taxonomic studies did not produce classifications that were clear improvements over earlier ones, so that the additional labor hardly seemed worthwhile. Protistology and especially bacteriology provide the principal exceptions to that statement, and it is significant that one of the present authors, Sneath, is a bacteriologist. The attitude of the authors is more appropriate to his field than to any other.

Perhaps the most serious problem was that more and more different characters and kinds of characters were entering into progressive taxonomy. A sufficiently satisfactory key or typological classification may be based on a few characters, perhaps of only one kind, but evolutionary taxonomy must use all possible. It must evaluate their nature and direction, and also of course their degree. Multivariate coefficients of similarity clearly might help toward the latter evaluation, but the computation involved was discouraging to taxonomists, or quite beyond their capacities, when the numbers of characters rose into the dozens and higher. Attempts to deal mechanically with quantity were clearly less satisfactory than more conventional simultaneous treatment of quality and quantity. If only on those grounds, advanced quantitative methods of this sort had little chance for further development before the 1950's when electronic computers began to be generally available.

It must be admitted that all these difficulties still exist. Some of them are, however, alleviated by Sokal and Sneath's book. The heart of this book is a highly useful discussion of measurements of resemblance and association potentially useful in taxonomy and of methods for recognizing, describing, and arranging sets or clusters.

In addition to basic concepts and formulas, fairly detailed and simple instructions for actual calculation are given. With a small number of characters, these can be carried out on desk calculators and hence are valuable for learning and comprehension. The actual research procedures recommended are, however, almost completely impractical without large, powerful computers.

Almost everyone will agree that the concepts and methods so well discussed by Sokal and Sneath are or can become a most important adjunct to taxonomy. They are already so recognized by many evolutionary taxonomists. Unfortunately, however, the authors have made themselves leaders of a small group which, with the fervor of conversion, holds that these numerical methods bearing on certain aspects of classification are not simply adjuncts to taxonomy but, in themselves and completely, *are* taxonomy. That viewpoint and their fervor have led them into many unintentional misrepresentations and exaggerations, to unjustified antagonism toward much recent progress of the science, and to retrogression in taxonomic principles. (Ultramodern machine computation has curiously led to a conscious revival of preevolutionary, 18th-century principles.)

The present ferment in taxonomy is a healthy sign. Eventually taxonomy will surely profit by the incorporation of a "numerical taxonomy," less rigid and less fanatical. This book by Sokal and Sneath will be a milestone in that desired development, but in the meantime I fear that its biased attitude has done not only some good but also some harm to taxonomy and, indeed, to its own basic thesis.

GEORGE GAYLORD SIMPSON
Museum of Comparative Zoology, Harvard University

Communicative Systems of Animals: Acoustic Behavior

The study of animal communicative systems has been a dominant theme in the remarkable growth of interest in animal behavior during the past decade. Sparked by von Frisch's exciting discoveries on bee dancing, and supported by the postwar development of electronic instrumentation and other special methods and apparatus, data on animal communication have contributed a thread of continuity that, in some ways and at some times, has seemed to be the principal axis of synthesis in the entire field of animal behavior. Of all the possible and proved kinds of animal communicative systems, acoustical ones received the most attention first. There are probably two reasons: (i) portable recording devices and excellent sound-analyzing instruments became available quite soon after World War II and (ii) acoustical signals seem to capture the imagination more quickly than other less noticeable or less easily recorded and translated kinds of informational transfer. Review articles on acoustical communication in the different vertebrate and arthropod groups were appearing as early as the mid-1950's, and the first book on the topic, in which modern techniques were utilized, was *L'Acoustique des Orthopteres*, also edited by R.-G. Busnel, which was published in 1955 as the outcome of an international symposium held in April 1954. In 1958, Hubert and Mabel Frings published a bibliography containing 1752 references on sound production and hearing in insects. Work on vertebrate acoustical behavior was developing a little more slowly, with certain investigations especially prominent during the early and middle 1950's—spectrographic studies of bird songs by Borror and Reese (Ohio) and by Thorpe and Marler (Cambridge), experimental work on bat sounds and echolocation by Griffin (Harvard) and by Möhres (Tübingen), and investigations on amphibian acoustics by Blair (Texas). The International Committee on Biological Acoustics, an organization of workers on animal acoustics, was developed as the result of a meeting held at University Park, Pennsylvania, in 1956; that meeting was sponsored by the National Science Foundation and organized and hosted by the Frings. In 1961 the Cornell Laboratory of Ornithology began publishing a small quarterly, *The Bio-Acoustics Bulletin*, under the editorship of William R. Fish, which in turn began an annual review of bio-acoustical work, with contributions by various authors on invertebrates, amphibians and reptiles, birds, underwater acoustics, techniques, and methods. As Busnel notes in his preface to this book, several books and symposium volumes on bio-acoustics have been published during the past seven years.

