Societies from Underground

The Biology of the Naked Mole-Rat. PAUL W. SHERMAN, JENNIFER U. M. JARVIS, and RICHARD D. ALEXANDER, Eds. Princeton University Press, Princeton, NJ, 1991. xvi, 518 pp., illus., + plates. $65; paper, $24.95. Monographs in Behavior and Ecology.

Sabre-toothed sausages. Such was the apt description of naked mole-rats given by C. Faulkes when interviewed on the Canadian Broadcasting Corporation's science program "Quirks and Quarks." Protuberant teeth used to excavate tunnel systems that can exceed 2 kilometers in length and a virtually hairless body combined with an inability to thermoregulate endothermically are only two of the exceptional characteristics exhibited by these small subterranean inhabitants of Ethiopia, Kenya, and Somalia. In 15 chapters encompassing systematics, genetics, ecology, behavior, and reproduction, Faulkes and 21 other contributors from South Africa, the United Kingdom, and the United States of America describe and discuss the uniqueness of naked mole-rats. The chapters are roughly grouped into five sections. The first three chapters provide introductory information about the concept of eusociality and about Bathyergids, the rodent family to which the naked mole-rat belongs. The next four chapters, which are based on field studies, provide information on colony size and composition, burrow architecture and foraging behavior, molehill formation, and genetic variation within and between colonies. The following four chapters, which are based on laboratory studies, describe the basic behavioral repertoire and vocalizations of naked mole-rats, division of labor among colony members, and the role of the breeding female in colony organization. The next three chapters form a section that focuses on reproduction, reproductive suppression of non-breeders, and growth. The final chapter addresses the major questions that remain to be answered about the physiology, behavior, and evolution of naked mole-rats.

A recurring and unifying theme in this book is the social organization of naked mole-rats, decidedly the most startling of many unique attributes of these rodents. J. U. M. Jarvis focused scientific attention on naked mole-rats when she reported in her now-famous article published in *Science* in 1981 that these mammals live in social groups that bear striking similarities to those of eusocial insects. Jarvis's work stimulated field studies and the establishment of captive colonies of naked mole-rats by P. W. Sherman at Cornell University and by R. D. Alexander at the University of Michigan. Jarvis, Sherman, and Alexander then agreed to co-edit a book that, 10 years after Jarvis's original report, confirms most aspects of Jarvis's interpretation of eusociality in naked mole-rats while providing extensive detail about the lives of these remarkable mammals.

For those biologists enthralled in 1981 by Jarvis's pioneering, but brief, report of a eusocial mammal and tantalized by persistent reports over the past five years that a tome on mole-rats was forthcoming, this book provides a large body of supportive data to indicate that naked mole-rat colonies are indeed made up of a single, large, long-lived breeding female and her infants, several breeding males, and many (usually about 70, but sometimes over 200) non-breeding adults of both sexes that perform much of the colony work and seem to be classifiable into several castes. Such characteristics bear striking resemblances to those found in eusocial insects, especially the diploid termites. The evolution of sterile castes is so counterintuitive that it has occupied a special position in evolutionary biology, beginning with Charles Darwin. The continuing quest to understand the precursors and necessary conditions for the evolution of sterility and eusociality is reflected in the first chapter of this book, coauthored by Alexander, Noonan, and Crespi, which is a lengthy treatise that reviews and speculates on eusociality in insects as well as naked mole-rats. Alexander *et al.* credit C. D. Michener with introducing the term "eusocial" to the scientific literature in 1969, though Michener (personal communication) ascribes precedence to his former graduate student S. W. T. Batra, who defined the word in a 1966 article in the *Indian Journal of Entomology*. Although eusociality is recognized as common among bees, wasps, ants, and termites, it seems an unlikely social system for mammals. In their chapter, Alexander *et al.* argue that naked mole-rats occupy a niche uniquely compatible with the evolution of large groups of non-breeding helpers associated with a reproductive female and her mates. In particular, they focus on the role of a safe, subterranean tunnel system that is expandable and from which animals never exit because food items are locatable underground. Contributors to this volume do, however, disagree on the relative importance of predation pressure and geophyte distribution for the evolution of eusociality in naked mole-rats.

"A naked mole-rat (*Heterocephalus glaber*)." [From Jarvis and Bennett's chapter in *The Biology of the Naked Mole-Rat*; photo, C. Springmann]

Although the evidence for a marked division of labor, especially the ability to participate in reproduction, is definitive, ambiguity still exists about which naked mole-rats perform what work and the relative contributions of size and age to determination of non-breeder function. For example, the dirtiness of the teeth of recently captured animals and the identities of diggers given continuous exposure to sand in captivity suggest that small adults are the primary excavators. In contrast, diggers at a newly introduced plug of soil in captivity and at molehills in the wild tend to be the heaviest adults. Such disparities perhaps will be resolved by sophisticated remote sensing of field animals to determine the roles of small adults in excavating foraging tunnels and large adults in defending the colony. Jarvis contends that the concept of age polyethism to account for division of labor is an oversimplification because same-aged littermates can differ markedly in size and worker function, whereas Lacey and Sherman find that age and size covary in a manner that determines worker function. The different conclusions reached by contributors to the volume is stimulating because it causes the reader to ponder the extent to which differing colony conditions contribute to disparate findings and to contemplate methods that would provide clearer answers.

