ANIMAL COMMUNICATION

Hubert and Mable Frings

Communication

Second Edition, Revised and Enlarged

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Norman

TO

Our Animal Associates

FROM WHOM WE HAVE LEARNED SO MUCH

ABOUT WHOM WE KNOW SO LITTLE

Preface to the Second Edition

TWELVE years ago, when the first edition of this book was published, almost none of the titles of articles and books that we had consulted contained the word "communication." We had the task of compiling most of the information on animal communication from papers dealing with more general studies of behavior, ecology, or physiology. Today, even though the definition and limits are still being debated, animal-communication study has emerged as a recognized biological entity. While definitions and limitations are still uncertain, the fact that animals communicate with each other is fully accepted.

So far no canonical organization of materials in the field has emerged, and the functional organization that we used in the first edition still seems as good as any. Others have organized the materials around communicative channels—chemical, acoustical, and so on—seeking thus to derive generalizations applicable to the media of communication. Still others have accepted a taxonomic organization—communication in protozoans, insects, and so on—seeking thus to find evolutionary trends. Any system that, at this stage, yields insights is useful. We happen to find the functional organization most suggestive, and so we retain it here.

It would be easy, in view of the tremendous number of publications since 1964, to select a different set of examples to illustrate the uses of communication signals by animals. We feel, however, that little would be gained by doing so. The observations of 1964 remain valid in the late 1970's. The last chapter of this edition presents a review of work since 1964. The next ten years seem bound to produce a rapid growth of knowledge that will result in much greater understanding and many more secure generalizations. If this book arouses still further interest in the study of animals in their natural interrelationships, we shall feel greatly rewarded.

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Preface to the First Edition

THE idea that animals communicate with each other is as old as mankind. Only recently, however, has the study of animal communication emerged as a formal entity in science. The foundations of this study are barely laid; even the definition and limits of the field are still uncertain. This book is an attempt to present some of the concepts that are emerging and to illustrate them with examples drawn from an extensive literature on animal behavior.

This is not meant to be an exhaustive treatise, but is intended primarily for nonspecialists—students, specialists in other fields of science, and educated laymen. With this in mind, literature citations in the text have been avoided, although every effort has been made to verify the facts. Realizing that even biologists might have difficulty in identifying animals by scientific names only, we have tried to relate the species mentioned to larger animal groups at least. Otherwise, some knowledge of biological concepts and terms is assumed. The bibliography, likewise, is not meant to be a research tool, but a list of works which should generally interest nonspecialists. Some references are included for those specialists in animal communication who may find the book useful and want original sources.

We hope that the reader will share our enthusiasm for the study of the remarkable communication systems of animals and will be led to read further or, better yet, to observe for himself. This is a field which can use the talents of professional and amateur alike. With further knowledge, the provisional organization of communication patterns presented here—even possibly many of the "facts"—will undoubtedly need to be revised or discarded. It is stimulating to realize that impending discoveries may soon render the book itself outdated, a brief review of the state of our knowledge—or lack thereof—at this time.

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By Hubert and Mable Frings

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Introduction

HAVE you ever wondered, on seeing a swarm of tiny insects around an outdoor light, how creatures so tiny find mates in a world so vast?

It is hard for us to realize how gigantic this world is for other animals, most of which are so much smaller than we. Many small moths, for instance, cruise in areas some miles in diameter. Suppose we were to convert the moths' travels to human equivalents. The codling moth is about ¾ of an inch long, whereas the trunk of man's body is about 3 feet long. A mile for a codling moth would, therefore, be equal to about 50 miles for man. The male codling moth searches for a mate in areas up to 2 miles in diameter, equal to man's searching an area 100 miles in diameter. Is it any wonder then that these insects have methods for the female to signal to the male so that he can find her?

Honey bees scout up to 2–3 miles from the hive for food sources, thus covering search areas 4–6 miles in diameter. When a scout bee finds a rich source of food, she returns to the hive to recruit others to help gather it. If, again, we state these distances in human equivalents, by comparing the sizes of bee and man, we find that the bee scouting area is equivalent, for man, to an area of 70,000 square miles. This is equal in size to Uruguay or the State of Washington, equivalent to one-third the area of France, and locating an object in it would be a formidable task, even given powers of flight. It would certainly be almost useless for a scout bee to indicate to its hive-mates only that it has found food, without indicating where the food is; thus honey bees have means to communicate this information.

Male and female mosquitoes fly away from the places where they spend their aquatic larval life to hunt for food. Then they must find each other in order to mate. *Anopheles maculipennis,* in Europe, regularly flies 2–3 miles from its breeding place. This is equivalent, for man, to a distance of 400–500 miles. *Aedes vexans,* in Canada, flies as far as 15 miles from the place where it was reared. For a human being, this is equivalent to 3000 miles. A human male seeking a female, under these conditions, would have to search an area of 30,000,000 square miles, equal to one-half the total land mass of the earth. Without some means for the sexes to signal to each other at a distance, the prospects for the species would be dim indeed.

