Book Reviews

Animal Communication: A Summing Up

How Animals Communicate. THOMAS A. SEBEOK, Ed. Indiana University Press, Bloomington, 1977. xii, 1128 pp., illus. $57.50.

Jorge Luis Borges's conjecture that "the zoology of dreams is far poorer than the zoology of the Maker" seems amply supported by the documentation presented in this book on biological communication. Consider the following recently reported phenomena, each of which would have been difficult to predict in advance or perhaps even to imagine with the knowledge of 20 years ago:

□ The solitary amoebas of the slime mold *Dictyostelium discoideum* are able to aggregate—and eventually to form into a sluglike pseudoplasmodium—because under conditions of starvation a few send out autonomous pulses of cyclic adenosine monophosphate. The pulses are damped extracellularly by phosphodiesterase, so that only when the amoebas are as close as 70 micrometers do they respond accurately to the signal and relay it with pulses of their own. After receiving a signal an amoeba becomes refractory, insuring that the bulk of the cells stream only in the direction of the congeries of amoebas within which the relaying has become "critical." (Described by Anthony Robertson.)

□ Gymnotids and a few other fishes use electric fields not only to orient through murky water and to locate prey but also to communicate with one another. Different patterns of pulses are used in threat, submission, and courtship. The fish, in effect, sing electrical songs. (Reported by Carl D. Hopkins.)

□ The blind snake *Leptotyphlops dulcis* feeds on army ants of the genus *Neivamyrmex*. It finds these prey by following the odor trails laid down by the ants while they are in the process of searching for other kinds of ants on which they themselves prey. (Reported by A. Ross Kiester.)

□ "Female fireflies of the genus *Photurus* mimic the mating signals of females in the genera *Photinus*, *Pyractomena*, *Photuris*, and *Robopus*, attract the males of these species, seize them, and devour them." (James E. Lloyd.)

□ Slave-making ants of *Formica subintegra* use "propaganda substances" to disorganize the societies of other species of *Formica* and to capture their immature forms. When raiding parties of workers reach the victim's nests, guided by the odor trails laid by their scouts, they spray acetates that mimic the alarm substances of the other ants. The acetates, which evaporate more slowly than the natural pheromones, repel and scatter the raided ants but attract the slave-makers. (Reported by Bert Hölldobler.)

To this list can be added pheromonal self-anointment in hedgehogs, duetting in shrikes, territorial stink-fighting in lemurs, pedipalp boxing in male whip spiders, ultraviolet courtship signaling in sulfur butterflies, balloon dancing in empidid flies, flehmen in horses, and penile displays in mangabeys.

Modern evolutionary theory predicts that much of animal communication will be complex, extremely specific, or both—and thus frequently either esthetic or bizarre from the human viewpoint. Complexity increases in one or another of several circumstances: as males compete during courtship, as the environment becomes more demanding and less predictable, and as the number of other signaling species in the near vicinity increases, "polluting" the communication channels available to the organism. There is a risk that an imprecise signal will lead to a mating with a member of the wrong species, resulting in the wastage of gametes on the production of inviable or infertile offspring. As a consequence courtship communication often appears to evolve so as to become more idiosyncratic and different, reinforcing the premating isolating mechanisms that arose during the process of species formation. Species also run the risk that predators will acquire an ability to track their signals, as blind snakes do while searching for army ants. In the resulting evolutionary race between predator and prey, the communication systems of the prey become increasingly sophisticated, peculiar, and private.

The study of animal communication has expanded remarkably during the past 20 years. It was only in 1958 that H. W. Lissmann published his first articles on electrolocation by fishes. The ramifications of this phenomenon and electric field communication are now the subjects of a small discipline. That same year the word "pheromone" had just been invented; the structures of only several chemical signals were then known. Now hundreds of pheromones have been characterized, and the physical properties of transmission and sensory physiology of chemoreception have been worked out for some of them. The field is currently large and growing, the object of symposia and textbooks. Ethology, which promised so much when Lorenz, Tinbergen, and other pioneers first made it respectable, has come to full flower. Its phenomenology, which is even richer than the optimists imagined, is being integrated with physiology and evolutionary theory.

A key portion of contemporary ethology is well laid out in *How Animals Communicate*. The editor, Thomas A. Sebeok, is a distinguished linguist who has long argued the necessity of what he calls "zoosemiotics" for a full understanding of human communication. His strong but somewhat distanced interest is perhaps a good qualification for an editor, for Sebeok systematically attempted to recruit the best potential reviewers in each specialty, according to the opinions of their peers, and he largely succeeded. The resulting compendium is encyclopedic, authoritative, and well organized. One can say of it, with more conviction than usual, that it belongs in the library of anyone with even a marginal interest in animal behavior. The chapters, each by a different specialist, are grouped into three sections. These deal respectively with various aspects of general theory, with the mechanisms of communication in the various sensory modalities, and—constituting a large and especially detailed part—with the known systems of selected animal groups, including cephalopods, arachnids, crustaceans, insects, and most of the major vertebrate orders.

In addition to reviews that are largely complete to 1975, there is a substantial amount of new information. One chapter consists of a long-awaited study of cephalopods by Martin H. Moynihan and Arcadio F. Rodaniche. The cuttlefish squid *Sepioteuthis sepioidea*, studied near the San Blas Islands of Panama, has a flexible set of visual signals based largely on swiftly changing body colors. Its convergence in this regard with the Cichlidae and some other fish groups is especially noteworthy. Another chapter contains a welcome review of our rapidly expanding knowledge of Old World Pri-

mates by the French zoologists J.-P. and A. Gautier. The most complicated and intrinsically interesting species, the chimpanzee, has been ably treated by Peter Marler and Richard Tenaza.