This volume, **Acoustic Behaviour of Animals** (Elsevier, New York, 1963. 933 pp. Illus. $45), edited by R.-G. Busnel, is a remarkable compilation, and a tribute to the energy and perseverance of its editor, who was chiefly responsible for the idea and for the long, arduous task of seeing the book through to publication. Some of the "chapters" are exhaustively detailed—for example, Bernard DuMortier's three-section treatment of arthropod acoustics: (i) morphology of sound emission apparatus, (ii) physical structure of acoustical signals, and (iii) etho-

logical and physiological aspects of acoustical behavior. Other chapters on arthropods deal with flight sounds of insects (Sotavalta, Finland), acoustic behavior of Hemiptera (Leston and Pringle, Great Britain), anatomy and physiology of sound receptors in invertebrates (Autrum, Germany), sound reception in Lepidoptera (Treat, U.S.), and the role of the central nervous system in orthopteran stridulation (Huber, Germany). The chapters on vertebrates consider vocal communication in monkeys (Zhinkin, Russia), echolocation (Vincent, U.S.), audiogenic seizures (Lehmann and Busnel, France), comparative anatomy and performance of the vocal organ in vertebrates (Kelemen, U.S.), comparative anatomy and physiology of the auditory organ in vertebrates (Vallencien, France), emission and reception of sounds at the level of the central nervous system in vertebrates (Chaucard, France), and acoustic behavior of fishes (Moulton, U.S.), amphibia (Blair, U.S.), birds (Bremond, France), and mammals (Tembrock, Germany). The other chapters treat methods in bioacoustic terminology (Broughton, Great Britain), techniques for study of signal structure (Andrieu, France), underwater acoustics (Brandt, France), electroacoustic techniques for the study of behavior and certain aspects of animal acoustics (Busnel, France), animal language and information theory (Moles, France), and inheritance and learning in the development of animal vocalizations (Marler, U.S.). There is an alphabetical index to scientific and common names, a systematic index (which includes well over 1000 species names and almost 1000 genera), and an 86-page glossarial index (by Broughton) that is sprinkled with essays on definitions and the history of usages.

With all the advantages and disadvantages inherent in a treatise by many authors, this book can by no stretch of the imagination be termed an impeccable work; its "chapters" vary almost as much in quality as they do in style. One thing that is bound to confuse readers is the inconsistent terminology—a chirp is not always a chirp, nor a pulse a pulse; and if a syllable or a ripple or a figure is carefully defined somewhere, that still doesn't make it easy to remember what is meant. Terminology is a formidable problem for those who work in animal acoustics, for they have to discuss a vast array of signal patterns that often bear no resemblance to any sound familiar to their readers.

The number of pages in the volume could have been significantly reduced by eliminating the repetition between articles and combining at least some of the reference lists that overlap broadly. The first condition would have been difficult for Busnel and his coworkers to accomplish, however, and I doubt that many Americans (at least) are going to complain about either repetition or the frequently awkward translations, in view of the fact that Busnel went to the trouble of having many of the 33 different contributions (including six addenda) by 24 different authors from six different countries translated into English (more than half of the articles were originally in some other language).

As with all such publications, this one is already sadly out-of-date, with references in the body of the book rarely dated later than 1960. Several addenda, however, list or discuss work published through 1962. The rate of publication in this field is evidenced by the more than 100 papers that have been published on arthropod acoustics alone since DuMortier wrote his chapters.

