

An Introduction to Molecular Ecology

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Source: BioScience, 55(4) : 376-377

Published By: American Institute of Biological Sciences

URL: [https://doi.org/10.1641/0006-3568\(2005\)055\[0376:GFE\]2.0.CO;2](https://doi.org/10.1641/0006-3568(2005)055[0376:GFE]2.0.CO;2)

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Genes for Ecologists

An Introduction to Molecular Ecology. Trevor J. C. Beebee and Graham Rowe. Oxford University Press, New York, 2004. 370 pp., illus. \$49.50 (ISBN 0199248575 paper).

An *Introduction to Molecular Ecology*, by Trevor Beebee and Graham Rowe, is among the first books to describe how the methods of molecular biology are being used to revolutionize ecology. By combining molecular technologies with field studies, ecologists have created a new arena of investigation in which genetic markers are used to answer questions—about population dynamics, species diversity, adaptation, and conservation, for example—that until recently were beyond science's reach. The authors of *An Introduction to Molecular Ecology* are excited about this emerging field, and in their introduction they set an optimistic and energetic tone that they maintain throughout.

The book provides a comprehensive review of the area, and would serve as an excellent supplemental text for a general ecology class or as a stand-alone resource in a more advanced course focusing on the use of molecular methods in ecology. Because it explains difficult molecular terms in language that is easy to understand, the book would also be useful to members of the general public who are interested in ecology.

Trevor Beebee is a professor of molecular ecology in the School of Life Sciences at the University of Sussex, and Graham Rowe is a lecturer in the School of Biological Sciences at the University of Wales, Bangor, United Kingdom. The authors' backgrounds and expertise are in both ecology and molecular biology, and their excellent command of these fields allows them to present complex material (for example, genetics, genomics, and molecular methods) in a clear and concise manner. They are highly qualified to comment on the topics covered in the text and are sure to become known as experts in the new discipline.

The first chapter provides an introduction to molecular methods and techniques, highlighting methods—including DNA fingerprinting, polymerase chain reaction (PCR), and DNA sequencing—that have had a significant impact on experimental molecular biology and, in recent years, molecular ecology. Throughout the book, the authors discuss additional molecular technologies, such as microarrays and the identification of single-nucleotide polymorphisms, in the context of specific ecological topics. A more detailed description of relevant molecular methods and a glossary of terms are provided in an appendix. This organization permits readers who lack an extensive background in molecular biology to focus on the ecological discussion, yet allows them to consult explanations of specific molecular techniques as necessary.

Later chapters cover specific topics, such as behavioral ecology, population genetics, phylogeography, conservation genetics, and microbial ecology. The authors describe major scientific issues within these fields and cite studies that have used molecular methods to answer specific questions. In the chapter on behavioral ecology, for example, the authors review studies of species-specific male and female mating patterns, including mate selection, monogamy and promiscuity, reproductive success, and sexual competition. Beebee and Rowe describe several research projects that have made use of DNA fingerprinting to determine the paternity of individuals of various bird species, for instance. These investigations have allowed ecologists to identify some species as monogamous and others as polygamous on the basis of their genetics alone. Beebee and Rowe note that “one of the biggest revelations from molecular paternity analysis has been that many socially monogamous species are in fact polygamous in terms of mating behavior.”

Elsewhere in the same chapter, the authors demonstrate how DNA sequencing methods have improved our under-

standing of mate selection. Experimental work has shown that an individual's choice of mates is influenced by major histocompatibility complex (MHC) genes. MHC molecules play an important role in the immune response, and having diverse MHC genes (high polymorphism) allows an individual to cope with a large number of pathogens. Both humans and mice select mates on the basis of smells associated with particular MHC genes; specifically, females choose mates with MHC genes unlike their own. This phenomenon, which has also been demonstrated in fish (Arctic char), supports the inbreeding avoidance hypothesis, which posits that females recognize kin and avoid mating with them on the basis of their MHC type. On the other hand, behavioral tests with the three-spined stickleback have shown that although a stickleback's choice of a mate is affected by MHC type, females choose males that have highly diverse MHC genes, rather than males that are simply unlike the choosing females in terms of MHC type. This observation supports the “good genes” hypothesis, which predicts that females will choose the healthiest males to mate with. MHC gene polymorphisms have also been used as genetic markers in studies of adaptive variation.

In another chapter, Beebee and Rowe demonstrate how powerful new molecular technologies such as DNA sequencing, PCR, and DNA microarrays have improved microbial ecology. With these techniques, ecologists have been able to identify microbial species more accurately and define genes involved in specific processes. DNA microarrays enable researchers to analyze thousands of genes at a time, and have been used to distinguish, for example, different strains of *Pseudomonas* bacteria in a complex sample. Microarrays are rapidly being constructed for numerous microorganisms.