Insects, however, are large compared with many other animals. Some species of moths carry in their ears minute relatives of the spiders, called mites. The ears of moths, obviously, are very tiny, and the mites even more so, for many of them can live in one ear. Consider how vast this world is for a mite, about 1/50 of an inch in length and unable to fly as insects can. Yet somehow males must find females if mating is to occur.

Part of the problem is solved because both sexes are attracted to the same animal, a moth. Once the mites find a moth, they have an area to explore equivalent, in human terms, to a football field. However, a further problem arises. The mites, in feeding, destroy the ear of the moth. Since the moth uses its ears to hear hunting sounds of bats, its major predators, and to avoid them, it is essential that the mites do not invade both ears, and totally deafen the moth. They do not. In a world that for them is almost infinitely vast, these mites find moths to live on, find members of their own species to mate with, and possess systems of communication that allow themselves and the moths to survive.

DEFINITION OF COMMUNICATION

Communication between animals involves the giving off by one individual of some chemical or physical signal, that, on being received by another, influences its behavior.

The definition seems rather straightforward, but there are some difficulties. For instance, is it communication when a human being attracts a mosquito to his warm body? We shall not consider this so, for the mosquito is merely reacting to a feature of the human body over which the human being has no control. One might be tempted to say that the human being does not give off warmth for the purpose of attracting mosquitoes, whereas a female moth gives off an odor for the purpose of attracting a male. This, however, raises the question of purpose, and it is impossible to know whether a female moth has any purpose in giving off an odor. We can avoid the difficulty, however, by considering communication to be involved only when the sender uses some specialized structures or methods to produce signals.

Some persons would use the term "communication" only to refer to signaling by an individual at some distance from another. This, however, is too restrictive. After all, do we not think that communication has occurred when one person squeezes the hand of another to denote sympathy? Why should we, then, deny tactile communication to animals?

Does a flower communicate with bees when it gives off a scent that attracts them? Certainly the bees' behavior is influenced by the scent, and so the scent could be regarded as a chemical signal. However, one might think that the plant has not really produced a signal, because the odor is built right into it. Unfortunately for this idea, there are plants that produce odors only at certain times of the day or night, when insects are available to fertilize them. The yucca plant, for instance, opens its flowers only at night, when yucca moths are active. Certainly, this is a border-line case, but it more nearly resembles the attraction of mosquitoes to a human being by body-heat.

For our purposes, we shall adopt the idea that, in communication, the sender and receiver are of the same species. Where individuals of one species react to signals of another, the reactions are probably learned and usually not shown by all members of the species. This is illustrated by the African Honey Guides. These birds feed on beeswax, but cannot tear open hollow trees containing bee colonies. Therefore, if one of them finds such a bee-tree, it signals its find to a weasel-like mammal, the ratel, or to a human being, by flying overhead and calling. Both, in time,

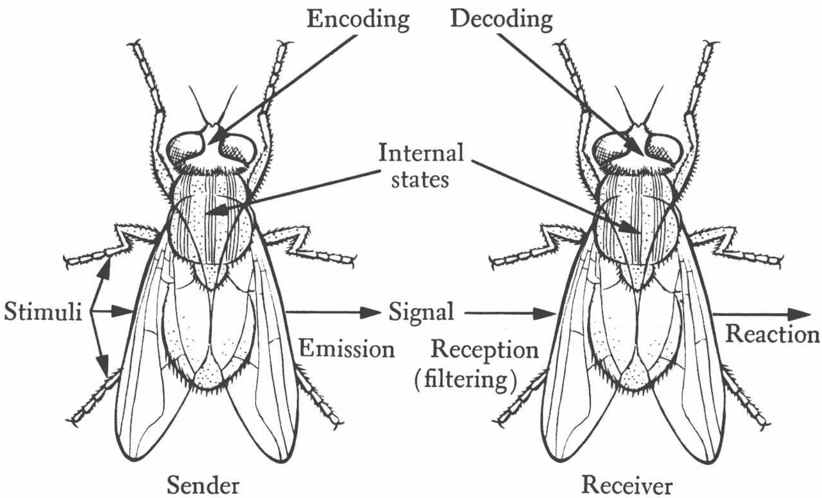

FIGURE 1. *Diagram of animal communication.*

learn what this means and follow the bird to the bee-tree. They then expose the honeycombs, kill the bees, and steal the honey. This leaves the wax for the Honey Guide to eat unmolested.

Our operant definition is illustrated in Figure 1. Here we show an individual, the sender, under influence of external and internal factors, producing a chemical or physical entity, called the signal.

This signal is received through the sense-organs of a receiver, causing changes in internal conditions which result in changes in external behavior. We can study scientifically all phases of this operation: the methods used by the sender to produce the signals, and the influences of internal and external factors on the methods; the chemical or physical nature of the signals; the means by which the signals are received; and the reactions of the receiver, as affected by external and internal factors.

COMMUNICATION IN THE ANIMAL KINGDOM

Communication, thus defined, occurs throughout the Animal Kingdom. Among the simplest of animals, if they be animals at all, are the slime molds. For much of their lives slime molds crawl about feeding on the forest floor as tiny, amoeba-like creatures. They form multicellular groups only to reproduce. An individual gives off a special chemical which attracts others nearby; these crawl to the "caller" and fuse with it to form the breeding body.

