Preface

This SpringerBrief focuses on how the numbers of randomly moving organisms caught in monitoring traps can be translated into reliable estimates of their absolute rather than just relative density. Quick and inexpensive methods for establishing absolute density are sorely needed to enable pest managers to sharpen their decisions about when pesticides are or are not justified, thereby boosting profits as well as human and environmental safety.

This book grew out of seemingly disparate experiences by Dr. James Miller during a research and teaching career as a quantitative insect behaviorist and chemical ecologist working at Michigan State University, a Land-Grant University where fundamental and applied science are expected to blend seamlessly to produce knowledge that makes a difference in the world. Our applied research on how insect control might be effectively achieved using sex attractant pheromones to disrupt mate-finding led to fundamental research on the mechanisms whereby sex pheromones impact insect behavior and physiology. One highly productive approach explored parallels between mating disruption of moth pests of apple and enzyme kinetics. The goal was to determine whether mating disruption was or was not mediated principally by competition between artificial and natural point sources of pheromone ("substrates") for the attention of responsive males ("enzyme"). However, the "test tubes" for these quantitative experiments interrelating capture numbers in traps with manipulated numbers of female and male insects as well as dispensers of artificial pheromone were 20 field cages, each covering 12 full-sized apple trees. Nevertheless, striking and useful parallels were found between these inanimate and molecular vs. macroscopic and whole-organism systems. Highly reproducible patterns in the capture data convinced us that insects and molecules were behaving similarly at their given spatial scales, e.g., both diffusing randomly throughout their test tubes before complexing for measurable times with any agents for which they had affinity. Moreover, we discovered that the known absolute density of insects deployed in the cages could accurately be derived from graphical plots of the number of attractive pheromone dispensers deployed per cage against the inverse of catch per monitoring trap. That insight piqued our curiosity about whether such an approach might also be successful in the open-field situation.

Further insights into random elements in animal behavior came from teaching a graduate-level course in insect behavior. One of the laboratory exercises required students to record and analyze the tracks of dispersing insects. The picture emerging across years of data was that most insects not influenced by cues from resources, move randomly and display normal distributions of headings for new steps whose width is characteristic of the species, but varies across species. Additionally, striking matches were found between the tracks produced by real vs. the randomly-based computer-simulated movers we developed for teaching the mechanisms of insect orientation and their consequences when foraging.

Yet another line of research on egg depositional behaviors of onion flies interacting with artificial host plants of varying quality gave evidence for the existence of some sort of "random number generator" that injected randomness into the investment decisions of insect herbivores, essentially allowing them to diversify investments across the full range of resource qualities while investing most heavily in the best resources. The patterns of investment by real insects were faithfully reproduced by simple computer simulations where the strength of the positive factors promoting egg deposition was divided by the strength of any negative factors to yield a quotient then increased or decreased by a random input. A bout of oviposition was envisioned to turn on when the overall outcome fell above some threshold value.

This convergence of data from various systems points toward a central and highly valuable role for random elements within the mechanics underpinning the biology of simple organisms like insects. We elected to tackle the important puzzle of understanding the mechanics of trapping with the confidence that random elements and random outcomes would feature prominently in the problem, and that computer simulations permitting the manipulation of random elements would be an essential tool in that exploration. We also recognized that this effort would best be accomplished by a team bringing expertise from biology/behavior (J.R.M., C.G.A., P.A.W.), computer science (P.A.W.), and mathematical physics (J.H.S.). Thus, the product you are about to read represents an interdisciplinary synthesis.

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Trapping of Small Organisms Moving Randomly
Principles and Applications to Pest Monitoring and Management

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