Overall, the book contains helpful visual aids: each chapter has figures and tables that illustrate specific topics, as well as sidebars that highlight major points,

and ends with a bulleted summary that reiterates the most important content. Original research studies are well documented in the reference section.

Beebee and Rowe's book will serve as a valuable resource for a diverse population of students and readers. It highlights topics that are relevant to ecologists, biologists, and environmentalists, and I am confident it will have a significant impact.

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LESSONS FROM THE MAYA

The Lowland Maya Area: Three Millennia at the Human–Wildland Interface. Arturo Gómez-Pompa, Michael F. Allen, Scott L. Feddick, and Juan J.

Jiménez-Osornio, eds. 2003. Food Products Press (an imprint of Haworth Press), Binghamton, NY. 659 pp. \$79.95 (ISBN 1560229173 paper).

One of the most fascinating mysteries in the history of humankind is the long-term persistence of some societies. The Maya civilization is one of them. Over the past 3000 years, Maya peoples have inhabited some of the most biologically rich regions in the world (the Yucatán Peninsula, portions of the Mexican states of Tabasco and Chiapas, Guatemala, Belize, and Honduras). This would suggest that Maya farmers have successfully managed natural resources of tropical ecosystems, and especially biodiversity, to preserve both nature and culture over the long term. Although archaeological evidence indicates that the Maya populations collapsed several times (during the Terminal Classic collapse and at the European conquest), they never disappeared as a culture. For this reason, the Maya peoples and the regions in

which they live have attracted the attention of countless scholars from many different disciplines over the years.

Thousands of articles and dozens of books have examined different aspects of ancient and present-day Maya. However, it is within the last 30 years that major advances have been made. To my mind, there are three books that can be considered seminal contributions to the cultural and ecological comprehension of Maya civilization, ancient and current.

The first, *Pre-Hispanic Maya Agriculture* (Harrison and Turner 1978), was the result of a symposium, held in September 1976 in Paris, that challenged the previously dominant idea that Maya civilization was sustained by extensive slash-and-burn systems of cultivation. In fact, this book significantly altered the image of the Maya as mere swidden farmers by demonstrating the existence of several intensive types of cultivation in the Maya region, such as terracing, raised fields, orchards, forest gardens, and other sophisticated modes of hydraulic agriculture.

A second book, *Maya Subsistence* (Flannery 1982), was published four years later. Dedicated to the Maya archaeologist Dennis E. Puleston, this volume presented 13 outstanding chapters on ancient records of hydraulic agriculture, water and soil conservation strategies, use of plants, management of animal species, and agroecological experiments.

A third significant contribution was published in the past decade (Feddick 1996). Twenty-one chapters, most of them written by archaeologists, were dedicated to reexamining the land-use patterns of ancient Maya. The title of the book, *The Managed Mosaic: Ancient Maya Agriculture and Resource Use*, reflects the intent to analyze the theme from a landscape perspective, emphasizing technoproduktive adaptations to regional variability in the Maya territory.

tributions, the book suffers from some inconsistencies: some chapters are not in logical order, and two or three contributions are out of context. Beyond this, however, the book offers new and relevant evidence and discoveries, such as a detailed historical analysis of the effects of hurricanes on the Yucatán Peninsula (chapters 10 and 27), an examination of the potential use of periphyton (a complex community of algae of wetland soils) as an agricultural fertilizer (chapters 11, 21, and 22), and a comparison between ancient and contemporary Maya conceptions about agriculture and forests (chapter 26).

For originality, high quality, and relevance, I recommend five outstanding chapters. These are the historical analyses of three millennia of land use in southern Yucatán by Turner and col-

the human response to local variations in geology, topography, and hydrology, which influence soil development and the structure of biological communities and ecosystems. If archaeological evidence clearly points to exceptionally high population densities across the Maya lowlands, this is the result of wise management of tropical forests. The persistence of high biodiversity in an area that was completely occupied in the past suggests a mode of resource use that takes advantage of such biological richness without destroying it.

Most of our fascination with the Maya can be attributed to the fact that the study of this civilization creates great potential for diachronic analysis of the human-nature interface. Comprehending the long-term permanence of the Maya requires interdisciplinary approaches, models, and methods to understand the role played by original strategies of resource use and the ways that these strategies are organized, guided, and implemented both by cultural worldviews (cosmovisions) and by social institutions.

In a forthcoming article, Narciso Barrera-Bassols and I offer abundant evidence derived from a detailed analysis of studies carried out in the Yucatán Peninsula on the use of natural resources by the Yucatec Maya (Barrera-Bassols and Toledo 2005). We framed our analysis according to the principles and methods of ethnecology (Toledo 2002), an interdisciplinary approach that seeks to understand the links among beliefs, knowledge, and practice. Our conclusions point to the multiple use of tropical ecosystems, and the sacred view of nature that organized it, as two key resilient mechanisms that explain the long-term presence of Yucatec Maya.