At the other end of the scale of complexity in the Animal Kingdom are the elaborate communication systems of honey bees and man. Bees can tell their hive-mates the distance, direction, and nature of food with great precision. Man, as we all know, has the most elaborate and sensitive of all communication systems in the Animal Kingdom, usable even for transmitting information from one generation to the next.

The degree to which animals use communication systems in their daily lives is directly related to the level of development of their sensory-neural systems. Animals, such as jellyfish, that have simple nervous systems, have few channels for communication, and communicate little in general. On the other hand, animals such as insects and vertebrates, that have well-developed senses and highly developed nervous systems, use a multitude of signals for a wide variety of purposes.

Since communication signals must be received through sense-organs, the nature of the sense-organs determines the available communicative channels. The tactile senses and the chemical senses, that is, taste and smell, are well-developed in almost all animals, and are the most widely used of all the senses for communication. However, where the visual sense and auditory sense are highly developed, as in the vertebrates and insects, these are the major communication channels. Visual or auditory signals can communicate a greater quantity of information more exactly than other kinds of signals.

USES OF COMMUNICATION BY ANIMALS

In man, information is mainly transmitted by speaking and writing. Most of this has a social function; some of it has to do with relations between males and females. A small amount is used to transmit information about the surrounding world not immediately related to biological needs, as this book does. This last category is probably missing from the communication systems of animals, for their lives are held too precariously to waste time on it. Otherwise, animals transmit essentially the same major classes of information as do humans.

Man does not have problems in identifying his own species, although he may be concerned about differentiating his particular group or race from others. Animals, however, need to be able to identify other members of their own species, and they have communication signals for this purpose. In some animals, species identification is used to form aggregations, but this is not the usual pattern. Usually, individual animals live more or less separately, except during mating, and they use signals to identify themselves to other members of the species, so that spacing can be maintained, thus assuring a food supply for each individual.

Wherever animals exist in social relationships with each other, communication signals are used for many purposes. Even if animals do not aggregate, they may have warning signals which can be used to alert others. These signals may also serve to ward off prospective predators by calling in cohorts to frighten the enemies. Most animals feed separately, but higher animals share food. In such cases, signals may be used to indicate sources of food. These may be merely attractive, such as those of some birds, or they may evolve into a system of complex guidance signals, such as those which social insects use to guide their fellows from the nest to distant food sources.

By far the most important animal communication signals are used in mating. Males and females must somehow come together, so that the fertilized eggs necessary to found the next generation can be produced. Where males and females of different species are similar in appearance, species identification becomes doubly important. Sperms should not be sent to eggs that they cannot fertilize. Communication signals act as "passwords" to identify members of a species to each other. They also afford a method for the sexes to meet that is safer than mere chance wandering.

When the sexes are brought together, communication signals may be used in courtship and mating. Often the attractive signals have afforded only rudimentary identification. Before actual mating occurs, positive identification must be made. The courtship dances of spiders and rituals of birds serve to identify the males to the females and to prepare both for the final mating act. Generally, mating is a rather exact process, requiring a great deal of cooperation between male and female. Often it involves a reversal of the usual habits: for example, predatory forms, which jump on anything that moves in front of them, must not pounce upon and kill prospective mates.

The mating act results in the production of fertilized eggs and ultimately young. Some animals give no care to either, but many animals care for the eggs or for both the eggs and the young. If both male and female care for the eggs, they must have means of signaling to each other about food or danger. Where the adults take care of the young, as do the birds and mammals, family life develops, and signals used by the adults take on added importance, for the young also respond to them. As the young grow, they develop their own signals, and these affect the behavior of the parents. It is no accident that the animal with the most highly evolved family type of social organization—man—has developed the most elaborate communication system.

WHY STUDY ANIMAL COMMUNICATION?

There are at least three reasons why biologists study animal communication. First, there is the hope that an understanding of communication systems of animals can be used to manage useful species or to control pest species. Second, there is the belief that studies on communication of animals will disclose the biological origins of human communication and suggest methods of communication other than those we now have. Both of these have practical and useful implications for man.

Third, there is the often impractical goal of zoologists: to understand animals better. A long-standing difference of opinion among zoologists divides those who regard animals as totally predictable machines, from those who regard animals as complex, often mysterious, organisms. Studies on animal communication can lead us to sympathize with, and draw on, both of these viewpoints. Certainly, we have every reason to use all the means afforded by chemistry and physics to study the physiology of the signal-sender, the physical and chemical nature of the signals, and the means by which the signals are converted by the sense-organs of the receiver into nerve impulses. When, however, the signals reach the central nervous system of the receiver we find elements of indeterminancy. These need not be due to mysterious forces in the animal. It is just that the human mind, in trying to conceive of the ultimate complexity of this system, is limited. Perhaps one of the difficulties is that our own communication system breaks down when faced with anything so complicated.

The study of animal communication, then, is central for an understanding of animal behavior in general. More and more, biologists are coming to realize that animals cannot be completely