios, discriminating doses, and models for estimating modes of resistance inheritance. This chapter also provides specific examples using case studies from the literature.

Chapter 10 is a revision of a chapter from the first edition by the same name that deals with testing mixture treatments. The chapter is built around the null hypothesis in such types of research, i.e., that the toxicity of each component in a mixture is not affected by toxicity of the other component or components. The chapter also addresses the fundamental concepts of synergism and antagonism among mixture components, as well as introduces the reader to another analytical software package developed and marketed by the authors called PoloMix™. Chapter 11 considers time as a variable in bioassay experiments. This chapter considers 2 alternative bioassay approaches in depth, independent vs. serially sampling, and provides decision rules that can help in choosing which approach is best for a particular situation.

Chapters 12 and 13 are closely intertwined chapters that cover the topic of binary quantal responses with multiple explanatory variables. For example, such variables could be the body weight of a test subject in a dose-response bioassay, the temperature at which the assay was conducted, the sex of the test subjects, or the diet fed to the test subjects. Chapter 12 discusses efficient experimental designs and introduces another specialized software package called PoloEncore™ for analysis of binary quantal response bioassays. Chapter 13 is a continuation of the multi-explanatory-variable theme with specific focus on body weight, which has proven to be one of the most important variables in multi-regression analyses.

Chapter 14 takes the multivariate concept one step further by overviewing polytomous (multinomial) quantal response bioassays that consider multiple dependent variables in a multiple regression format. This chapter is a must-read for researchers faced with the problem of investigating toxicity of insect growth regulator (IGR) chemistries where responses are far more complex than dead or alive.

Finally, chapter 15 follows on themes presented in chapter 6 which considered natural variation and bioassays as tools to sample population responses. This final chapter has a strong philosophical component and seems to be proposing the concept of "population toxicology" in the same way that pest managers would consider population ecology in deciding whether or not to make pesticide applications. The idea behind population toxicology is to use realistic bioassays and conditions to effectively predict pesticide efficacy to field populations.

In conclusion, *Bioassays with Arthropods* is an excellent desktop reference and guide for use in designing, conducting, and analyzing a wide variety of bioassays that investigate a wide variety of chemistries and simulated environmental treatments. The book has utility for everyone from the beginning graduate student to the seasoned professional researcher. Additionally, this reviewer further recommends the book as a very suitable companion book for courses specifically dealing with arthropod toxicology and pest management science.

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