Multiple use, compared to specialized uses, signifies lower production per unit of land used, but higher production for the aggregate landscape and a dynamic, permanent system based on the benefits of a natural feature: diversity. Thus, a multiple-use strategy is the response of ancient and contemporary preindustrial societies to the high variety of landscapes, soils, relief, and biotic elements, and the dynamic process of ecological succession.

"If anything is to be learned from the changing Maya world, it is that understanding space and time is absolutely critical to human persistence. There is no absolute k value to which we, or any culture, can strive; the k value is variable. Humans must allow for fluctuations in both wildland and agricultural use of lands."

The Lowland Maya Area, published in 2003, is a relevant new examination of the Maya puzzle. This book contains the contributions to the 21st Symposium on Plant Biology, held at the University of California at Riverside. Arturo Gómez-Pompa, the organizer of the symposium and senior editor of the book, is a well-known tropical ecologist who has been working on the Maya enigmas for decades.

The book is made up of 36 chapters written by 78 authors (30 of them Mexicans), with the novelty that—in contrast to the other books cited—no particular discipline is privileged. Instead, the authors examine a range of themes: biological inventories (algae, myxomycetes, ants, butterflies, mollusks, and mosses), ethnobotany and ethnomycology, plant domestication, soils, hydrogeology, climate, hurricanes, land-use patterns, cosmology, and social conflicts. Despite the editors' efforts to give a coherent sequence to the numerous con-

tributions (chapter 20), the contribution of Ogata concerning the domestication of the chocolate tree (chapter 23), Feddick's archaeological analysis of ancient resource use of a wetland (chapter 19), and both the introductory and concluding chapters.

In the introductory chapter, Gómez-Pompa revisits an idea postulated in a pioneering paper published almost three decades ago (Barrera-Vázquez et al. 1977), namely, that the ancient Maya created innovative modes of tropical ecosystem management, many of which are still embedded in the productive practices of Maya peasants today. Thus, the hypothesis that the ecological collapse of Maya civilization occurred because of overpopulation and the overuse of resources is critically questioned.

This basic idea is elaborated also in the last chapter. The mode of resource use by the Maya, both in the present and in the past, is a clear case of a mosaic pattern on a range of scales. This pattern reflects

Because natural forces will always tend to restore systems to their mature stage, the maintenance cost will increase with greater intensity of management. Maya civilization, like many other preindustrial societies, benefits from the acceptance and manipulation of the process of forest recovery. In maintaining landscape mosaics, tropical producers take advantage of forest restoration processes such that they derive benefits from the land conversion process itself and from the various fallow stages (Toledo et al. 2003).

Two remarkable paragraphs in the concluding chapter underscore the themes of *The Lowland Maya Area*. In the first, Allen and colleagues note, "Understanding how the Maya survived past perturbations, how they live today, and how they perceive the future make these studies important to the future of our world" (p. 624). Later, they conclude, "If anything is to be learned from the changing Maya world, it is that understanding space and time is absolutely critical to human persistence. There is no absolute *k* value to which we, or any culture, can strive; the *k* value is variable. Humans must allow for fluctuations in both wildland and agricultural use of lands" (p. 631). I anticipate that future research will demonstrate the strong relations between the multiple-use strategies created as cultural reactions to the biological diversity of tropical landscapes, the concept of resilience, and the paths to a sustainable society (Holling 2001, Redman and Kinzig 2003). All of these are lessons coming from the Maya.

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MERGING NEW TECHNOLOGY WITH LONG-TERM DATA SETS

Soay Sheep: Dynamics and Selection in an Island Population. Tim Clutton-Brock and Josephine Pemberton, eds. Cambridge University Press, Cambridge, United Kingdom, 2004. 383 pp. \$120.00 (ISBN 0521823005 cloth), \$50.00 (ISBN 0521529905 paper).

Most field biologists working with large mammals would be delighted to have a nearly 20-year data set to work with—and animals marked from birth, to boot. That's the world in which Tim Clutton-Brock, from the University of Cambridge, and Josephine Pemberton, from the University of Edinburgh, appear to live. *Soay Sheep: Dynamics and Selec-*

tion in an Island Population is a study of the population dynamics of the survivors of the "earliest domesticated sheep that spread through Europe in the Bronze Age, reaching Britain's remotest islands between three and four thousand years ago.... [A] remnant population of original sheep was abandoned on Soay, a 99-ha island where their existence was protected by the difficulty of access" (p. 1). Soay sheep also inhabit other islands, collectively known as St. Kilda, off the northwest coast of Scotland. Because the contributors to this work were able to catch, mark, and monitor Soay sheep on St. Kilda and use other data from the mid-1950s to the present, they had a unique opportunity to monitor breeding success throughout the lives of the sheep, document growth patterns and conditions, and compare the effects of starvation on different classes of animals. These data provided the basis to "examine the interactions between population dynamics and selection" (p. 5).

