Note: *The following essay is taken from a book manuscript in progress on the social behavior of horses.*

Investigative Procedures and Sources of Evidence in Biology

Any attempt to analyze the life of an organism depends on observations and experiments conducted on the organism itself. In the end, this is the only real source of facts about any particular species. But, by itself, this is a oversimple and misleading view. The number of observations and experiments that can be performed on any animal's behavior far exceeds the financial and other capabilities of humans to conduct them. This means that whatever experiments are actually performed represent a small, selected subset of those possible. As a result, it is crucial to know how best to select the observations and experiments to be conducted. A poor method of selection is unlikely to lead to to useful or interesting findings. Even if one's purpose is to develop a broad understanding of the entire life and behavior of a species, it is not easy to accomplish this purpose by simply wading in and trying to do every observation or experiment that comes to mind or seems feasible. Instead, one wishes to consider central questions, the answers to which result in a weaving together of facts and ideas that will provide a coherent picture of the species repertoire.

How can appropriate observations and experiments be selected? In some studies there appears to have been little guidance of any kind, and the results usually reflect this aimlessness. Another all too frequent situation is that the observer simply perceives that a particular experiment is feasible or affordable, or can be accomplished with little expenditure of time and energy, whether or not it might yield an important result; a good example is injecting into the brain whatever man-made chemical might be easily and inexpensively available and then attempting to measure the corresponding behavioral changes. The result of such "shotgun" experiments might have significance in, say, identifying medications appropriate to alleviating particular symptoms, but it is unlikely to contribute to understanding the overall life or behavioral repertoire of a species.

Still another possibility is that someone wants to solve a practical question about, say, horse behavior or training. Even here, a general understanding of the background of horse behavior, and the knowledge to compare it with the behavior of other similar and related species, is essentially certain to be useful. For example, anyone who wishes to teach a horse anything at all, such as entering a trailer or allowing itself to be saddled and ridden, can profit from realizing that horses have for millions of years been prey animals, in almost constant danger from predators likely to attack suddenly and unexpectedly from any direction.

A fruitful approach in trying to learn something important about the "normal" or usual behavior of any species -- and probably the most widespread one -- is for an observer to watch until he notices something interesting or puzzling and then begin by trying to work out what is going on. Such watching may consist of either systematic or casual observations. Systematic observations have the distinct advantage that they result in the accumulation of quantitative information right from the start, giving the possibility that the observer will eventually perceive something significant that he would not have noticed in the absence of systematic, quantitative observations. For example, systematic observations on distances between horse herd members and their behavior toward one another might reveal changes in the behavior of the herd as biting flies become more serious late in summer, or as foals become older and more independent. Without quantitative information on the earlier periods, no comparisons could be made.

The danger in engaging in extensive systematic observations prior to establishing specific hypotheses to be tested is that the observer may occupy all his time with observations that he cannot yet know will ultimately turn out to be insignificant; and he may come to feel that continuing every single observation that has been made across the past is so important that there is no time for thinking about new approaches and no way to begin additional observations. Sometimes no change in procedure seems justifiable because of its interference with statistical procedures only possible if prior observations are continued. This is a real problem, and the results of succumbing to the sacredness of one's systematic but unguided observation pattern are attempts to publish voluminous but trivial results. An example of such procedures is what some wildlife specialists do upon locating, say, a deer carcass; by the time the measurements, countings, and other observations already established as "required procedure" have been carried out, there is no time or energy to examine the carcass while considering what obscure or difficult but important kind of observations may not have been made. Such lengthy and mind-deadening procedures may continue indefinitely, even though nothing is been accomplished as a result of them, and no possibility of their being important in the future can easily be established. It is difficult to dream up significant hypotheses to be tested if one's time and energy is all being used in systematic description initiated in the absence of useful hypotheses beyond the sometimes vainly optimistic one that "if I keep on watching and counting the same things, something useful will eventually come of it."

To understand the "watch until you see something interesting or puzzling and then concentrate on it" way of operating we still have to ask what causes observers to regard an event as interesting or puzzling. Probably the first thing a biologist tends to look for is any behavior that does not appear to be consistent with the general rules or understanding of the process of organic evolution that is responsible for all organisms and their characteristics. Evolution, which is guided chiefly by natural selection, results in certain kinds of cumulative changes and excludes other possibilities. Thus, we expect that adult organisms will either assist their own offspring or at least not interfere with their success; and we expect that they will not favor the offspring of other individuals over their own. Tendencies of this sort, which (in *nearly* all situations) increase genetic reproduction, are believed to develop and become developmentally reliable and elaborate as a result of the cumulative effects of differential reproduction; that is, any genetic alternatives, or alleles, that reduced genetic reproduction would be outcompeted and rendered extinct by alleles that increased (or did not decrease) their own genetic reproduction and that of their bearer. To locate any apparent exception to this general rule would represent an observation contrary to general principles of the evolutionary process. As a result, if a biologist sees an organism do something that looks as though it reduces rather than enhances reproduction, he is likely to focus on it and continue intensive observations or experiments until he finds out what is really going on.