A major function of this volume will be its role in pointing up not only what is known in each area, but also the paucity of data with respect to questions that today are often considered long-settled. For example, efficiency in reproductive isolation among sympatric species has been presumed to be a principal function of acoustical signals in several different kinds of animals, particularly insects, amphibians, and birds; and, by extension, this has been presumed to represent a principal selective context in the shaping of sex signals. The indirect evidence for this contention is fairly good; thus, species that are sexually active in the same places at the same times have never been found to have identical sex signals, although closely related allopatric and allochronic species sometimes do (at least in insects). But for the third and clinching sort of indirect evidence —that overlapping species are more different in this respect where they overlap than where they do not—we are still presented with but two cases: W. F. Blair's studies on frogs in the genera *Acris* and *Microhyla*. There is scarcely more evidence of the direct sort from experimentation on interspecific signal discrimination—T. J. Walker's studies on tree crickets (1957); Perdeck's studies on grasshoppers (1958); Alexander and Moore's studies on periodical cicadas (1959); and Littlejohn and Michaud's study on the frog genus *Pseudacris* (1959). None of these examples is satisfyingly conclusive, and only that of Walker, on the simple pulse successions (trills) of tree crickets, has clearly shown what the significant call differences are. Additional studies on this topic, again dealing primarily with amphibians and insects, have been carried out since the work cited in this volume, but there is no reason to consider this question closed; almost every positive result is so qualified that we cannot reasonably say that we fully understand how the signals work.

Its comprehensive coverage allows one to use this book to make some interesting comparisons of different kinds of acoustical systems in different kinds of animals. For example, three kinds of gross changes are encountered in comparing acoustical communicative systems from arthropods through lower vertebrates to primitive mammals and finally primates. There is a more or less steady increase in the maximum number of acoustical signals per species or system; the different signals of a species (with some obvious and significant exceptions) are more likely to blend together than to be entirely discrete or distinct from one another; and the structure of the signals is more strikingly influenced by events that occur during development, in particular by stimuli of the same general nature as the signals themselves (acoustical signals produced by conspecifics). All of these are not unexpected comparisons, but, as in the data on reproductive isolation, it is convenient to be able to back up one's suppositions with a few facts.

My overall impression is that this volume represents a tremendous collection of facts, but not an adequate synthesis, although the synthesis may be as good as could have been devised prior to the publication of this volume. Certainly it is safe to say that at no previous time has there been available in one volume so much information about any aspect of animal communication, perhaps about any particular aspect of animal behavior. Each worker in animal behavior will have to examine it and make his own decision about the value of the contributions in his areas, but it will be useful to all. The fact that it is priced beyond the means of most individuals is all the more un-

fortunate, for it is the kind of book that has to be examined and re-examined, and explored at one's leisure, if its full value is to be realized. Those who are able to purchase personal copies will perhaps be gratified by the preface statement that all royalties will be used to establish a fund to support travel by young investigators; the fund will be administered by the International Committee on Biological Acoustics.

RICHARD D. ALEXANDER
Museum of Zoology and
Department of Zoology,
University of Michigan, Ann Arbor

Pollen Analysis

The Last 10,000 Years: A Fossil Pollen Record of the American Southwest. Paul S. Martin. University of Arizona Press, Tucson, 1963. viii + 87 pp. Illus. $4.50.

This thin book with big pages recounts the efforts of a Pleistocene pollen analyst and biogeographer, who has broad interests, to reconstruct through pollen analysis the vegetational and climatic history of the semidesert country of southeastern Arizona since the last glacio-pluvial period 10,000 years ago. This task is fraught with many more difficulties than are encountered in pollen studies of the bog sediments of glaciated regions, where one rarely encounters such problems as poorly preserved pollen, low concentrations of pollen, redeposition, and "long-distance" importation of pollen by variable winds from not-too-distant mountain ranges. Martin's is the first comprehensive research program in which arid-region alluvial sediments have served as the basis for an extended pollen chronology. Its success should pave the way for comparable studies in other arid regions, such as the Mediterranean area, where the archeological record should stimulate efforts of equal magnitude.