Soay Sheep focuses on three broad, fundamental questions:

- How do demographic processes contribute to observed population fluctuations?
- How do changes in population density influence natural and sexual selection?
- How does population density influence the costs and benefits of reproduction and the evolution of reproductive strategies?

These questions are addressed by a group of scientists with diverse backgrounds and skills, and this book exemplifies how cooperation among scientists can foster understanding of population ecology. *Soay Sheep* is particularly well organized by Clutton-Brock and Pemberton to logically answer the questions asked.

The names and addresses of the 25 contributors are listed in the front of the book and at the beginning of each chapter they authored, yet one hardly notices these bylines; the editors have made all the components blend together so that the volume reads like a single-author book.

Soay Sheep comprises 10 chapters, three appendices, an excellent list of references, and an index. Chapters 1 and 2 describe the study area, general methods, causes of changes in population size, and consequences of these changes for growth, breeding success, and survival. Chapter 3 addresses the dynamics of the Soay sheep population, reviews attempts to predict abundance, and examines the effects of variation in population size on population dynamics. The relationship between sheep numbers and vegetation is investigated in chapter 4. The importance of parasites is discussed in chapter 5. Chapter 6 discusses male mating success, using data from behavioral observations and from molecular genetic techniques. The rest of the book ties basic species biology into selection of phenotype, genotype, and adaptive reproductive strategies. Chapter 7 explores how selection is influenced by survival, fecundity, and population size and examines evidence for phenotypic selection.

Chapter 8 focuses on selection on molecular genetic variation by looking for evidence of inbreeding and selection acting on specific loci. This new approach for examining life-history traits in large mammals will become more refined as molecular techniques become more sophisticated. Chapter 9 investigates optimal life histories by examining variation in the quality of individual organisms (i.e., their possession of traits that favor successful survival and reproduction) and in their environment. This task is accomplished through mathematical modeling. In the final chapter, the authors conclude with four take-home messages: (1) biologists need to understand the mechanisms that cause changes in population size; (2) selection pressures are influenced by population density and density-independent factors; (3) there are benefits and limits of models in relatively simple environments; and (4) scientists from different disciplines and with broader expertise enhance studies. Finally, the authors offer a plea to main-

tain populations that can provide long-term records of the life histories of individuals, because they represent natural laboratories from which ecological and evolutionary questions can be answered.

The three appendices provide information on flora, descriptions of the coat color and horn type of Soay sheep, and life tables. Each contributes to a better understanding of different parts of the book.

The organization of each chapter is direct and systematic. The authors do an excellent job of introducing each section, reviewing the literature, incorporating their results with findings of others, and offering logical, data-based conclusions. Anyone interested in the population dynamics of large mammals, and related selection and adaptation, will learn from *Soay Sheep* and welcome its addition to his or her library.

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NEW TITLES

Bacterial Protein Toxins: Role in the Interference with Cell Growth Regulation. Alistair J. Lax, ed. Cambridge University Press, New York, 2005. 239 pp., illus. \$95.00 (ISBN 052182091X cloth).

Caddisflies: The Underwater Architect. Glenn B. Wiggins. University of Toronto Press, 292 pp., illus. \$125.00 (ISBN 0802037143 cloth).

Centennial History of the Carnegie Institution of Washington, vol. V: The Department of Embryology. Jane Maienschein, Marie Glitz, and Garland E. Allen. Cambridge University Press, New York, 2005. 227 pp., illus. \$80.00 (ISBN 0521830826 cloth).

Insights from Insects: What Bad Bugs Can Teach Us. Gilbert Waldbauer. Prometheus Books, Amherst, New York, 2005. 311 pp., illus. \$18.00 (ISBN 1591022770 paper).

The Nature of Plants: Habitats, Challenges, and Adaptations. John Dawson and Rob Lucas. Timber Press, Portland, OR, 2005. 312 pp., illus. \$39.95 (ISBN 0881926752 cloth).

Patterns of Behavior: Konrad Lorenz, Niko Tinbergen, and the Founding of Ethology. Richard W. Burkhardt Jr. University of Chicago Press, Chicago, IL, 2005. 496 pp., illus. \$29.00 (ISBN 0226080900 paper).

People and Plants in Ancient Eastern North America. Paul E. Minnis, ed. Smithsonian Books, Washington, DC, 2003. 423 pp., illus. \$34.95 (ISBN 1588341089 paper).

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Waterlilies and Lotuses: Species, Cultivars, and New Hybrids. Perry D. Slocum. Timber Press, Portland, OR, 2005. 328 pp., illus. \$34.95 (ISBN 0881926841 cloth).