

When social creatures act in concert

Collective Animal Behavior

David J. T. Sumpter
Princeton U. Press, Princeton, NJ,
2010. \$80.00 (302 pp.).
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Reviewed by
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Bird flocks in flight, fish schools flashing among the coral reefs, and ant colonies forming trails at the summer cottage are just a few of the amazingly dynamic behaviors that intrigue biologists, modelers, and physicists studying pattern formation. In *Collective Animal Behavior*, mathematician David Sumpter treats us to a feast of selected quantitative studies about animal societies. Having researched ants, locusts, bees, and other social bugs, Sumpter provides experimental- and theoretical-biology perspectives that are well informed and display his unique knowledge. Both behavioral ecologists and general scientists interested in techniques for studying groups or examples of group behavior will find this book quite readable and informative.

Collective Animal Behavior summarizes many core problems and puts them into biological context. Seven chapters cover the aggregation of group members and how they share information, make decisions, collectively move, temporally synchronize, build structures or trails, and self-regulate. The other two address the evolution of cooperation and more elaborate complex interactions.

Sumpter's book generally makes for a gentle introduction to modeling, with quantitative simplified models that are amenable for exploration by students and nonexperts. The reader can choose an appropriate level of engagement, by



either working through the models or reading the text for an overview. I particularly liked the organization of text and boxes; I found but rare sign errors in box 10.A, which discusses two-player discrete-strategy evolutionary games. The author, though, occasionally jumps to more advanced topics, such as phase planes and bifurcation diagrams, without adequately preparing the reader.

In his conclusion, Sumpter points out the tricky problem of formalizing and categorizing individual-based models. Slightly varying the behavioral rules or the values of interaction parameters can lead to very different group behaviors, an issue that is rarely analyzed adequately in simulation studies. Physicists have grappled with the issue using statistical mechanics, and mathematicians have opted for continuum partial differential equation models to represent group densities. Such efforts bring new tools to bear on the subject, enabling a fuller understanding of stability, regimes of behavior, bifurcations, parameter dependence, and so forth.

Collective Animal Behavior stands out for several reasons. At a technical level, it provides wide coverage of both mechanistic modeling, which is used to connect individual rules with group behavior, and functional analysis, which explains why some behaviors might confer advantages over others. Stylistically, Sumpter synthesizes perspectives, comparisons, critiques, and examples of human and animal behavior into his book. He expresses his opinions directly and presents provocative case studies—for example, of the segregation of blacks and whites.

No book can cover every aspect of a field; this one largely focuses on optimality principles in animal groups rather than on their self-organization. Nonetheless, it is a pity that Sumpter fails to mention, even briefly, some important contributions that have been made to the new understanding of the self-organization of social groups. The absence of a discussion of recent articles by such authors as Andrea Bertozzi, Andrew Bernoff, Maria D'Orsogna, and Chad Topaz make chapter 5, "Moving Together," more anecdotal than authoritative.

Sadly, some of the classical history is also omitted. Not mentioned are the 1951 article "Studies on the structure of the

fish school" (Charles Breder); the 1973 simulations of individual-based models for groups (S. Sakai et al.); or even Akira Okubo's classic book *Diffusion and Ecological Problems: Mathematical Models* (Springer, 1980), which has been revised with Simon Levin as *Diffusion and Ecological Problems: Modern Perspectives* (Springer, 2001). Also overlooked are the computational works conducted in the 1980s and 1990s by Andreas Huth, Christian Wissel, and others.

Using distinct sets of rules and algorithms, many researchers have been able to simulate lifelike group behavior, which leads to the question of how to validate models against reality. That question is only recently being addressed in combined experimental and theoretical works, for example, in the 2010 *Proceedings of the National Academy of Sciences* paper "Inferring individual rules from collective behavior" by Ryan Lukeman, Yue-Xian Li, and me. I suspect that a second edition of Sumpter's book might be quite different from the current volume.

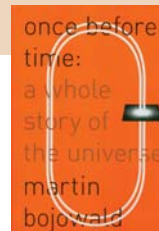
Despite its few oversights, I enjoyed reading *Collective Animal Behavior*, sharing it with students working on undergraduate summer research, and finding a few nicely covered topics relevant to my own research.

Once Before Time A Whole Story of the Universe

Martin Bojowald
Alfred A. Knopf, New York, 2010.
\$27.95 (320 pp.).
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Of the four known forces of nature, gravity was the first to be described and remains the least understood. In contrast to the trio of gauge interactions—the electromagnetic and the strong and weak nuclear forces—gravity has resisted all efforts to render it in a quantized form. Indeed, quantizing gravity is a challenge that has kept some of the brightest minds in theoretical physics busy for several decades.

Most theorists hope that general relativity and quantum mechanics will be unified, as special relativity and



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