Second, a biologist with broad general knowledge about organisms uses it together with his knowledge of evolution to develop, from repeated comparisons, a variety of more or less specific hypotheses or expectations. Thus, to discover that the males of a mammal species tend to be larger and stronger than the females implies polygyny, or that males more often produce offspring with multiple females than vice versa; the reason is that more intense competition among males -- a result of some males getting multiple females and leaving fewer for the others -- causes larger, stronger males to be more successful in reproduction, to a greater extent than under monogamy. Similarly, to discover extensive and complicated cooperation among adults, other than mated pairs, implies that close relatives remain together. A biologist may also notice that horses appear to behave differently from a closely related species or from unrelated forms that have the same general pattern of behavior in other regards. For example, as already noted, the members of a horse herd do not displace the dominant mare even after she has become enfeebled as a result of old age; yet some other species do. What is going on here and how can one find out? In such cases the biologist may concentrate on the surprising, seemingly deviant, or differently patterned behavior, first checking his observation carefully to make sure it was correct, and then examining all the correlated conditions to see if a reason can be discovered for the apparent deviation from expectations, based on what either related or behaviorally similar organisms were known to do. Finally, a variation within the species may represent a puzzle worth special attention. For example, in my breeding herd the stallion seems to ignore oestrus mares with foals while tending constantly any oestrus mare that does not have a foal and mating with her at short intervals day and night throughout her oestrus. Obviously, he mates with mares with foals some time, because they become pregnant, but why does he show such continuous and almost frantic attention to mares without foals? As I will show, this unexpected and apparently unreported behavior appears to be related to a report by Hans Klingel that the virgin females of the Plains Zebra seem to advertize oestrus more extensively than other mares, thereby attracting the attention of outside stallions and typically being stolen by one of them.

Knowledge of organic evolution actually guides biologists in still a third fashion. Any information about the actual pattern of evolutionary changes in organisms across geological time, and about what was going on in the organism's environment at any particular time in its history -- as can be acquired from sequentially dated fossils, and sometimes also by comparative analysis -- has to be compatible with whatever is observed about an organism today.

5 Sources of Evidence

So, in the end, the evolutionary biologist continually compares (1) what he sees today in, say, the behavioral repertoire of the species he studies with (2) how its closest relatives behave, (3) how any other species with extensive parallels in its life pattern (or explicit dissimilarities or opposites) behaves, (4) expectations from the cumulative effects of natural selection and the general evolutionary process, and (5) what is known from the fossil record about the chronology of changes in the species and its environment during all of evolutionary history. Such a multi-faceted approach encourages the establishment of procedures and techniques designed to test particular hypotheses or answer particular questions rather than the simple accumulation of nonspecific or undirected observations in the hope that they will become important some time in the future. Only through such an approach is there strong likelihood of eventually developing an overall coherent picture and thorough understanding of the behavior of any organism, including ourselves. The reader may now realize, however, that anyone who becomes well versed in evolutionary theory and also develops a broad comparative knowledge of organisms is considerably more capable right from the start of planning systematic observations, on a species he has not previously studied, that will lead rather directly to the exposure and answering of significant questions and the testing of multiple hypotheses.

In organizing my own study of horses, and in putting this book together, I considered how the above procedures might be employed to investigate and explain horse social behavior. As a result I decided to begin with a discussion of the likely evolutionary background of the most general aspects of horse social behavior, relating them to both organic evolution and what is known about the social behavior of other related and unrelated but similar organisms. This beginning, in which I have attempted to discuss only widely known and universally agreed-upon observations, establishes a general set of hypotheses, to be tested by examining the data already published in the horse literature, and through my own observations and experiments. Following the introductory discussion I review and critique the existing information on all aspects of horse behavior, both to see if the initially drawn general picture is supported or must be discarded in favor of some other view, and to fit the different pieces of information together to create a reasonable overall picture. All of my own observations and experiments, reported in this section, were conducted to test particular hypotheses, developed as a result of initially considering the probable evolutionary background of horse sociality.

At the end of the book I attempt to synthesize and draw conclusions from all of the different sources of evidence and different approaches. At every step my intent has been to produce a discussion of all aspects of horse sociality, which will enable the reader to understand his own horse better and interact with it in a more pleasant and effective way, as well as to interpret wisely whatever he may read or hear about horse social behavior.

There is one final thing to say here about sources of evidence, which applies specifically to horses and other domesticated animals. Because so many people have watched and worked with horses for so long, and written and talked about their experiences, there are countless anecdotes about what horses do and don't do. This is not true of the wild species that biologists study, for which sometimes virtually nothing is known except what a single investigator has discovered. Anecdotes -- or accounts claiming that some particular behavior was witnessed once or an uncounted number of times, usually without careful accompanying notes -- are typically not considered scientific evidence because most often there is no way for a skeptic to repeat the observation and thereby test its accuracy. Generally the incident must be recounted from memory because detailed and accurate notes were not taken at the time it happened; relying on memory introduces strong possibilities of error and bias. Nevertheless, in my opinion it is neither appropriate nor possible to ignore all anecdotes about horses. Especially if they are carefully recorded, anecdotes are really just single observations, not necessarily less scientific than any others. In the end, from single observations come all valuable clues that are used to