Acquisition of information about naked

mole-rats is no simple feat. In the field, they remain sequestered underground in hard-packed soils breaking through to the surface only rarely to spew out loose soil, thereby creating the volcano-like molehills that are the sole above-ground evidence of their presence. Because they are adapted to a remarkably stable and impregnable environment, captive naked mole-rats are sensitive to the least disturbance, so environmental conditions must be carefully regulated and observations need to be performed surreptitiously in the laboratory. Although Jarvis provides information on capture, transport, housing, and maintenance, naked mole-rats clearly are exotic animals unlikely to become common laboratory subjects. The frontispiece color plate by Jarvis and R. A. Mendez and the numerous photographs help convey to the reader who will never have an opportunity to see a naked mole-rat a sense of the atypical morphology and behavior of these bizarre mammals. Mendez's excellent color photography of naked mole-rats also appears in a popular article by E. Pennisi in *Discover* (March 1986).

Each chapter in the book includes a summary and each can be read as an independent entity and out of sequence, so selective reading is possible. However, because all the citations are collected into a single "literature cited" section that does not include references to the chapters, a reader who obtains a photocopy of a particular chapter will not have access to reference information. Ten of the 15 chapters have multiple authors, and the three editors each contributed to at least three chapters, so the book is a cooperative effort. Although the editors indicate that they "solicited contributions from everyone active in naked mole-rat research," some researchers who have published recently (for example, Lovegrove in *Behavioral Ecology and Sociobiology* in 1991) are not contributors, so this book does not include all points of view on evolution of eusociality in mole-rats.

This book will appeal to a broad selection of biologists because so many aspects of the biology of naked mole-rats, including reproductive physiology, energetics, diet, opportunities for dispersal, systematics, and social organization, are atypical for mammals. Further, the book is full of fascinating scientific trivia that will make it interesting reading for any avid naturalist. Readers will discover that all of the following can be answered by naming the naked mole-rat. What mammal: Is capable of prodigious digging feats with its teeth? Exhibits nipple development by non-breeding adults, including males, in the presence of a pregnant female? Begs for feces from its colony mates? Has females that are often twice the mass of adult males? Exhibits poikilothermy? Is so ugly that it is beautiful?

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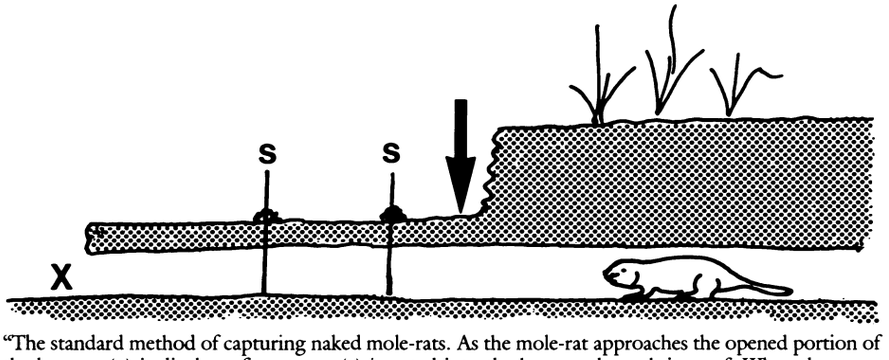
"Acrylic plastic (plexiglass) tunnel systems used to house and observe naked mole-rat colonies at Cornell University; a nest box is in the foreground." [From Lacey and Sherman's chapter in *The Biology of the Naked Mole-Rat*]



"The standard method of capturing naked mole-rats. As the mole-rat approaches the opened portion of the burrow (x) it displaces fine straws (s) inserted into the burrow through its roof. When the straw nearest the opening moves, a hoe is driven smartly down at the point of the arrow." [From the appendix of *The Biology of the Naked Mole-Rat*]

The Earth's Climate

Paleoclimatology. THOMAS J. CROWLEY and GERALD R. NORTH. Clarendon (Oxford University Press), New York, 1991. vii, 339 pp., illus. $59.95. Oxford Monographs on Geology and Geophysics, 18.

When most people think of climate change, their minds turn to thoughts of how weather has changed over the past decade or two. Climatologists usually go one step further when they are asked to evaluate the possibility of global "greenhouse" warming. They turn to the instrumental climate record of the past 100 to 150 years to answer questions such as: Are recent record high temperatures due to civilization's modification of the atmosphere, or are they just due to natural climatic variability? Could natural climatic forcing (for example, by volcanoes or the sun) counteract or reinforce global warming? and How realistic are the climate models that we are using to make assessments of future climatic change? A growing number of scientists, however, are coming to the conclusion that the instrumental record of change is too limited to answer these questions. Scientists across the spectrum of environmental disciplines need an observational base that is significantly longer and more variable than the instrumental record of the past century. The paleoclimatic record addresses this problem by extending our observational baseline back hundreds, thousands, and millions of years into the past.

Paleoclimatology has hit the bookshelves just in time to serve as a valuable resource for global change research and to help train a new generation of interdisciplinary scientists who will routinely use the record of the past as a key to the future. Crowley and North's book is written to be used by advanced students and professionals. All who are interested in how the climate system works and in how it is modeled will be interested in this balanced discussion of data and models. Students with backgrounds in meteorology, climatology, or oceanography will get the most out of the introductory coverage in the first two chapters of models and basic climatology, but such a background is not a strict prerequisite. The bulk