Some of the information in *How Animals Communicate* will no doubt be outdated in several years, but parts of the book are certain to have enduring value. For example, there will be few other places to find the facts about such endangered and rarely studied species as the snow leopard, the Tasmanian devil, the dugong, the white rhinoceros, and the Hispaniolan solenodon. Full indexes by author and taxonomic group are supplied, the latter taken down to species (providing both scientific and vernacular names), but unfortunately none by topic.

Much of the progress in the study of animal communication has been achieved through a steady expansion of natural history studies, especially in the tropics. These efforts now include a large component of behavioral biology, stimulated by the methods and concepts introduced by ethologists a generation ago. Refinements in experimental technique have been equally responsible for the advance. One striking example is the screening method developed by Wendell Roelofs and his associates at Cornell University to identify female moth sex attractants. Instead of purifying sufficiently large quantities of the pheromone to characterize it by mass spectrographic analysis and other traditional chemical methods, the Cornell researchers use male antennae to scan likely candidates among synthetic products. First a small amount of the natural pheromone is extracted from a few females, chromatographically separated, and roughly classified. Then male antennae are separated and attached to electrodes. When this preparation is exposed to an array of synthetic substances considered promising, the natural pheromone and the most closely related compounds are found to produce the strongest response in the antennal nerve. This method of successive approximation has dramatically speeded the rate of identification. An analogous technique is used by Robert Capranica, also at Cornell, to identify the active components of frog calls. The natural call is first analyzed with respect to spectral structure and wave-form periodicity. Next, synthetic calls are created that vary these qualities, and their effectiveness is measured by the behavioral response of male frogs and the physiological activity of their auditory sensory units.

The major topics of future research on animal communication appear to me to be relatively easily identifiable. They are also technically challenging and as intellectually important as those that attracted biologists during the simpler, pioneering era just ended. They include the effect of specific qualities of the environment—for example, turbulent versus quiet water or dense forest versus grassland—on the transmission properties of signals in each sensory modality; the role of context in the meaning of signals; the sites of the screening process in the sensory and nervous systems by which signal specificity is achieved; the decomposition of complex signals into components of different meanings; the proximity of approach to the optimum design in the evolution of the system, and from this the very meaning of an evolutionary optimum in the case of animal communication; the classification of messages, and the meaning of message in zoology. And—perhaps constituting the grail of this field—the full explication of the differences between animal and human communication, which could narrow the set of pathways along which human language conceivably evolved.

In summarizing our already voluminous knowledge and defining some of the more profitable directions of future research, *How Animals Communicate* is a success. There is still a need for a shorter, more tightly written textbook for students, but as a scholarly review and reference work the Sebeok book will probably be unsurpassed for years to come.

EDWARD O. WILSON
Museum of Comparative Zoology Laboratories, Harvard University, Cambridge, Massachusetts 02138

Changes in Mortality

Mortality Patterns in National Populations. With Special Reference to Recorded Causes of Death. SAMUEL H. PRESTON. Academic Press, New York, 1976. xii, 202 pp., illus. $16.50. Studies in Population.

Despite the fact that death can be handled easily by demographers' methodological tools, empirical studies of the structure and patterns of change in mortality have lagged far behind studies of other demographic processes. Whereas explanations of and theoretical approaches to variations in fertility levels abound, differentials in mortality levels have received little or no attention from demographers. *Mortality Patterns in National Populations* is therefore welcome. It takes a systematic look at mortality patterns across 165 national populations, representing 43 nations at various points in time. The patterns referred to in the title are basically the patterns of mortality by cause of death. The data for all the populations were published in Preston, Keyfitz, and Schoen's *Causes of Death: Life Tables for National Populations* (Seminar Press, 1972). In the book under review Preston presents an analysis of the data that provides us both with some additional tools to be used in mortality research and with some clues to explanations of mortality differentials and trends. He traces out the methodological implications of the cause-of-death structure of mortality better than he traces out the theoretical implications—maybe all demographers do—but his contributions concerning the latter are important if for no other reason than that explanations of mortality differentials supported by empirical data are hard to come by.

Preston's most important methodological contribution is that the analysis and summary of causes of death for national populations result in models of death by cause akin to the models of death by age provided by model life tables. The significance of this work for researchers using data in which statistics on cause of death are more readily available than statistics on age at death is apparent. Preston also provides numerous examples of the use of cause-of-death data in the analysis of mortality differentials. He describes the contributions of various causes of death to age patterns and sex differentials in mortality and the role of various causes of death in producing different levels of mortality in different national populations. Demographers, historians, anthropologists, and others doing mortality research can use the book as a methods handbook and a guide in their own research.

Substantively, Preston addresses "the question that currently seems most central to sociological and economic analyses of mortality . . .: how much of the improvement in mortality levels is in general attributable to improvements in living standards and how much to changes in health levels at a particular standard?" The analysis of the decline in mortality by cause of death is a logical step in finding the answer to this question, since the etiologies of diseases vary and some diseases are likely to be affected by changes in income whereas others are not. In this regard the reader would have benefited from the inclusion of more information than Preston has given about the etiology of the diseases used in the analysis.

Because many of Preston's most interesting substantive findings have to do