The path to a substantial pollen chronology in a new region has many steps, and it is refreshing that Martin supports each one with peripheral studies—of the modern vegetation and modern pollen rain, of variation in the pollen content of multiple surface samples, of variation in size among the pollen of the nine species of Arizona pine, of the statistical validity of a pollen sum of only 200 to 250 grains, and of the effect of different preparation techniques on pollen recovery. All of these supporting studies undercut a skeptic's criticism of the basic premise of pollen analysis—that the pollen stratigraphy of the sediment records a sequence of real vegetational changes.

Martin establishes two important pollen baselines that cannot be controverted—first, the modern pollen rain in its relation to modern vegetation, and second, the contrasting pine-rich assemblage that represents the last pluvial period when conifers, which are now restricted to the crests of the basin ranges, seem to have extended at least as far down as the piedmont. The latter baseline, which has been confirmed by several studies throughout the Southwest, illustrates the magnitude of the environmental changes during the Pleistocene. The former represents the kind of approach that makes modern biogeography and ecology specifically useful to historical pollen analysis on a local and on a regional basis—the kind of approach that is proving productive in several concurrent studies elsewhere in America but which has never been practiced in European work.

Between these two baselines lies the heart of the investigation—an attempt to work out the pollen sequence for the time since the last pluvial period and to relate it especially to the problems of the environment of Early Man and of the extinction of large mammals. Martin concludes that the pollen record does not confirm the long-held notion that an "altithermal" interval of persistent droughts occurred during the time 8000 to 4000 years ago. In fact, on the basis of the relative proportions of three groups of pollen types (Compositae for wet alluvial plains with high water table, Chenopodiaceae-*Amaranthus* for dissected alluvial plains with low water table and alkali soils, and *Pinus* for the mountain vegetation), he proposes that this period was not marked by drought but rather by greater frequency of summer rains, brought to the region by monsoonal circulation from the Gulf of Mexico. This leads to the conclusion that the large mammals were extinguished not as a result of the loss of forage but as a result of the hunting prowess of Early Man, who thereby exhausted his food supply and was forced to develop agriculture.

The presentation is logically organized, with chapters on the geology, climate, vegetation, and modern pollen rain preceding the description of the pollen diagrams from the individual sites, the discussion of the biogeographic or ecologic meaning of the several types of fossil pollen, and a consideration of the climatic sequence inferred from the diagrams. Most of the basic data are clearly presented in various graphs and diagrams whose explanations, however, are in some cases either insufficient or buried in the text.

The text is lucid, although there are gross errors in punctuation and an excessive use of questions at the beginning and end of a paragraph. However, the prize for provocative prose is the preface, by E. S. Deevey, which is replete with mixed and unmixed metaphors. All in all, *The Last 10,000 Years* is good reading for those interested in biogeographic history, Southwestern archeology, paleoclimatology, and the theory and practice of pollen analysis.

H. E. WRIGHT, JR.
Limnological Research Center,
University of Minnesota, Minneapolis

Deserts and Desert Animals

Desert Animals: Physiological Problems of Heat and Water. Knut Schmidt-Nielsen. Oxford University Press, New York, 1964. xvi + 277 pp. Illus. $7.20.

This book is divided into 16 sections, or chapters, that deal with man, the basic problems of desert life, and desert animals—the camel, cattle, the donkey, sheep, carnivores, rabbits and jack rabbits, the ground squirrel, the pack rat, the kangaroo rat, other rodents, estivating mammals, marsupials, desert birds and lizards, snakes and tortoises. Each section follows the same general format in that heat tolerance and regulation, water requirements and water balance are discussed in that order.

The author refutes many older concepts of heat tolerance and water requirements for animals. This is especially true with respect to the camel, which he and his associates have studied in some detail.

Schmidt-Nielsen uses an excellent method of citing authors. No parenthetical, highly abbreviated journal titles stop the reader's eyes as he scans each page. A number follows the cited author's name and this, in turn, is readily found in the "references" section at the end of the book.

It is to be regretted that the author did not have scientific names verified by a taxonomist. The name *Dipus*